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ONTARIO AGRICULTURAL COLLEGE

INSECTICIDES, FUNGICIDES and HERBICIDES

By H. L. Fulmer, B.S.A., M.A., Associate Professor of Chemistry.

It Pays to Control Pests

The above photograph was taken in June and shows an apple orchard almost completely defoliated through an attack by canker worms. Needless to say the present season's crop is completely ruined; and, since the leaves of a tree are comparable to the stomach of an animal, the very life of the orchard itself is at stake. Even if the trees survive, the crop of the subsequent season will be markedly jeopardized.

The timely application of an arsenical, such as lead arsenate, would have prevented the above disaster.

This illustrates but one of myriads of ways in which pests of all sorts are continually causing untold damage. And in the majority of instances an efficient method or methods of control are available.

Introduction

We are told by those who have made a careful study of the question over a period of years, and over wide areas representing all the varying weather and climatic conditions of the country, that the annual levy made by insects on economic vegetation, in America, amounts to the enormous sum of one billion dollars. And, in addition to this another toll is taken by fungi, pathogenic bacteria and weeds, giving a further combined loss which must be equally appalling.

Such losses as the above are not by any means confined to plants. Animals are also subject to attack from many varieties of enemies. It is said that there is a $7,000,000 loss annually suffered in Canada in the leather industry because of warble damage on the hides used; and a $6,000,000 loss in meat and milk caused from irritation of our beef and dairy cattle by these same insects. Add to this the losses caused by the myriad additional insects which attack the above and our other domestic animals; as well as those brought about by bacteria such as the ones which cause tuberculosis and hog cholera; by parasites such as lung worms, stomach worms, tapeworms, whipworms, and many others; and by protozoa similar to those which cause Texas tick fever, amebic dysentry and many additional diseases, and it will be realized that animal losses are comparatively commensurate with those met with in the plant world.

And then one must not neglect to recall the staggering losses which rodents and insects, particularly, inflict on our food, stored grains, feeds, clothing, furs, carpets, rugs, furniture and buildings.

It should not require much argument then, to convince anyone that any procedure or procedures which would curtail the above losses even in a small way would probably be well worth adoption; and, furthermore, that money spent on the evolvement of superior methods would be money well spent. Of course, one must always keep in mind when speaking of losses in terms of dollars and cents, that should it arise that there were no losses in yields of plant and animal produce, that the inscrutable law of supply and demand would probably equalize things and establish actual money returns at a point about the same as that obtaining in the face of such losses. As it stands now, however, the man or woman who practises control methods in production reaps a very substantial premium in improved quality and in increased yields at enhanced prices; and what amounts to the same thing, also materially prolongs the useful age of such expensive things as furs, clothing, rugs and so on, as well as that of his or her orchard, garden, or domestic animals.

Methods of Control

Nature, herself, operates a wonderful system of control in her effort to maintain organic nature in a state of equilibrium. Her method is more or less aptly stated in the words of the rhymster:

> "Great fleas have little fleas upon their backs to bite 'em,
> And little fleas have lesser fleas, and so on ad infinitum;
> And the greater fleas themselves, in turn, have greater fleas to go on,
> While these again have greater still, and greater still, and so on."

Unfortunately, however, man has so changed the face of the earth by clearing the land of trees, draining the swamps, irrigating the arid regions, spanning the oceans and continents by improved and more rapid and convenient means of transit and inter-communication, by the introduction and producing of exotic varieties, kinds, species, and types of plants and animals, and in a multitude of other ways, that we now all but live under artificial conditions, with the consequent result that natural factors of control are no longer capable of successfully coping with the circumstances. It has thus become necessary to employ, in great part, artificial methods of control. Some of these are *preventive* in character and others *curative* and consist in the discovery, development and use of resistant varieties; the employment of clean, hygienic methods of cultivation, housing and manipulation; the introduction and encouragement of multiplication of the natural enemies (birds, parasites, etc.) of the scourging organisms; proper timing of seeding and planting; and the selection and utilization of various chemicals which will, by virtue of their properties and method of employment, kill, deter, or in some fashion prevent attack or injury by the pest or pests in question.

Although parasitism and other biological aids, humidity and temperature and other climatic forces, cultural procedure, the use of resistant varieties, and the other measures listed above constitute the range of control forces used in the warfare against the destroyers of our possessions, it happens that the most effective of these weapons is the last, i. e. the chemical weapon. Approximately 80% of the effective control obtained to-day is accomplished by means of the utilization of a number of experimentally chosen chemicals and it is to a discussion of these selected "drugs" and their employment to which the following pages will be confined.

Terms Used

In dealing with the various chemicals employed in control work it is convenient to class the organisms requiring control into the two great recognized biological divisions, viz., *Animals* and *Plants*, because representatives of both of these classes are actually comprehended in the category of pests. These two classes are, by virtue of their enormous diversification, necessarily much subdivided in order to approach their study with some degree of system and intelligence. For our purpose the following plan of classification will be used:

Animals
- (a) Vertebrates—including man, our domestic animals, rats, mice, rabbits, gophers, ground hogs, etc.
- (b) Invertebrates — (1) Multicellular — including insects, spiders, worms, mites, etc.
  (2) Unicellular — the protozoa (trypanasomes)

Plants
- (a) Multicellular — including all our common green plants; also the parasites and saprophytes (fungi)
- (b) Unicellular — the yeasts, moulds, and bacteria.

For specific references to chemicals used for controlling some of the above, we have such terms as bactericides, disinfectants, or germicides for referring to substances used in checking bacteria; and for dealing with protozoa we use the term trypanasomicides for naming the materials employed; for destroying eggs, ovicides; and other such terms for additional cases. But for purposes of simplification we shall use only the following three terms, viz:

I. *Insecticides*—substances used for controlling pests of the animal class and their products (eggs, etc.).

II. *Fungicides*—substances used for dealing with fungi, bacteria, yeasts and moulds.

III. *Herbicides*—materials used for exterminating common weeds.

Forms and Methods of Application

In the employment of a chemical, it may be applied according to conditions, and as to the physical characteristics of the substance itself, in one or more of the following forms:

(a) As a liquid, or as a solution, suspension or emulsion in water or some other liquid diluent.

(b) As a finely divided powder alone, or absorbed upon or mixed with a finely divided, usually inert, solid "diluent" or "carrier."

(c) As a gas or vapour.

And applications may be by means of any one or more of the following methods:

(1) Spraying, when projected upon the host as a liquid "mist".

(2) Dusting, when applied as a fine dry dust.

(3) Fumigating, when disseminated in the form as a gas or vapor.

(4) Mouth or enema, when introduced into the elementary tract.

(5) Hypodermic injection, when introduced by needle, either intravenously, intramuscularly or subcutaneously.

(6) Washing, dipping or anointment.

In many cases, for economical reasons or otherwise, two or more active chemicals may be applied at one and the same time. Such an instance is where an arsenic compound, such as lead arsenate, may be mixed with Bordeaux mixture or lime-sulphur in order to combine into one application both an insecticidal and fungicidal effect; or a mixture of Paris green and calcium arsenate, the object being to secure a rapid insecticidal effect co-incident with a slower and more prolonged effect. It sometimes is the case, also, that two or more substances are combined in order to counteract some host-injuring quality of the active principle, such, for instance, as the inter-mixing of hydrated lime with Paris green in order to remove the leaf burning property of the latter.

The Colloidal State

When any solid, liquid or gaseous material is ground or broken up by mechanical or other means until its mass is made to exist in the form of individual particles so small that the presence of the latter cannot be indicated except under extremely high magnification in strong light or, in other words, until the diameter of the individual particle is reduced to from 1/250,000 to 1/25,000,000 inch then the substance is said to exist in the colloidal state. When such an extremely fine state of subdivision is effected the substance concerned takes on many very interesting properties. Among these are increased activity, greater or more efficient covering power on surfaces to which applied, better adhering qualities, more rapid action, and increased ease of spreading. The production of a colloidal state, therefore, in the preparation of control remedies for use, is a point worthy of consideration and wherever economically possible, is to be recommended. In any case, every effort should be put forth to get the materials into as fine a state of subdivision as possible, or to apply them in such a form that the active principle or principles will be left available for action in the greatest possible condition of fineness.

As an example illustrative of the above, one may take the case of sulphur when used as a fungicide. This substance may be applied as a dust of elementary sulphur, or applied as a dust or water solution of some one of the polysulphides, such as lime sulphur, or liver of sulphur. In every case the application of it as a polysulphide will leave the sulphur on the host in a much more finely divided form than it can possibly be put on as an elementary sulphur dust; and the consequent result is that the polysulphide is by far the most efficient way of applying sulphur as a fungicide. The reason here for the increased efficiency through the greater fineness is, as is probably most always the case in all similar instances, due to the fact that better covering is effected and thus a lesser area of the host is left without a supply of the remedy, and that the remedy in its turn can get into more intimate and closer contact with the pest.

Emulsions and Emulsifiers

There are several substances which have been found to be effective chemicals in control work but which, on account of their caustic properties or concentrated form, cannot be applied directly without dilution. Many of these, notably the petroleum oils, are insoluble in water or other suitable solvents and hence their dilution to a suitable strength becomes a more or less difficult problem. However, in most cases, it has been found that by breaking such liquids up into fine globules by means of various substances, such as soap, hydrated lime, flour, kaolin, calcium caseinate and various other things called *emulsifiers* that they can then be successfully mixed with water in any proportion. These diluted fluid mixtures are called *emulsions* and find extensive employment. They are opaque preparations, usually milky in appearance.

An emulsion might be defined as any milk-like mixture prepared by mixing an insoluble substance such as a mineral oil (e. g. kerosene) or an animal or vegetable oil, fat or resin (e. g. rape oil) and water by means of a third substance (e. g. soap) called an emulsifier.

The most prominent emulsions employed are kerosene oil emulsion, the lubricating oil emulsions, and the various commercial miscible oil preparations. And the most common emulsifiers employed are the soaps, of which the most efficient are the fish oil soaps made with potassium (soft soaps), and the iron or copper basic sulphates made from iron sulphate or copper sulphate, respectively, compounded with hydrated lime.

Choice of Control Substance

In choosing a chemical for any case in hand there are usually a number of substances available from which to make a selection. The first thing that has to be considered is the well being of the host in case the material is to be applied directly on or into it, or if it is going to be placed in a position where the host may come into contact with it. The life of the organism to be protected must not be jeopardized by the treatment. And second, the remedy used must be effective, and in this case the selection will rest with the most efficient one available.

The following points are the ones which will help in making a decision:

(a) Non-injuriousness to the host.

(b) High toxicity toward the pest.

(c) Good ability to cover and stick to the surface to which it is applied.

(d) Good lasting quality so that the effect will be exerted over the maximum period of time.

Spreading and Spreaders

The ability of substances to spread, or to be put into a form that will spread, into an area or over a surface to be protected is quite variable. Some substances are poor spreaders and others are good. This is an important point because it regulates the covering ability—a poor spreader gives poor covering. Oils are good spreaders if properly prepared because they have the power to creep along the surfaces on which they are placed.

In the case of gases, which disseminate themselves automatically, the density regulates the spreading power—the lighter the gas the more rapidly and uniformly will it spread, and the more effectively reach into cracks and crevices. A heavy gas like carbon bisulphide will not spread upward or outward very rapidly, but will quickly penetrate downward; a light gas such as hydrocyanic acid will act almost the opposite. Hence the former makes a good soil fumigant or a good fumigant when placed on top of stored products needing treatment; whereas the latter is good for fumigating greenhouses, buildings, tented orchard trees and such like, where the liberation of the gas is usually at the floor or at low elevations in the chamber to be fumigated.

The spreading of solids depends for the most part on fineness. For dusting, therefore, one should aim to have the material in a form as near to an impalpable powder as possible. Light, fine, fluffy solids spread better than heavy, coarse, crystalline solids. The solubility or wettability of a solid in the moisture of the environment in which it is placed, however, will also govern its spreading capacity. If a substance dissolves or becomes wet it will spread, otherwise it will stay practically where it is placed or where it falls.

In the case of a fluid material the ability of the surface on which it is placed to become wet by it will determine the extent of spreading over that surface. If a high interfacial tension exists between it and the surface very little wetting of the surface will occur, and not only will spreading be so poor that large areas will be left uncovered, but a great deal of the fluid will run away or drip off, and become wasted. In other words, the result will be about as good as pouring water on a duck's back.

For any fluid application a number of substances are available, such as soap, calcium caseinate, saponin and skim milk which, when added, decrease the surface tension of the fluid and increase its spreading power. Such substances are called spreaders and when the use of one of these is advisable, which is not always the case because sometimes of deleterious effects which its presence would induce in the quality or safety of the resulting spray, this use is always attended by superior results. For solids, these same substances sometimes increase wettability by their presence and thus improve spreading power.

If a solid or liquid remedy has good spreading power this results also in better contact with the pest which is being controlled, which, of course, is of the first importance.

Stickers

One of the things which regulates the efficiency of a remedy is its power to stick, either to the surface of the organism to be protected or to the organism to be destroyed. This can apply physically, of course, only to the solid and fluid remedies. For any substance employed which does not inherently possess this property sufficiently there are a number of materials available which, when mixed with such, serve to produce or to implement this attribute. Such substanaces must necessarily be of a glue-like character and include such compounds as the calcium caseinates, variously called under such names as "spray stick," "kayso" and "spreado", the resin soaps, glue, molasses, wheat flour and such like.

Anything which adds to the spreading power of a remedy will also materially add to its sticking power. Soap and saponin, therefore, will act in a similar capacity.

Stickers are particularly useful on smooth surfaces like cabbage and cauliflower, and they not only serve to hold the remedy on and thereby maintain a protective barrier over a longer period of time and over a higher percentage of area, but likewise they hold the pest more effectively in contact with the poison. And a sticker sometimes even holds a migratory enemy, such as an insect, down by glueing it to a certain spot and thus either kills it, in itself, by producing an asphyxiating covering about and over it, or by starving it to death by virtue of the fact that it is prevented from foraging for its food.

Many surfaces to which remedies are applied possess active electrical charges. A living leaf, for example, holds on its surface an active negative charge. In such cases, therefore, the application of a material carrying an opposite charge to the surface to which it is applied would result in an attractive force that would cause the remedy to stick on better. If Bordeaux mixture carries a positive charge it ought to stick more effectively to a leaf surface. Unfortunately, most of our present day remedies carry negative charges and hence, as foliage sprays they would not benefit from the presence of the active negative charge on the leaf, but rather the opposite. Some attempt is at present being put forth to place on the market actively charged remedies in order to aid adherence. This practice will be suitable only when assurance is made that the surface for which the substance is meant is in possession of the opposite polar attribute, otherwise, the practice will defeat its own end.

Suspensions

Many of the chemicals employed in control work are water insoluble solids, such as Paris green, lead arsenate, the basic sulphate of copper (the active principle of Bordeaux mixture), copper carbonate, and many others. In many instances these materials are applied as sprays, i. e., mixed up with water and applied in the fluid form. Being insoluble in water, these sprays are in the form of what are known as *suspensions.* A suspension is characterized by an opaque appearance and by the fact that when allowed to stand undisturbed for a time, becomes separated into two parts, a clear part (the water) and a sediment at the bottom or a floating mass on top (the remedy). This separation is most rapid when the particles of the remedy are coarse and much heavier or lighter than the water in which they are suspended. If the particles are very fine, or about the same weight (specific gravity) as the water, or both, the separation into the two parts is much slower. In some cases the separation is so slow that the suspension is practically permanent, but usually the conditions are such that the separation is quite marked at the end of a short time.

A case of a rapid separation is such as that observed in a mixture of Paris green and water, whereas a comparatively slow separation is seen in a sample of well made Bordeaux mixture.

Since uniform distribution of a remedy is all-important it is necessary, when applying suspensions, to maintain agitation of the mixture during the spraying operation in order to prevent separation of the parts. Paris green spray and all those sprays similar to it require constant and quite vigorous agitation; Bordeaux mixture and similar sprays require moderate but also constant agitation.

Suspensions are more permanent and hence less troublesome if the remedy is reduced to as fine a state of subdivision as possible before the suspension is made. Manufacturers of materials to be employed in this way aim to put their products on the market in as high a state of fineness as possible consistent with economy of production and users owe them much gratitude for the high proficiency which they have attained in this respect.

Many Remedies

To spray with any degree of success requires, beside a knowledge of the acting principle of the remedy which is being employed, a rather intimate acquaintance with the enemy which is being combated. The different pests do not show similar habits or characteristics. If they did, then the search for remedies would resolve itself into a very simple task—the discovery of one or two successful ones would be sufficient. But as it is, a great many of these remedial compounds are required in control work, the absolute number depending largely upon differences in anatomical and physiological structure and on differences in habits, life histories and methods of attack upon their hosts of the various pests. And these differences can be numbered by the score. The result of this is shown by the comparatively long list of substances found discussed in the following account.

INSECTICIDES

For purposes of control, insects may be grouped into two classes: (a) those which bite off, or lap up, and then swallow their food, known as insects with biting or lapping mouth parts respectively, and (b) those which obtain their food by piercing the skin or epidermis of the host, inserting a tube, and sucking up and swallowing the blood or sap thus secured.

It is obvious that insects of the first class could be killed by placing some poisonous substance on their food; but insects of the second class could not be so controlled because the placing of poison in the sap of a plant or the blood of an animal would also kill the host. A potato bug can be destroyed by poisoning its food on the outside, since a poison so placed, if properly chosen, will not enter the plant and harm it but will be picked up by the bug and introduced into its stomach along with its food, thus poisoning it; but imagine what the consequences would be of putting a poison into your blood in order to destroy a mosquito which feeds on it. Mosquitoes, flies, and such like insects, when attacking plants and animals can only be destroyed chemically by placing some gas liquid or solid, harmless to the plant or animal, about or on the surface that is visited, which by coming in contact with the outside of the insect in some way either destroys it or prevents it from attacking the host. Of course, insects of the first class could be controlled by this latter method also, but since this mode is less effective, on the whole, and slower, the poisoning of the food is the preferable plan in such cases.

Many insects, however, of both classes, attack the host from the inside. The corn borer is a good instance of such a case, also the raspberry cane borer, the leaf miners, the grain weevils, the tree borers, and many additional ones. Evidently, such insects could only be reached by disseminating some gas or vapour, which might, if there is a clear opening into the channel or cavity in which the insect is working, penetrate sufficiently so that contact with the pest might be effective. Asphyxiating, paralyzing, and poisonous gases or vapours would destroy such insects; odoriferous ones might cause them to leave. It is clear, of course, that such a treatment has to be carefully chosen when plants and animals which are susceptible to the same gases are also present.

All other pests belonging to the animal group would naturally require similar control methods under like circumstances.

It is seen, then, that insecticides might be divided into three classes, viz:

1. Stomach poisons.
2. Contact poisons.
3. Fumigants.

and it is under these three headings that they will be discussed.

STOMACH POISONS

Stomach poisons are those substances which, when eaten and passed through the intestinal tract, become digested and absorbed into the system and cause death by some sort of toxic action. There are many varieties of these compounds, but the most commonly employed in control work are those in which arsenic is the death dealing principle. These latter compounds are grouped together and referred to as the *arsenicals;* and substances with a lethal effect produced by some other principle or principles than arsenic are grouped under the term *non-arsenicals.* Under these two classes, therefore, will these poisons be described.

When any poison is designed for control through direct application to a living host it is obvious that it must be applied in such a form, or in such a way that it will not find access to the sap of the plant or the blood of the animal.

In case of plants this is accomplished by ascertaining that the poison principle is practically insoluble in the water of the environment, and in the case of animals that it is not applied in contact with any skin or flesh lesions, nor in such a situation that the animal can get it into its mouth.

All stomach poisons must be handled with extreme care. They should be plainly labelled POISON and carefully stored out of reach of irresponsible people; and when used as remedies must be manipulated with every precaution in order to safeguard man and beast.

Arsenicals

Arsenic trioxide, As_2O_3

This substance, known also as ratsbane, arsenious oxide, white arsenic and arsenious acid, is the basis of many food poisons. It is a white solid, occurring in a vitreous non-crystalline form and also in two crystalline forms. It is sparingly soluble in water, the solubility varying with circumstances. If water at 15° C. be shoken for a long time with the solids, 100 parts of the water will dissolve .28 parts of the crystalline and .92 parts of the vitreous, while if saturated solutions at 100° C. be cooled to 15° C., 2.18 parts of the crystalline and 3.33 parts of the vitreous form remain in solution. Water containing carbon dioxide, however, dissolves much greater quantities than does pure water. White arsenic completely and readily dissolves in solutions of caustic alkalies, such as ammonia, and in solutions of alkaline carbonates, such as washing soda. To both plants and animals it is a powerful poison, one grain being sufficient to cause the death of a human being and cultural solutions containing as little as .0002% being capable of destroying plant life.

Its solubility and high toxicity prevent its use in those cases where it has to be employed in direct contact with the host. And beside, with water it produces a distinct acid reaction and thus, on such tender moist tissues as leaves, strongly tends to produce a burning effect. Hence, its use as an insecticide is practically confined to the preparation of poison baits, for which it is both cheap and efficient, and as an intermediate for making such remedies as calcium arsenite.

Manufacturers of arsenicals use it extensively as a starting point for making nearly all the arsenic compounds on the market. This is due to the fact that arsenic trioxide is the chief form in which arsenic is initially recovered from nature, nearly all smelters securing it in large quantities as a by-product in the refining of their ores. Thus the manufacturer of Paris green, calcium arsenate, and other arsenicals used in control work is a consumer of white arsenic.

It is said that white arsenic is quite safe to use as the poison in combination with Bordeaux mixture or other preparations where lime is present in large excess as one of the constituents. However, without experience it is advisable that one should use either Paris green or calcium or lead arsenates in such instances.

In arsenic trioxide, the arsenic is present in the trivalent form, i. e. the lower form of oxidation, and all arsenicals which contain arsenic in this state are called *arsenious compounds.* Other substances which contain arsenic in this condition are Paris green, calcium arsenite, zinc arsenite and all compounds called *arsenites.* This is important because arsenic in this state is in its most poisonous form.

Arsenic Pentoxide, As_2O_5

This substance is also called arsenic oxide and is a white solid, very soluble in water, to which it imparts a strong acid reaction. It is a virulent poison but not so active as arsenious oxide, cultural solutions containing as much as .02% still allowing the growth of plants to continue.

It is not used as a control substance, but is the basis of many substances that are used as such, e. g., lead arsenate, lime arsenate and arsenate of sodium.

In this compound the arsenic is present in the higher state of oxidation, or what is known as the pentavalent form. All *arsenates* have their arsenic in this condition, e. g., sodium *arsenate*, calcium *arsenate* and many others, and in order to distinguish such substances from those compounds containing arsenic in the lower form of oxidation (arsenious compounds) they are referred to as *arsenic compounds.* Because of this fact all *arsenic* compounds are less toxic than the *arsenious* compounds and the consequence is that such a substance as arsenate of lead is a slower poison for insects than is a compound like Paris green.

Paris Green (Schweinfurt Green).

This substance was at one time used as an insecticide more largely than any other in the Province of Ontario, due to the fact that it was the first introduced (1867) and, therefore, better known. It is an olive green material consisting of a compound of arsenic, copper, and acetic acid or "vinegar", called by chemists copper aceto-metarsenite, $Cu(C_2H_3O_2)_2.3Cu(AsO_2)_2$, along with varying quantities of other substances present as impurities. Theoretically, pure Paris green contains 58.65 per cent. arsenious oxide, (As_2O_3), 31.29 per cent. copper oxide (CuO), and 10.06 per cent. acetic acid. Commercially, however, these proportions do not obtain, since there is always a small amount of moisture present in the green together with some sodium sulphate or Glauber salt and white arsenic, compounds formed in the process of manufacture and never afterwards completely removed. The first two substances have no insecticidal value, and if present in more than normal quantity only increase the cost of the green and should be classed as mere "make weights". If care is used in the manufacture there is no reason for them being present in more than very small amounts.

Free or Water Soluble Arsenious Oxide in Paris Green. It is on account of the presence of this substance in Paris green that we sometimes find that after spraying, the leaves of the plant treated turn black, having the appearance of being burnt, or even, in more extreme cases, drop off altogether, leaving the plant defoliated. This, of course, is very objectionable, since the physiological functions of the plant are thus severely checked, a case where the cure is as bad as, or worse than, the evil.

To account for the occurrence of this scorching, J. K. Haywood, of Washington, D.C., states three causes:*

(1) There may be a certain amount of arsenious oxide over and above that

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*U.S. Dept. of Agriculture, Bureau of Chemistry, Bull. 82, pp. 5-6.

combined with the other constituents. This is "free" arsenious oxide and until recently it has been considered the only cause of the scorching of the foliage by Paris green.

(2) The green may be poorly made, so that the constituents are very loosely held together. When such greens are brought in contact with water, especially water containing carbon dioxide, they soon break up and arsenious oxide is set free. Between the water of the spray and the action of dew and rain, enough oxide may be liberated to severely scorch the foliage.

(3) The green may be extremely fine. The best green when ground to a fine powder and applied to foliage will scorch. This is doubtless due to the fact that more surface is exposed to the action of water which, containing carbon dioxide, would soon set enough arsenious oxide free to cause serious damage.

Following up these statements, however, Mr. Haywood says: "It is a very common occurrence to secure a commercial Paris green that scalds because of one of the first two causes, but the writer has never found a commercial sample of green that scorched because it was in too fine a condition."

As to the breaking up of Paris green when in contact with water, with the liberation of free arsenious oxide, Colby, or California,* expresses some doubt, since, as he says, "aceto-arsenite of copper, as manufactured to-day, is instantaneously precipitated from complex solutions containing alkali and often excessive quantities of various acids." However this may be, we do know that Paris green often destroys foliage, and that it is likely due to free arsenious oxide. There is no sure and ready method by which the free arsenic content of Paris green can be ascertained. Reagents, such as ammonia, which dissolve Paris green also dissolve the oxide almost or quite as readily. The microscope has been highly recommended, especially for the detection of "white arsenic" which has been added as an adulterant, but not for that which has been retained in the process of manufacture. No doubt this is a valuable aid, still the actual amount present cannot be determined in this way, and the only way to decide whether this substance is present in injurious quantities is by chemical analysis, or by actual trial in a small way. According to Canadian standards more than 1.00% of soluble arsenic (As) in Paris green is considered a quantity which is injurious to foliage.

Precautions in the Use of Paris Green. Since the method of estimating the free arsenious oxide of Paris green is not within the ready reach of all, it is well to assume that it is present in harmful quantities and to use something to alleviate the difficulty, if such there be. Arsenious oxide, or "white arsenic" may be combined with other substances which will neutralize or destroy its acid or burning property. Lime is one of these substances. *If a double quantity of good, freshly slaked lime, or hydrated lime, be mixed with the Paris green and then the mixture made into a paste with water and allowed to stand in this form some little time before diluting and spraying, the lime will combine with the greater part of the free arsenious oxide and remove its leaf scorching property to a great extent.*

It is well also to know that some kinds of foliage are much more susceptible to the destroying power of arsenious oxide than others; thus the peach tree has foliage which is remarkably tender, whereas the foliage of the apple is quite hardy. From investigations carried on in 1902-3, the results of which are embodied in Bulletin 82 of the Bureau of Chemistry, Washington, D.C., J. K. Haywood was

*College of Agriculture Bull. 151, p. 19.

enabled to make out a schedule showing the amount of free arsenious oxide which the foliage of the more common fruit trees will withstand. His results, which also give figures showing the influence which lime exerts, and are thus doubly valuable, are summarized in the following table:

Average Percentages of Soluble Arsenious Acid Allowable.

	Apple	Pear	Peach	Plum
Without Lime	6	6	0	4
With Lime	7	7	4.5	6

This shows plainly that the orchardist must consider the kind of foliage he is spraying as carefully as the kind of Paris green he is using.

Total Arsenious Oxide in Paris Green. Since Paris green owes its insecticidal value to the arsenic which it contains, it follows that the larger the proportion of arsenious oxide there is present in it, the more effective it will be when used against insects. The value of any arsenical is chiefly determined by its arsenic content. Pure Paris green contains 58.65 per cent. As_2O_3. Any quantity above that must be present in the free state, and any quantity below that lowers the insecticidal, and, thus, the market value, just to the extent to which it is deficient. The commercial article is never ideal; in reality its manufacture is difficult, and many chemicals enter into the process. However, from analyses which we have made here and from results obtained elsewhere, most Paris greens contain at least 56 per cent. and there is no reason why they should contain less than 56 per cent. of arsenious oxide, providing any reasonable degree of care be exercised in the making.

Total Copper Oxide in Paris Green. Copper aceto-metarsenite contains 31.29 per cent. CuO, which bears a relation to the total arsenious oxide present of 1:1.87. Since it is necessary that arsenious oxide be combined with copper in order that it be not in the free state, then, any result of analysis showing a greater factor than 1.87 indicates free arsenic. White arsenic cannot be added as an adulterant without seriously disturbing this ratio.

Physical Conditions. The best grade of Paris green is a powder that will pass through a sieve of not less than 100 meshes to an inch. A coarse green is one that will settle rapidly from its suspension in water and will require constant agitation during the spraying operation in order that it may be distributed evenly over the foliage.

Adulterants and their Detection. The more common ones occurring in Paris green are white arsenic, barium carbonate, barium sulphate, gypsum, and road dust. The white arsenic may be added to bring the arsenic content up to the standard, but the presence of any of them is fraudulent, and they can only be classed as mere "make weights" which increase the cost of purchase for actual insecticidal value received. As previously stated, added white arsenic may be detected under the microscope, when it appears in the shape of white octahedral crystals. The other adulterants mentioned are all insoluble in ammonia, thus any quantity of residue left on dissolving the green in ammonia gives good ground for rejecting a sample on account of adulteration. This test is simple and can be applied by any one. A teaspoonful of the sample is placed in some receptacle, preferably glass, and about ten teaspoonfuls of strong ammonia (sp. gr. .90=25° Be.) added and the whole then thoroughly stirred and left to stand for half an hour. The Paris green readily dissolves to form a deep blue solution, whereas the adulterants present are left as solid particles in the bottom of the vessel. As before stated, white arsenic is also quite readily soluble in ammonia, and a complete solution does not show the absence of this material.

Paris Green in Ontario. The consumption of Paris green in this province amounts to several score of tons annually and the product put upon the market is of excellent quality. Samples analyzed from time to time in the Department of Chemistry of this College show all greens to be well made and of an entirely satisfactory standard. The following table shows how the composition usually runs:

Composition of Some Paris Greens Analyzed at the O. A. C.

No.	Moisture 110°C.	Sand	Sod. Sulphate	Copper Oxide	Total arsenious acid, As_2O_3	Acetic acid by difference	Soluble arsenious acid, As_2O_3	Ratio CuO: As_2O_3
1	1.29	.11	.34	30.68	56.55	11.03	2.36	1: 1.84
2	.99	.23	.13	31.62	56.91	10.12	2.73	1: 1.79
3	1.25	.26	.37	30.59	56.8	10.73	2.11	1: 1.86
4	1.26	.15	.36	30.39	56.12	11.72	2.85	1: 1.85
5	1.29	.71	.57	30.23	56.01	11.19	2.73	1: 1.85
6	1.41	.12	1.80	30.29	56.33	10.05	4.35	1: 1.86

These greens are all as satisfactory as we can expect the commercial article to be. No. 6 contains somewhat more sodium sulphate than there is any need for, and is also somewhat high in soluble arsenious acid, indicating under-washing in the manufacturing process; otherwise there are none of them but could be highly recommended for spraying purposes.

Paris green because of its comparative insolubility in water and high toxicity makes an excellent poison for poison baits. Its bright color also makes its presence easily visible on substances to which it is applied, and this fact is of considerable importance.

London Purple

London purple was first introduced as an insecticide in 1878, as a substitute for Paris green. At that time, and probably in part still, it was manufactured from a purple residue obtained as a by-product in the preparation of a dye known as magenta. This residue contained free arsenious and arsenic oxides and by boiling it up with slaked lime these oxides were changed into calcium arsenite and calcium arsenate, respectively, thereby making these latter compounds the active poisonous principle of the resulting insecticide. The adhering purple color of the residue being still present in the final product, thus giving the whole a purple color, it was quite natural to name it in such a way as to indicate that fact.

At first this substance was quite variable in composition because the arsenic content of the residue used varied considerably. In fact, analysis at various times showed the amount of arsenic present, calculated as arsenious oxide, to range all the way from 30 to 50 per cent. This variableness made it very unreliable. At the present time, however, it is standardized at about 26 per cent, stated as metallic arsenic or about the same arsenic content as the standard calcium arsenate now used so much as an insect poison.

At present this material is not found on the Canadian market, but large quantities of it are still manufactured and utilized in the United States for the control of the Cotton Leaf Worm, the Tobacco worm and the Potato bug. It is cheap and safe to use and by virtue of its make-up has a quick killing action comparable to that of Paris green together with a slower prolonged action similar to that of lead and calcium arsenates. It has also been found a very suitable arsenical to use as the poison principle in poison baits to be employed for the control of cutworms, having an efficiency about equal to Paris green for this purpose.

Substitutes for Paris Green.

The success which attended the use of Paris green right from the very beginning of its introduction, 1867, as a stomach poison, together with a number of drawbacks associated with it, such as the general necessity of using lime along with it in order to insure against foliage injury, has lead from time to time to the introduction of additional substitutes for it, besides that of London purple in 1878. Many of such have come and gone, among them "Black Death", Bug Finish," "Kno Bug," "Slug Shot," Bug Death," etc. But a number of them have become real and successful substitutes for the older standard remedy. So successful, indeed, have some of them become that they have almost superseded in use the earlier poison. The most important of these are those which contain large quantities of arsenic, and commonly called commercially the "arsenoids." They are invariably either arsenates or arsenites.

Among them we have copper arsenite (green arsenoid), lead arsenite (pink arsenoid), barium arsenite (white arsenoid), calcium arsenite, calcium arsenate, lead arsenate, and zinc arsenate. A sulphide of arsenic has also been used with some success. Only the more important of the above will be discussed and the following few pages give a short description of those most commonly and successfully used.

Lead Arsenate

This arsenical has become very popular and has replaced Paris green to a great extent since its introduction in 1892. This is because it is much safer to apply than Paris green, especially on the more tender foliage, such as peach; and further, because it stays longer suspended in water on account of its extremely finely divided condition; and that it adheres more firmly to bark and foliage, and therefore exerts its influence over a longer period of time. It also can be safely mixed with lime-sulphur solution, while Paris green cannot.

There are three forms of lead arsenate, the PbH or acid lead arsenic ($Pb\ H\ As\ O_4$), the Pb_3 or neutral lead arsenate, $Pb_3(AsO_4)_2$), and the Pb_5OH or basic lead arsenate, ($Pb_5OH\ (AsO_4)_3$).

It is not known definitely which of these is the best form to use, all three, if well made, are quite insoluble in water.

The following table* shows the composition of these three forms of this arsenical, calculated on a water free basis:

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*Mass. Agr. Expt. Sta. Bull. 201.

Composition of the Three Forms of Lead Arsenate.

Constituent	Acid.		Neutral.		Basic.	
Lead Oxide, PbO		64.291		74.440		75.924
Arsenic Oxide, As_2O_5		33.114		25.560		23.463
Equiv. to As (%)	21.590		16.667		15.299	
Ratio, As_2O_5: PbO	1:1.942		1:2.912		1:3.236	
Water of Combination		2.595		0.000		0.613
		100.000		100.000		100.000

The acid form is the richest in poisonous material (As_2O_5) and therefore would seem to be the best; but, on the other hand, it seems to be the general opinion that the neutral and basic forms are the safer to use with lime-sulphur solution, a combination in which this arsenical is often necessarily applied, since they are not so likely to decompose the wash nor to themselves break up and liberate soluble arsenic. The formation of soluble arsenic would, of course, make the wash injurious to foliage, and the decomposition of the lime-sulphur solution would lower its efficiency as an insecticide or fungicide. It is doubtful, however, that any of the lead arsenates tend to produce any appreciable amount of soluble arsenic in the presence of lime sulphur, since examinations we have made here have never indicated such; but destruction of an extensive amount of the sulphide sulphur of the lime-sulphur does take place, in fact, the acid lead arsenate destroys as high as 30 per cent. of this valuable part of the sulphur content of the lime-sulphur wash, almost as much as does Paris green (32-33 per cent.). So too, does the neutral lead arsenate, but only to the extent of about 8½ per cent. and thus not a very serious matter. We have never studied the basic form in this connection, but it is quite probable that it would have a less effect than the neutral, and certainly, at least, not more.

The destructive effect of acid lead arsenate on lime sulphur can be lowered to a point no greater than that of the neutral by mixing with it three and a half parts of fresh hydrated lime at the time of making the spray, and unless this is done it is advised that when using lead arsenate and lime-sulphur in combination that either the neutral or basic form of the arsenate be used.

Following is a table showing the effect of acid and neutral arsenate of lead on the sulphur content of lime-sulphur wash. It also shows the effect of the use of three and a half parts of hydrated lime along with the acid arsenate in reducing the loss of dissolved sulphur. As a point of added interest the effect of calcium arsenate, Paris green, and of hydrated lime on the dissolved sulphur of the lime-sulphur wash is also included.

It is seen that the use of hydrated lime along with the acid arsenate of lead reduces the destruction of dissolved sulphur down to a point where it amounts to about the same as that caused by the neutral arsenate of lead.

It is also interesting to find that the destructive effect of Paris green on the dissolved sulphur of lime-sulphur wash is also largely counteracted by the presence of lime. Using 6.6 parts of hydrated lime to one part of Paris green lowers the loss from 33.27 per cent. down to 7.22 per cent. But it must be pointed out here that this treatment does not render the Paris green-lime-sulphur combination a safe mixture to use, and the use of Paris green with lime-sulphur is at no time to be recommended.

Effect of arsenates of lead, calcium arsenate, hydrated lime, acid arsenate of lead + hydrated lime, and Paris green + hydrated lime on the dissolved sulphur content of the lime-sulphur wash.

Material added to the L.S. wash. S.G. of wash= 1.008	Rate per lbs. 40 gals.	Total dissolved sulphur per 100 cc. spray (gms.)	Amount of dissolved sulphur destroyed per 100 cc. spray (gms.)	Per cent. of dissolved sulphur destroyed
1. Acid lead arsenate	1.90	.6554	.2740	29.52
2. Neutral lead arsenate	2.50	.8480	.0814	8.76
3. Calcium arsenate	1.16	.8779	.0515	5.54
4. Paris green	1.00	.6202	.3092	33.27
5. Hydrated lime	6.60	.9240	.0054	.058
6. Acid lead arsenate	1.9			
Hydrated lime	6.6	.8568	.0726	7.81
7. Paris green	1.0			
Hydrated lime	6.6	.8623	.0671	7.22
8. Check		.9294		

Some investigators claim that a fourth form of lead arsenate exists, viz., the pyro arsenate of lead ($Pb_2As_2O_7$). Its presence or the extent to which it occurs in our lead arsenates is unsettled. It is a form which is fully as rich in poisonous material as acid arsenate of lead is, but it is not such a stable substance as the latter and would readily break up when mixed with water, especially alkaline water, or with lime-sulphur solution, and liberate arsenic acid. It would thus be extremely destructive to foliage. Not enough complaint is on record, however, to warrant us in believing that any quantity of the pyro arsenate is present in our lead arsenates.

Commercial Lead Arsenate. This term is applied to those brands of lead arsenate which are manufactured by various chemical companies or firms. The commercial brands come on the market in two forms, as the *paste* and as the *powder*. The former has enough water in it to keep it in a moist and pasty condition, whereas the latter is dry and in the form of a powder. The manufacturer of the paste usually sells it on the 40 per cent. water basis, i. e., that his product will contain forty pounds of water in every one hundred pounds. But this will vary slightly up and down for the same brand. Among different brands the range runs from 25 to 50 per cent. of water. The powders run about ½ to 1 per cent. In arsenic (As_2O_5) the powders are fairly constant, varying only with the form of the lead arsenate, whether it be basic, neutral or acid; while the pastes, besides varying from the same factor also vary with the water content, and thus show a wider difference in arsenic content. If a limit were given for arsenic content it would be that the pastes should not go much below 15 per cent. and the powders 23.0 per cent. As_2O_5. The pastes were the first to come on the market because it was claimed for them that they could be worked up more readily with water and into a more finely divided condition. Because of this they would require less agitation in the spray tank, and would adhere more firmly to bark and foliage. This advantage was always largely over-estimated, however, and at the present time has entirely disappeared. The powders are now produced in such a fluffy and finely divided form (70-80 cubic inches per lb. as compared with 40 cubic inches formerly) that they are, if anything, superior to the pastes in mixability with water and adhesiveness. Further than this, the powders are less bulky to handle, and in this way result in a material saving in cost of containers and transportation; they also are less subject to loss by leakage or to injury on storage,—freezing and thawing destroying, in great part, the suspension power of pastes. The powders are also more uniform in their composition, varying only within narrow limits in regard to their moisture content, whereas the pastes vary as much as 25 per cent. among different brands. This latter point is very important when it comes to weighing out the required quantity of lead arsenate to use. A pound of lead arsenate paste containing 25 per cent. of water will contain half as much again of actual lead arsenate as a pound of lead arsenate paste containing 50 per cent. of water. If the manufacturer of pastes would ship his output with always 40 per cent. of water in it as nearly as he can make it, and if the user would keep it from drying out after he buys it, the above difficulty would, of course, be overcome. If the buyer uses the paste form he should keep a layer of water over its surface all the time in order to keep it from drying out and to maintain its water content uniform. On the whole, the many advantages of the powders over the pastes has led, in great measure, to the displacement of the latter from popular favour. The recent introduction of the dusting practice has also further served to popularize the former so that, at the present time, very little of the paste is on the market.

The composition of some of the more common commercial lead arsenates is given in the following table:

Composition of Lead Arsenate.

No.	Paste or Powder	Water H_2O	Lead Oxide PbO	Arsenic Oxide As_2O_5	Figured to Dry Basis		Water Soluble Arsenic-Oxide As_2O_5
					Lead Oxide PbO	Arsenic Oxide As_2O_5	
		%	%	%	%	%	%
1.	Paste	40.49	40.33	16.74	67.78	28.14	0.24
2.	Paste	38.83	42.70	17.43	69.81	28.49	0.39
3.	Powder	0.53	68.14	27.15	68.50	27.29	0.35
4.	Paste	50.48	35.02	13.68	70.72	27.62	
5.	Paste	42.07	42.25	13.97	72.67	24.03	0.29
6.	Powder		64.29	32.36			0.75
7.	Paste	48.32	32.90	16.63	63.67	32.18	
8.	Paste	48.45	32.72	16.98	63.47	32.94	0.39
9.	Paste	24.23	54.49	18.54	71.92	24.47	
10.	Paste	45.14	34.90	17.77	63.44	32.40	
11.	Paste	47.24	30.56	16.43	57.93	31.14	
12.	Powder	1.01	73.43	23.63	74.17	23.87	
13.	Paste	48.52	33.34	15.78	64.76	30.65	0.36
14.	Paste	41.39	39.24	17.23	66.95	29.39	0.98
15.	Paste	38.91	39.17	19.43	64.12	31.81	0.30
16.	Powder		64.15	32.50			0.41
17.	Paste	48.33	37.10	13.84	71.60	26.71	0.26
18.	Paste	48.64	38.15	11.25	74.39	21.94	0.13

From a perusal of the above table it will be noted that the paste lead arsenates vary considerably in respect to the amount of water which they contain, especially among the different brands, these ranging from 24.23 per cent. to 50.48 per cent.; and even the same brand is not always constant in this regard. It is because of this factor, as before noted, that it is impossible to state definitely what quantity of paste lead arsenate should be weighed out in order to get a spray of known strength.

Another thing to be noted from the above table is that the majority of the brands here given are composed of a mixture of the various forms of lead arsenate, viz., basic, acid and neutral. This can be seen by an examination of columns six and seven showing the percentage amount of lead oxide and arsenic oxide by weight present when calculated to the dry basis. If the sample is made up entirely of neutral lead arsenate the percentage amount of lead oxide will be about 74, and the percentage amount of arsenic oxide will be approximately 25, whereas, if the sample is composed of acid lead arsenate the percentage amount of lead oxide and arsenic oxide will be about 64 and 33 respectively. Should the basic form be the arsenate present there would be about 76 per cent. of lead oxide and 23 per cent. of arsenic oxide. If the sample be composed of a mixture of these arsenates then the percentage amount of these two constituents would lie in between the upper and lower limits for each, viz., between 23 and 33 for As_2O_5, and between 64 and 76 for the lead oxide. The exact amount of each of these will be in ratio proportionate to the amount of each kind of arsenate present. Thus it will be seen that Nos. 7, 8 and 10 arsenates of lead are practically made up solely of the acid lead arsenate, Nos. 5, 9 and 12 of neutral lead arsenate, No. 18 of basic lead arsenate, and the others a mixture of the various varieties, usually. At the present time, however, nearly, if not all, of the arsenates of lead on the market are composed entirely of the acid lead arsenate.

Lead arsenates should be of such a quality that when mixed with water, they will give only inappreciable quantities of soluble arsenic, not more than 0.75 per cent. Samples which, when boiled with ammonia water, will give in the filtrate a precipitate with lead acetate and acetic acid, are as a rule injurious to foliage. The addition of a solution of lead acetate or nitrate to such arsenates till there is an excess of lead, as shown by potassium iodide paper (see under home-made lead arsenate), would be beneficial.

Home-made Lead Arsenate. If one cares to he can make his own lead arsenate at home. The only drawback to this is the assurity of obtaining materials of suitable quality. Bulletin 131, Bureau of Chemistry, U.S. Department of Agriculture, gives the following directions:

	Ozs.
Formula A.	
Sodium arsenate (65 per cent.)	8
Lead acetate (sugar of lead)	22
Formula B.	
Sodium arsenate (65 per cent.)	8
Lead nitrate	18

"If the sodium arsenate employed is 50 per cent. strength, use ten and a half ounces instead of eight. Of the pure crystallized salt fourteen ounces would be required to furnish the same amount of arsenic oxide as would be furnished by the given amount of the 50 and 65 per cent. grades if they actually contained these per cents. In only one technical sample examined, however, was the arsenic oxide content over 45 per cent. The formulas are based on lead acetate containing 60 per cent. of lead oxide and lead nitrate containing 66 per cent. of lead oxide.

"*Dissolve each salt separately* in from one to two gallons of water* (they dissolve more readily in hot water), using wooden vessels. After solution has taken

*The solution of lead acetate may have a milky appearance. This will be no objection, and it need not be filtered.

place, pour slowly about three-fourths of the lead acetate or nitrate into the sodium arsenate. Mix thoroughly and test the mixture by dipping into it a strip of potassium iodide test paper,* which will turn a bright yellow if lead is in excess. If the paper does not turn yellow, add more of the lead acetate slowly, stirring constantly, and test from time to time. When the solution turns the paper yellow sufficient lead salt is present, but if it should occur that the paper does not turn yellow after all the lead salt has been added, dissolve a little more and add until an excess is indicated. The great advantage of this test is that it is not necessary to filter the solution or wait for it to settle.

"If the paper is not at hand, the test may be made by adding a few drops of solution of potassium iodide, when, if lead is in excess, the instant the drops touch the solution a bright yellow compound, lead iodide, will be formed.

"It is very essential that the lead salt be added in *slight excess*, but a large excess should be avoided.

"If the material has been carefully prepared with a good grade of chemicals it will not be necessary to filter and wash the lead arsenate formed, though it would be a safe precaution to allow the lead arsenate to settle, then decant the clear solution and discard it. Approximately one pound of actual lead arsenate will be obtained by using the amounts of chemicals specified, which is equivalent to practically two pounds of commercial lead arsenate in the paste form. It may be made up to forty gallons with water if a formula is being used which calls for two pounds of commercial lead arsenate paste to forty gallons, or if a stronger application is desired, add less water.

"As these chemicals are all extremely poisonous, vessels in which they have been dissolved or mixed should be plainly marked, and not used for any other purpose.

The authors of the above publication claim that Formula A will produce neutral lead arsenate and Formula B acid lead arsenate.

The economy of making home-made lead arsenate will depend on the cost of materials, labour, convenience, ability to secure the chemicals of suitable quality, etc.

Amount of Lead Arsenate to Use. The amount of lead arsenate to use in spraying, according to published instructions, varies all the way from one to six pounds per forty gallons, (either water, lime-sulphur solution, or Bordeaux mixture). Using Paris green (56 per cent. As_2O_3) as the standard spray, applied at the rate of one pound per forty gallons, however, lead arsenate in the different forms should be applied in about the following strengths:

Kind	Condition	Pounds per 40 gallons
Neutral	Paste	4 2/5
Neutral	Powder	2 2/3
Acid	Paste	3 2/5
Acid	Powder	2
Basic	Paste	4 2/3
Basic	Powder	2 4/5

The above quantities are estimated on the basis that the paste will contain 40 per cent. of water; and that the neutral lead arsenate in the paste and powder form will contain 15 and 25 per cent. of As_2O_5 respectively; and that the acid lead

*If potassium iodide test paper cannot be obtained, it may be prepared by dissolving a few crystals of potassium iodide in about a teaspoonful of water and saturating filter paper or blotting paper with this solution. After the paper has dried, cut into strips and keep dry until needed.

arsenate in the paste and powder form will contain 19½ and 33 per cent. of As_2O_5 respectively; and that the basic lead arsenate will contain 14 and 23 per cent. As_2O_5 respectively. As these percentages vary up and down from these averages, however, and since some lead arsenates may be a mixture of forms these amounts will have to be varied accordingly. In addition to this the fact must not be overlooked that Paris green is a more active poison, pound per pound of arsenic present, than is lead arsenate, through the fact of it being an arsenite. For this reason the amount of lead arsenate to use should be slightly greater than the quantities given. However, so many factors determine or modify the strength of poison to be used at any given time, as, for example, the insect to be attacked, the seriousness of the infestation, the kind of plant, the time of year, the weather conditions, etc., that no hard and fast rules can be given as to quantities to use. The above amounts, therefore, are only meant to be suggestive.

Calcium Arsenite.

This is a home-made substance and several formulae have been published for making it. There seems to be no doubt about the insolubility of the compound when it is used immediately after it is prepared, but when allowed to stand for days or weeks before applying there may be some decomposition take place and soluble arsenites be formed which will destroy foliage.

The following method can be followed in making it:

White arsenic (As_2O_3)	5 pounds.
Washing soda, crystallized ($Na_2CO_3 10H_2O$)	5 pounds.
Water (soft, such as rain water)	2½ gallons

(In place of the crystallized washing soda one can use instead one and a half pounds of the anhydrous washing soda. It is a white powder. The crystallized washing soda changes into it after long exposure to the air, so that it is a common thing, therefore, to find that the crystallized washing soda after bought changes, if kept in an open container, to the anhydrous form.)

The washing soda and white arsenic are added to the water. The mixture is then brought to the boiling point and boiled till everything is dissolved. This takes about five minutes of boiling. When solution is effected, about eight pounds of good fresh stone lime are added. When slaking has ceased, continue boiling for 10-15 minutes. This mixture, when diluted with water, will make about 400 to 800 gallons of spray. It can be made in smaller quantities if so desired, by reducing the quantity of white arsenic, washing soda, and lime given above, but still retaining the same proportions. If stone lime is not to be had, hydrated lime can be used in its stead. Should hydrated lime be used, however, ten and a half pounds must be taken and the boiling continued for twenty minutes.

The chief advantages of the calcium arsenite preparation is that it is cheap, the materials are easily procured, it is easily prepared, and that it is a reliable and fairly safe insecticide.

Calcium Arsenate.

This arsenical was introduced about 1912. The idea in mind at that time, mainly, was to get an arsenic compound which would mix well with lime-sulphur, the old standard arsenicals up to that date having been found not to be ideal in all respects, or, in some cases, entirely unsuitable. Both lime-sulphur and the lime arsenate being calcium compounds it was deemed that they should present the nearest approach to compatibility. It was soon found, of course, to be a decidedly efficient and suitable food poison, and at that time comparatively cheap. The result is that it has come to stay. Indeed, it is now used practically as a specific in the United States for the cotton boll weevil; and is also being extensively used in the control of forest insects, in which case it is dusted from aeroplanes. The late war, with resulting high prices, brought it into great prominence because the copper and lead compounds became more inflated than those of calcium. It is still much the cheaper.

There are three forms of this product:

(1) Acid .... $Ca\ H\ As\ O_4 .\ H_2O$.
(2) Neutral .... $Ca_3\ (AsO_4)_2 .\ H_2O$.
(3) Basic .... Variable formula, according to the amount of excess of life.

The third one is the commercial article, and it comes on the market both in the dry or powder form, and as the paste form carrying about 50 per cent. of water.

The composition of commercial arsenate of calcium is as follows:

Calcium oxide (CaO)	44.128 per cent.
Arsenic oxide (As_2O_5)	45.238 per cent.
Equivalent to As 29.497 per cent.	
Ratio As_2O_5 : CaO— 1 : 0.975	
Combined water	10.634 per cent.
	100.000 per cent.

If the paste form is used then the above percentages become approximately one half that given.

It is thus seen that the dry form of this arsenical carries about two-thirds as much arsenic as does Paris green (44.35 per cent.); but it would not be so effective, in proportion, as the latter remedy, which is an arsenite. It will be safer to use on foliage than Paris green, the excess of lime in the basic form making the calcium arsenate in it more stable; and at the same time it is useable with lime-sulphur, liberating no appreciable amount of soluble arsenic, and only destroying 5½ per cent. of the dissolved sulphur of the summer wash. (See Table on p. 18).

It is a white powder, bulky, giving 80-100 cubic inches to the pound. It has good suspension and adhesiveness and can be easily prepared for spraying. Calcium arsenate also forms a good dust, alone or in mixtures.

Zinc Arsenite.

This arsenical was brought out about 1911, but has never come into general use as yet, mainly because of its costliness. It was first made in California, and the long shipment and the incident freight charges made the price almost prohibitive to the Ontario consumer. However, it is at present made nearer home (Baltimore, Md., and Detroit, Mich.), and the cost is not now so high.

Two samples have been analyzed in this laboratory for total arsenic, and the percentage amount found to be 36.63 and 42.0 respectively, expressed as As_2O_3. A New Jersey analysis (Bulletin No. 286) gives the amount of As_2O_3 found as 30.58 per cent. in a sample secured by them from the Thomsen Chemical Company of

Baltimore. Giving 36.0 per cent. as about the average it will be seen that zinc arsenite on the basis of equal arsenic content, is a little less than two-thirds as poisonous as Paris green. Hence, about half as much again should be used.

Arsenical Injury

After the application of an arsenical to foliage or to young and tender growth it often happens that considerable injury results. This is thought to be due, and undoubtedly is, to *soluble arsenic*, and is usually spoken of as *arsenical injury*. Carbon dioxide and ammonia of the atmosphere, in conjunction with dews, fogs, or light rains and high temperatures, will materially increase the amount of soluble arsenic and the consequent burning. "When the arsenic is in solution in a spray liquid, or drops of rain or dew on the foliage, some of it is absorbed by the tissues of the leaf. A very minute amount may have no injurious effect, and that from an arsenate less than that from an arsenite, and if, on account of a high soluble arsenic content of the spray material, or to long standing of the liquid before drying, as will happen in humid weather, a sufficient amount has been absorbed, then the tissue will be killed.

Two types of injury are distinguished — *acute* poisoning and *chronic* poisoning. In cases of acute poisoning the leaf, or large areas of it, turns black within twenty-four hours after the application; or sometimes, when the insecticide has dried rapidly after application, the blackening may not appear till after the first period when water has stood on the foliage for some time. In chronic poisoning there are no definite lesions, but after two or three weeks the leaves prematurely turn yellow and drop off. Apparently in this type of poisoning not enough arsenic is absorbed to kill the cells outright, but yet enough to interfere with and finally stop the functioning of the cells.

Conditions favouring a rapid drying of the arsenical and its continuance in a dry state are propitious, i. e., a relatively high temperature, low humidity and a good circulation of air at the time of application. If this is followed by warm, dry weather, there should be a minimum of arsenical injury. On the other hand, factors conducive to solubility of the arsenic and its passage, by osmosis, into the substance of the leaf or twig are detrimental, i. e., warm, "muggy" weather, or warm weather accompanied by fogs or heavy dews. Rains are not necessarily injurious if heavy enough to wash off the soluble arsenic as soon as formed."*

For most farm crops it is unwise to use an arsenical without protecting the plant against injury. The addition of milk of lime affords this protection. Four pounds of high-grade quick lime (95 per cent. CaO) are generally sufficient for one barrel of spray. The lime should be carefully slaked, sieved, diluted to nearly forty gallons, and the arsenical added slowly with thorough agitation immediately before application. Hydrated lime of good quality may replace the quick lime, using five and a quarter pounds, carefully sieved and worked up to a smooth paste with a small amount of water before making up to nearly the forty gallons.

According to "The Agricultural Pests' Control Act" of Canada, arsenical poisons should be regarded as injurious to vegetation if the water soluble arsenic (As) calculated on the dry basis exceeds 1.00 per cent. in Paris green and arsenate of lime, 0.50 per cent. in arsenate of lead, and 0.25 per cent. in all other preparations or combinations of arsenical materials. In the case of lead, sulphur and copper arsenic dusts, the water soluble arsenic content should not exceed the proportional amount which is permitted for the arsenical ingredients in the mixture.

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*Mass. Agr. Expt. Sta. Bull. 201, p. 9.

Non-Arsenicals

This group of stomach poisons includes those substances whose toxic action is due to some other principle than arsenic. It thus comprises a number of chemically non-related materials.

Hellebore, Sabadilla

This is a powder prepared by grinding the dried roots of certain plants of the botanical group known as the Liliaceae. Unfortunately the true hellebores belong to the group Ranunculaceae, therefore the term is a misnomer.

The specific group of lilies which is used for these preparations is the Veratrum genus. White bellebore is made from *V. album* and green hellebore is made from *V. viride* (American hellebore). Each of the powders are of a greyish color, usually, but sometimes they are of a light yellow color. They possess a rather pleasant odour and contain as their toxic principle certain alkaloids of which protoveratrine, $C_{32}H_{51}O_{11}N$ (principle one) cevadine, jervine, pseudojervine and rubijervine have been recognized. The total content of these poisons is about 1.0%. Hellebore is much less poisonous than the arsenicals, and hence is only used in special cases. These special cases are denoted by the fact that the alkaloids responsible for the activity of this insecticide are poisonous to insects, but in the quantities ordinarily used not of any serious action on man. This means, of course, that it could be used as a remedy on fruits and vegetables about to ripen or soon to be eaten, or as a combatant for insects infesting the household and our domestic animals. The alkaloids of hellebore are very volatile and the strength and efficiency is soon lost if exposed to the air. This means that it must be kept in tightly closed containers and preferably used fresh, and that the efficiency soon disappears after application.

It is applied as a spray, one ounce to two gallons of warm water; or dry, alone, or mixed with some diluent such as flour or finely divided air-slaked lime in the proportion of about one to five.

Hellebore is mainly a stomach poison, but no doubt has some efficiency as a repellant, and as a contact by clogging the breathing pores of the insect.

Veratrum root is sometimes called sneezwort because the powder, when brought into contact with the muscous membrane of the nose, causes violent sneezing. This action is probably caused by the alkaloids present.

A powder which is very closely related to hellebore is that known as Sabadilla. This is prepared by grinding the seeds of *V. sabadilla*, and *Schoenocaulon officinale*, and the activity is also due to a group of alkaloids, a mixture of which is prepared and used in medicine under the name of "Veratrine". The chief alkaloid here is cevadine (crystallized veratrine), $C_{32}H_{49}O_9N$, associated with cevadilline, sabadine, sabadinine and veratridine.

Sabadilla powder also loses its activity on exposure because of the volatility of the alkaloids present and thus has to be stored with the same care as hellebore. It likewise has similar uses because of its comparative harmlessness to higher animals.

Powders prepared from the real hellebore plants also are useful as stomach poisons. Here the poisonous principle is imparted by certain glucosides, chiefly *helleborein* and *helleborine*, probably belonging to the saponin group.

Sodium Fluoride, NaF.

This is an old and well established poison for cockroaches and ants, having a toxicity equal to that of arsenious oxide. It, therefore, makes a good substitute for the arsenicals in the manufacture of poison baits. Its solubility in water, however, is sufficiently high so that in field work it would be rapidly lost by leaching. This same fact also precludes its use on foliage because of the injury it would exert.

Sodium Fluosilicate (sodium silicofluoride) Na_2SiF_6

This material is recovered as a by-product in the manufacture of acid phosphate from rock phosphate. The occurrence in this natural rock of calcium fluoride and silica serves as the source of the fluocilicic acid which is ultimately turned into sodium fluosilicate by treatment with sodium chloride.

Sodium fluosilicate is a white solid, slightly soluble in cold water and is decidedly toxic to many forms of lower life such as insects and protozoa, decidedly more so than the arsenicals that are so commonly used, and at the same time it is less toxic to man and the higher animals than are the arsenicals. Which latter fact, of course, indicates that sodium fluosilicate may become a suitable substitute for the arsenicals in the spraying of nearly mature fruits, or of fresh vegetables about to be eaten, or as a household remedy.

Sodium fluosilicate was first tried out as an insecticide in 1924 and has already found to be more effective than calcium arsenate in the control of the cotton boll weevil. It is also more effective in poison baits for grasshoppers and cutworms than is arsenic and at the same time produces a bait which is distasteful to birds and poultry. It is also an excellent poison for the larvae of mosquitoes. *Larvex* contains sodium aluminium silicofluoride as its active principle.

No doubt time will extend the usefulness of this important substance; and demand will result, and has already resulted in the production of it of a suitable mechanical quality. Being a by-product it is comparatively inexpensive and there is no shortage of supply.

Borax, $Na_2B_4O_7 . 10H_2O$.

This substance is found in large quantities in nature as "tincal", a crude mineral containing 55% of the salt. Pure borax is prepared from this. Much of that on the market is also prepared from naturally occurring calcium borate by boiling the latter with sodium carbonate.

This chemical is a white solid, soluble in water, and finds extensive commercial use as a mild antiseptic in lotions and ointments, as a preservative in foods, etc., in making enamels, optical glass, soap and metal varnishes; in the manufacture of drying oils, and in many other ways.

It is poisonous to insects when eaten but not an active poison to man or the higher animals. It, therefore, is considerably used as a household insecticide for combatting such pests as cockroaches, croton bugs and ants. Many commercial preparations on the market designed particularly for destroying insects such as the above contain this chemical as their chief active ingredient.

Powdered borax mixed with an equal quantity of corn meal or other ground cereal, and sweetened with a little molasses or honey makes an excellent combative for ants and roaches.

Phosphorus.

Elementary phosphorus is a solid substance that exists in two main forms. One form is red in color and granular in condition and possesses practically no toxic power, whereas the other form is yellowish in color and waxy in condition and is very poisonous. Furthermore, the red phosphorus is very inert in contact with air while the yellow phosphorus throws off copious white fumes in contact with the atmosphere, and readily takes fire. The latter form also, when brought into contact with the skin produces serious, deep burns, which are extremely hard to heal.

Many rat poisons and roach and water bug preparations contain yellow phosphorus as the active ingredient. These remedies are very effective but the fire hazard, and the need for careful handling makes it such that they cannot be highly recommended. Other substances, such as the arsenicals, the fluorides, borax, etc., which are just as reliable and far safer to handle, are available and preferably used.

Strychnine, $C_{21}H_{22}N_2O_2$.

This compound is one of the most poisonous of the plant alkaloids and is obtained from the seeds of *nux vomica*, of which latter drug preparation and of its tincture, it is the chief active ingredient. It crystallizes in colourless prisms which melt at 268°C. and are insoluble in water, but will dissolve in alcohol or in water acidified with a mineral acid. It has an alkaline reaction and a bitter taste.

As a poison it acts principally on the spinal cord, causing excessive reflex irritability resulting in convulsions or tetanus in which all the muscles of the body are involved. The respiratory muscles are affected in this general response and usually, after two or three convulsions respiration ceases. Large doses cause almost immediate death.

This alkaloid is used considerably for poisoning the food of rats and various other rodents for which it is very efficient. But its extreme toxicity makes it very necessary that it be handled and utilized with every possible care.

Miscellaneous Stomach Poisons.

There are a number of other materials, such as lead chromate, tartar emetic, the sodium, ammonium and potassium salts of dinitro ortho cresol (cresylic acid), copper cyanide, and copper thiocyanate which are sometimes stated to be useful stomach poisons under certain conditions. However, they are not of sufficient importance to receive more than passing mention.

It is also the case that certain remedies, such as the tobacco extracts, black leaf 40, nicotine sulphate, etc., also act partly as stomach poisons. But these and others are chiefily contact poisons, and will be dealt with under that division.

CONTACT POISONS.

As previously stated, these remedies are employed to destroy sucking insects which must be killed by contact. They will kill any kind of insect with which they come into contact, however, and in this way are more or less general in their effectiveness. Nevertheless, the biting insects are, as a general thing, more efficiently controlled by means of the stomach poisons. It might be given as a rule that the weaker the surface tension of the spray, and the thinner the chitin of the insect, the more effective will any contact remedy be, other things being equal. *To be effective,* *the plant or animal or infected area must be very thoroughly covered, and in many cases the insect must be actually "hit."* This means that the under side of foliage and other surfaces must be sprayed as well as the upper part. In the case of the San José scale, for instance, which may exist in a spot no larger than a pin head, one scale left untouched may produce as many as a million offspring in one season. Consequently, *thorough spraying is essential to success.*

A large number of various kinds of substances are used for contact purposes, some being gases, others either liquids or solids. The compounds used may act in any one or more of the following ways:*

(1) Glue the insect down.

(2) Attack the body, dissolving fat and muscle, precipitating proteins, etc.

(3) Act as a narcotic, paralyzant or anaesthetic.

(4) Asphyxiate the insect by clogging up the breathing pores or, by saturating the body, prevent necessary aeration.

In any given case, however, it is usually difficult to define the exact way or ways in which a substance acts.

The Sulphur Compounds

Sulphur

Sulphur is a pale-yellow, brittle solid substance which melts to a thin straw-colored liquid at 114.5°C., and boils at 448.4°C., changing to a brownish yellow vapour. When these vapours strike a cool surface they are condensed and deposited as a fine yellow powder, called "flowers of sulphur." Sulphur also appears on the market in the form of hard masses called "sulphur rolls", or "rock sulphur." When these hard masses are ground to a fine powder we have it in the form known as "flour of sulphur". *Flour* and *flowers* of sulphur are the two forms which are used for combating insects. They are applied as dusts or sprays or are boiled up with lime water and applied as lime-sulphur, heated with sodium or potassium carbonates and used as liver of sulphur (soluble sulphur), combined with barium and used as barium tetrasulphide (B.T.S.), or combined with ammonia and used as yellow ammonium sulphide. In these several compounds just mentioned the sulphur is in the form of what is known as "polysulphide" sulphur and in this condition is quite caustic; and it is probably this *causticity* which gives the chief insecticidal value to these materials. In addition to this these polysulphides are easily decomposed by contact with air, resulting in the deposit of very finely divided free sulphur on the surfaces on which they have been placed. This latter fact undoubtedly gives rise to an efficient powder for aiding in asphyxiating insects, and at the same time provides the chief fungicidal constituent of the polysulphides.

Lime-sulphur Solution.

This solution came into use in Ontario about the year 1900 for combating the San José and other scales. It has also been found to be very effective in

*Mass. Agri. Expt. Sta., Bull. 201 p. 10.

destroying other kinds of the smaller insects, and is considered by many to be one of the best general "cleaning up" sprays that has been devised. In addition to its insecticidal value, it is an efficient fungicide.

A disagreeable feature of this wash is that it is very caustic, and its application is often attended with considerable discomfort, especially in windy weather. Some of the irritation to the face and hands of the operator may be avoided by smearing the former with vaseline and covering the latter with rubber gloves. Leather is easily corroded by this solution and care should be taken that the spray does not come in contact with harness. Unless it is a still day, the horses should be covered with blankets, or always kept to the wind-ward.

Home-made Wash.

A number of formulae have been recommended for the preparation of this wash. The one usually adopted in Ontario is as follows:

Fresh hydrated lime	25 pounds
Sulphur (flowers or flour)	15 pounds
Water	40 gallons.

With warm water make the sulphur into a paste, put in the lime and add about fifteen gallons of water with stirring. This may be done in the same vessel in which the subsequent boiling is to be conducted. Boil *vigorously* for an hour in a pan or kettle, with direct fire, or in a barrel with live steam. If direct fire is used for boiling it will be necessary to add a small amount of water from time to time to make good that lost as steam. If this is not done, the cooking material gets quite thick and the resulting wash becomes much injured. When the hour is up add enough water to make the whole mixture come to forty gallons; strain into the spray tank and apply as a dormant spray. If the wash is to be used as a foliage spray, dilute to about 160 to 200 gallons instead of to 40 gallons. Although effective, this wash is practically obsolete, as it is cheaper to make the homemade concentrated wash described later, particularly if one needs and is using large amounts of lime sulphur spray. If one requires but a small quantity of spray then this formula still remains useful. Much smaller amounts than 40 gallons can be made by the same procedure by merely reducing the quantities of the materials called for, but retaining them in the same proportions.

Self-boiled Wash.

To make this wash it is essential to have a freshly burned quick-slaking stone lime. The directions for making it as given by Mr. W. M. Scott, of the Department of Agriculture, Washington, D.C., are:—

Stone lime (fresh, high grade and quick slaking)	40 pounds.
Sulphur	40 pounds.
Water	200 gallons.

Place the lime in a barrel and pour enough water (about three gallons per twenty pounds) to start slaking and to keep the sulphur off the bottom of the barrel. Then add the sulphur which should first be worked through a sieve to break up the lumps, and finally enough water to slake the lime into a paste. Considerable stirring is necessary to prevent caking on the bottom. After the violent boiling which accompanies the slaking of the lime is over, the mixture should be diluted ready for spraying, or at least enough cold water added to stop the cooking. Five to fifteen minutes are required for the process according to whether the lime is quick acting or sluggish. Only a small percentage of the sulphur—enough to improve the adhesiveness of the mixture—goes into solution, but if the hot mass is allowed to stand as a thick paste the sulphur continues to unite with the lime, and at the end of thirty or forty minutes enough of the reddish liquid is produced to burn peach foliage and even apple foliage in some cases. Hence the necessity for cooling the mixture as soon as the lime is well slaked.

This wash has been specially developed for summer spraying—it does not contain enough of the calcium polysulphide to cause any foliage injury.

Concentrated Wash — (1) Commercial.

The commercial concentrate is, as its name indicates, a wash manufactured by a commercial concern. It is made in large quantities by several firms and forms a very ready and convenient source of the lime-sulphur wash.

The concentrate is strong (concentrated), usually carrying between 25 and 26 per cent. of total dissolved sulphur, and needs to be diluted with water before spraying. To dilute properly it is necessary to use a hydrometer and obtain the specific gravity of the *clear liquid.* The greater the sp. gr. the larger is the quantity of water that must be added. A hydrometer for this work should have its scale graduated from 1.000 to 1.400, and preferably should also have the Beaumé scale marked on its spindle. A hydrometer of this kind can be secured at a nominal price from or through dealers in spray materials. The proper quantity of water to be added is found by dividing the decimal portion of the specific gravity of the concentrated solution by .030 for the winter wash, and .007 for the summer wash, because 1.030 and 1.007 are respectively the standard specific gravities of the winter and summer sprays.

E. G., Specific gravity of concentrate — 1.300 $\therefore$ each gallon would be diluted to

(a) $\dfrac{.300}{.030} = 10.00$ gallons for winter wash.

(b) $\dfrac{.300}{.007} = 42.85$ gallons for summer wash.

The dilution for the spray, both winter and summer, will vary, however, depending on the fungus or insect being sprayed for, the nature of the foliage and the severity of the infestation. A spray calendar should therefore be consulted in order to find the correct figures to use in place of .030 and .007.

Following is a table showing the number of gallons of the concentrated solution over a series of given Beaumé (Bé) strengths commonly met with (with the corresponding Gay-Lussac (G.L.) reading also given) which need to be measured out in order to make 40 gallons (one ordinary barrel full) of spray of the two different strengths given above.

Dilution Table for Concentrated Lime-sulphur Solution.

Strength of Concentrates as Bé	G. L.	Gals. of concentrate needed to make 40 gallons of 1.030 spray	1.007 spray
22	1.180	6.66	1.55
23	1.190	6.32	1.47
24	1.200	6.01	1.40
25	1.210	5.71	1.33
26	1.220	5.45	1.27
26.9	1.230	5.22	1.22
27.9	1.240	5.00	1.16
28.8	1.250	4.80	1.12
29.7	1.260	4.62	1.08
30.6	1.270	4.44	1.04
31.5	1.280	4.29	1.00
32.4	1.290	4.14	0.96
32.8	1.295	4.07	0.95
33.4	1.300	4.00	0.93

1.030 G. L. = 4.22 Bé.
1.007 G. L. = 1.00 Bé.

In connection with this same work, since sometimes the strength of the solution is given in terms of Bé and at other times as G.L., it is well to know how each of these specific gravity scales can be converted into the other by calculation.*

Formula (1) To change G.L. reading into Bé. reading.

$$145 - \frac{145}{\text{G.L. reading}} = \text{Bé reading.}$$

Formula (2) To change Bé reading into G.L. reading

$$\frac{145}{145 - \text{Bé reading}} = \text{G. L. reading.}$$

In case of the concentrates, since they contain no sediment or "sludge", it is sometimes desirable to add freshly slaked or hydrated lime. The main function of the lime is to act as a marker so that the thoroughness of the spraying can be controlled. This is especially important when an inexperienced or careless man is at the nozzle. But it has other uses besides: (1) It prevents a great deal of waste by dripping, (2) some claim that it improves the sticking quality of the wash, (3) lime possesses in itself marked insecticidal and fungicidal properties and (4) it takes care of any arsenical poison that may be added to the summer spray. If lime is added it should be slaked first, unless it be hydrated lime, worked up to a thin batter with water, strained free of large particles and then poured into and well mixed with the diluted wash. Never add it to the concentrate before dilution. The amount used varies from two to six pounds of stone lime per forty gallons of spray or a proportionate quantity of fresh hydrated lime.

*These formulae are for calculations of the gravity of liquids heavier than water, and are not applicable to liquids lighter than water.

(2) Home-made:

It is quite possible to make the concentrated wash at home if one wishes to go to the trouble and expense for equipment. After some experience the wash can be made of as nearly good quality as the commercial kinds, and at less expense. Directions for making and handling are as follows (See Bull. 99, Penn. Expt. Station) :—

50 pounds best stone lime, or 66 pounds of fresh hydrated lime
100 pounds sulphur (flour or flowers),
40-45 gallons of water, *at finish.*

"Put eight gallons of water in kettle and start fire. Place lime in kettle. After slaking is well started, as is only the case where stone lime has been used, add the dry sulphur and mix thoroughly, adding enough water to maintain a thin paste, which requires about five gallons. After the slaking and mixing is completed, add water to the height of forty gallons on the measuring stick, bring to a boil and stir until the sulphury scum practically disappears. Then add water (preferably, but not necessarily, hot) to the fifty-five gallon height, and boil to forty-five gallons. The material should be kept well stirred, especially during the early stages of the process, and any lumps of sulphur or lime should be thoroughly broken up.

"The total time of actual boiling should be about one hour, though a ten-minute variation either way is not objectionable providing the sulphur is evidently dissolved. This fact is best determined by dipping and slowly pouring some of the material. The amounts of water indicated above are ample for one hour's fairly vigorous boiling, with the finishing volumes as indicated. If it is not at the desired height at the close, it may be made so by more water or more boiling, and either the amount of water in the second addition or the vigor of boiling can be so modified in later trials as to enable the total to be brought to the desired height approximately at the end of the hour.

"The finished product may be immediately poured or strained into a barrel or settling tank or into the spray tank. The straining is merely a safeguard to prevent any possible clogging because of imperfect materials or failure to break lumps in the sulphur. When properly made the amount of sediment left in the strainer is insignificant, being less than 1 per cent., and may be thrown away. To avoid any considerable loss of materials, however, the sediment in the strainer can be washed with part of the water used in making the next lot, simply by pouring the water through the strainer into the kettle, and any lumps of sulphur discovered may be broken up and used again.

"If the straining is not done, the whole product may be put into a settling tank or barrel, and the clear liquid drawn off later as required. This process, however, is likely to lose efficient liquids in the sludge, as well as the fine sludge itself, which may be of value in several ways, and is of no apparent hindrance in the spraying.

"The crust which forms on the finished material is prevented by immediately covering the solution with a layer of oil about an eighth of an inch thick, and avoiding unnecessary exposure to air in the transfer from kettle to storage tank. An ordinary paraffine oil was very satisfactory in our work, but there is no reason to believe that any other oil, not injurious to trees nor likely to take fire at boiling temperatures, may be used with equal success.

"The crust may also be prevented by immediate storage in tight, closed vessels, filling them completely. But partially filled vessels are likely to develop some crust with continued exposure."

Lime of good quality should be used for making the home-made concentrate. Beachville lime (0.6 per cent. impurity) is of ideal quality and any lime with not more than 10 per cent. impurity would be suitable, such as Ottawa, Coboconk, Trenton, Amherstburg, Caledon, etc.

Fresh stone or hydrated lime should also be used, because air-slaked lime combines with sulphur very slowly. The latter is very good for making the ordinary home boiled wash where the amount of lime used is usually greater than the amount of sulphur, but for the manufacture of the concentrate it is wholly unsuitable.

If a lesser quantity of this wash is required than is furnished by the above formula, one can reduce the amount to any desired fraction thereof. Likewise, a greater quantity can be prepared at the one operation if so desired. In such cases, however, care must be taken not to change the proportion of the materials used. One must necessarily work with amounts suitable to the size of the vessel in which the boiling is carried on. And, furthermore, since the material is apt to froth copiously during the early part of the boiling period, the operator should aim not to utilize more than about four-fifths of the capacity of the boiler, a matter, however, which can be adjusted through experience.

Dry Lime-Sulphur.

This substance, which is in the form of a yellow powder, was first marketed by Sherwin-Williams in 1915, but is now made by other firms as well. It is the liquid lime-sulphur with the water, which amounts to about 70 per cent. of its weight, removed till only a small portion is left, and the whole thing assumes a dry state. The removal of the water changes somewhat the state of the sulphur, but does not materially disturb the efficiency as a remedy. A great saving is affected through the removal of the water, in containers, transportation, storage, and possible leakage; and, furthermore, with the introduction of dusting, it furnishes a form of the lime-sulphur which can be applied in that way.

Samples analyzed here average about the following in composition:

Total sulphur		56.785 per cent.
As polysulphide	47.600 per cent.	
As thiosulphate	6.550 per cent.	
As other forms	2.635 per cent.	
Undetermined (Ca, H_2O and C.)		43.215 per cent.
		100.000 per cent.

Some of the sulphur, a small amount, is in the free form and thus probably largely inert. This undoubtedly is formed from the polysulphide sulphur during the removal of the water, for the percentage of the total sulphur in the form of polysulphide is 83.8 whereas in the average lime-sulphur solution it amounts to 93 or more.

Based on the strength of sprays made from concentrated lime sulphur solution one would need to use about 23 pounds of dry lime sulphur to make 40 gallons of winter or dormant spray, and about 6 1/3 pounds to make the same amount of summer or foliage spray.

The lime-sulphur solutions also make very excellent sheep dips. As a matter of fact they were first used for this purpose in Australia and Western United States, and their application as plant protectors was only first discovered, in California, in 1886 where they were found effective against the San José Scale. Their use for the same latter purpose reached Ontario in 1900. Since that time their wider usefulness has developed.

The Use of Aluminium Sulphate and Ferrous Sulphate with Lime-Sulphur Solutions.

Lime sulphur is one of our leading sprays and will probably remain so for some time to come. But it has many drawbacks, the chief one being its injurious action on foliage and fruit, and much work has been done in an endeavor to overcome this very serious defect. The most promising procedure so far discovered is the addition to the spray of either aluminium sulphate or ferrous sulphate. Both of these are cheap and easily procurable chemicals and the addition of either one of them to the wash markedly decreases its tendency to cause yellowing and dropping of leaves and the disfigurement of fruits. The aluminium sulphate is used at the rate of 3½ pounds for each gallon of concentrate and the copperas at the rate of 1½ to 3½ lbs. per each gallon of concentrate employed. With the latter the whole spray mixture becomes quite black; and there is also a tendency to cause blotchiness of the fruit, an effect which can be reduced or prevented, however, by substituting Bordeaux mixture for the last lime-sulphur spray.

There is some doubt at present as to the safety of mixing arsenicals with lime-sulphur sprays that have been treated with either of the above two chemicals. It appears that under most circumstances calcium arsenate can be safely used but some reports have come to hand, chiefly from the Maritime Provinces, that its use also sometimes results in the production of injury. At the present time, therefore, it is well to exercise caution in the employment of arsenical compounds along with lime-sulphur solution to which either aluminium sulphate or ferrous sulphate have been added.

Hydrated Lime as a Substitute for Stone Lime for Making Lime-Sulphur Wash.

For the manufacture of any of the lime-sulphur washes above mentioned, with the exception of the self-boiled wash, hydrated lime can replace the stone lime. It is well to know this because it is now much easier to secure hydrated lime than it is to get stone lime, the latter having been replaced largely in the building trade by the former, as a matter of convenience. When it is understood that hydrated lime is nothing but ready-slaked stone lime then the above will be clear.

In using hydrated lime, however, it must be kept in mind that one-third more, by weight, must be taken than if stone lime were used; and also that the same precautions regarding quality must be exercised, i. e., it must be made from high grade lime-stones such as those mentioned above, and must not have been exposed to the air for more than a short time.

Arsenicals and Lime-Sulphur Wash Combined.

In summer spraying with lime-sulphur wash it is often essential that an arsenical should be applied also, and in order to overcome the expense of a double spraying the two are mixed and put on together. Paris green, as already shown, cannot be used; and the acid arsenate of lead causes a serious loss of dissolved sulphur (30 per cent.) unless three and a half parts of hydrated lime are used along with it. Neither neutral nor basic arsenate of lead, nor arsenate of lime, causes a serious change in the lime sulphur wash, producing a loss of only 8 per cent. or less of the dissolved sulphur.

The arsenical to use with lime-sulphur wash is any one of the arsenates of lead or calcium arsenate. *Acid* arsenate of lead is the most common form of the lead arsenical now on the market; in fact, in 1921 it was the only form which we found and in that year we analyzed all the leading brands, both powders and pastes, to be obtained on the Ontario market. In practice it has been the experience of many investigators that the addition of arsenate of lead to lime-sulphur wash increases the fungicidal power, in some cases as much as 50 per cent. But with the acid arsenate the reaction between it and the lime-sulphur is so extensive that a considerable amount of soluble arsenic is liberated with consequent danger of foliage injury. Hence the use of the hydrated lime when this form of lead arsenate is used becomes doubly essential—both to conserve the strength of the lime-sulphur wash and also to prevent foliage injury. In case the other forms of lead arsenate are used, which would probably not be often because of their scarcity, or that calcium arsenate be selected, the interaction is so small and so little soluble arsenic is produced that the mixture would not likely be dangerous. The use of hyrated lime, however, at the rate of three and a half parts, is also here recommended as a precautionary measure.

In the above combination sprays the lime-sulphur wash takes the place of the water when the arsenical is used alone. The procedure in making up the spray is therefore the same as though water were being used, the directions for which have been previously given. The quantity of hydrated lime to use, viz., three and a half parts, is for the powder form of the arsenical. If the paste form is used then this quantity becomes reduced to two parts of hydrated lime to one part of the arsenical. The agitator must be kept continually running just as when the arsenical is mixed with water, so that there shall be a uniform distribution of the poison.

Soluble Sulphur (Liver of Sulphur).

This material is a solid, of a greenish yellow colour, and is sold in the powder, or a small-granule, form. It is not, as its name might suggest, a form of sulphur which is soluble in water, but, on the contrary, it is a compound of sulphur, and it is the compound which is soluble.

The particular combination in which sulphur is present in this substance is probably as the tetrasulphide (Na_2S_4). In this respect the sulphur is in much the same form as found in the potassium sulphide (liver of sulphur) of commerce, and will have much the same properties and uses. In the form of sodium sulphide, however, it is less expensive—sodium compounds always being cheaper than potassium compounds.

Soluble sulphur is made by heating together sulphur and sodium carbonate in a closed vessel in the proportion of about forty-eight pounds of sulphur to fifty-two pounds of sodium carbonate. The Niagara Sprayer Company of Burlington manufacture it. Samples examined here have been found to dissolve completely and easily in water to form an orange or yellow-coloured solution resembling in appearance a solution of lime-sulphur; and to contain 58 to 59 per cent. of total sulphur.

The use intended for soluble sulphur is that of a substitute for lime-sulphur. It is a solid and hence is less bulky, and thus more convenient to handle and store. It must be carefully protected from the air, however, else it will lose its efficiency very rapidly and completely, which, of course, is also true of lime-sulphur solution, but not nearly to the same degree. Furthermore, soluble sulphur has to be used with greater caution, as it is more likely to do foliage injury.

On the whole, soluble sulphur can be used in the same way as lime-sulphur, and for the same purposes; but it must be more carefully applied than lime-sulphur, when used as a summer spray, because of its higher drastic action; in fact, it should not be depended on as a summer spray unless an excess of hydrated lime is mixed with it. For dormant spraying about 10 to 12 pounds are used per 40 gallons of water and as a foliage spray from 1 to $1\frac{1}{2}$ pounds.

Other Materials Recommended for Destroying Scale Insects.

With the spread of scale, a large number of remedies of various kinds have been placed on the market from time to time. Among the more important of these are "Kil-o-Scale," and "Anti-Scale," or "Scalecide," "Emulsified Con-Sol" (also known as "Target Brand Emulsion,"), "Con-Sol," the "Webcide Solutions," "Zanoleum," "B.T.S.," and caustic soda and water. From the results of experiments conducted in this province and elsewhere,, it does not appear that these insecticides are any more effective, if as much so, as the lime-sulphur washes, in destroying scale. Prof. C. O. Houghton states that* the so-called "soluble oils," "Kil-o-Scale" and Emulsified Con-Sol," give satisfactory results when applied in the spring. Fall applications of "Kil-o-Scale" were satisfactory in one case, but not entirely so in another. "Scalecide" applied once as a fall spray was quite unsatisfactory so far as could be determined after a period of three months had elapsed. Applied to apple trees as a summer spray, at the rate of one part to twenty-eight parts of water, "Scalecide" gave valuable results. "Con-Scale", and the "Webcide Solutions" and caustic soda in water failed to give satisfactory results in any instance. "B.T.S." gives good results, but is too expensive, and has no advantage over the lime-sulphur wash. The full name of this last substance is barium tetrasulphide.

The Petroleum Products

The use of emulsions made from crude petroleum and some of its refined fractions has long been practised in insect control and their utilization has been attended by much success. The active principles of these preparations are hydrocarbons, substances which are very penetrating and which, when properly prepared, spread and stick well and exert their influence over a considerable period. The principal oils used are crude petroleum itself just as it comes from the well or partly refined, and its two fractions—kerosene (coal oil) and the lubricating oils.

Crude Petroleum

This material was first recommended for use against scale enemies by the late Dr. J. B. Smith, of the New Jersey Experimental Station. In the hands of many orchardists, however, it has been found to be decidedly damaging to many kinds of foliage, especially the more tender varieties, the apple and the pear being the only ones able to withstand its destructive power to any successful degree.

It is a very effective remedy, nevertheless, and whenever applied destroys the scale; but because of its general destroying tendencies, it cannot be recommended except for the most hardy trees.

If the crude petroleum can be emulsified, however, i. e., put into a form in which it will mix with water, it could be used with perfect safety, for it could then be diluted

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*Delaware Expt. Sta., Bull. 74, 1906.

down to a suitable strength. Formulae have been published for doing this, but these relate more to paraffine oil, a distillation product of crude petroleum, than to crude petroleum itself. Still, some investigators claim that they have satisfactorily emulsified crude petroleum, and we will, therefore reproduce one of these formulae. It consists of two parts, one for making the emulsifier, and the other for making the soluble oil. (See Bull. 4, Storrs Agr. Expt. Station, Storrs, Conn.).

The Emulsifier:

Carbolic Acid (liquid, crude, 100 per cent.)	2 quarts.
Fish Oil (Menhaden)	2½ quarts.
Caustic potash (granulated)	1 pound.

Heat to 300 degrees Fah., remove from fire and immediately add

Kerosene	3½ quarts.
Water	5 quarts.

The heating should be conducted in an iron kettle and away from buildings, as the mixture is inflammable.

The Soluble Oil:

Emulsifier	8 parts
Paraffine Oil	35 parts
(or Crude Petroleum, 20 to 30 parts)	
Resin Oil	5 parts
Water	1 part (more if necessary).

After the materials have been brought together in the above proportion they should be vigorously stirred with a garden hoe or some other suitable instrument. If the soluble oil has been successfully made, a few drops poured into a glass of water will give a milk-like emulsion.

For spraying, one part of the Soluble Oil is mixed with fifteen parts of water, or more or less if it is desirable to have a weaker or stronger spray, respectively.

Kerosene Emulsions.

The Kerosene Emulsions of various kinds are recommended for destroying many forms of insect life, and have long been employed, having been first introduced and used about 1870. The kerosene is, of course, the killing agent. The following procedure is very suitable for making the emulsion:

Kerosene (coal oil)	2 gallons.
Rain water	1 gallon.
Soap	½ pound.

Boil the soap in water till all is dissolved; then, while boiling hot, turn it into the kerosene, and churn the mixture constantly and forcibly with a syringe or force pump for five minutes, when it will be of a smooth, creamy nature. If the emulsion is perfect, it will adhere to the surface of glass without oiliness and will thicken into a jelly-like mass as it cools. This gives the stock emulsion, which must be diluted with water before using on vegetation. The above quantity of three gallons of emulsion will make a 2% spray if made up to 100 gallons with water. Stronger or weaker sprays can be made as desired.

The *K-L (Kerosene Lime) Emulsion* has been more or less strongly recommended for destroying San José scale. It is a mixture of kerosene, hydrated lime, and water, the lime acting as a carrier or emulsifier of the kerosene. Prof. C. P. Close gives the following directions for its preparation:* "Pour the kerosene and lime into a barrel and stir together well with a paddle. Add ten to twenty gallons of water, and stir to loosen the kerosene and lime from the bottom and sides of the barrel. Pour in water until the barrel is more than three-fourths full, and with a hoe or dasher, churn, splash and pound the K-L four or five minutes to emulsify it, then fill up the barrel with water, and spray. A long up and down stroke of a hoe or dasher is best, and if the hoe is held just right the blade goes straight down instead of glancing to the side of the barrel. *A terrific splashing can and must be made in this way.* A burlap bag or canvas should be thrown over the barrel to prevent the emulsion from splashing out. A board cover is better than burlap or canvas, and is easily made by nailing strips at the end of thin boards three feet long and boring a two-inch hole in the centre. Through this hole the hoe handle projects and the churning is more easily done than when a bag is used.

"Very small lots of two or three gallons can be emulsified by pumping the K-L back into itself through a nozzle throwing a small solid stream, but this method is not recommended for large quantities. In fact, *the fruit grower is hereby warned not to attempt to make lots larger than two or three gallons by pumping, nor lots of any size by stirring, but always to make K-L by the most violent churning, pounding and splashing with a hoe or dasher.*

"The prepared hydrates of lime on the market, or good stone lime dry slaked, are best for making K-L. Air slaked lime is not desirable, but may be used. If the lime is fresh, four pounds per gallon of kerosene will be ample, but if old, more may be required. Use enough lime to take up all the kerosene and mix into a thin, sloppy mass. If drops of kerosene gather on the top in less than a minute, sprinkle in more lime.

"*Proportion of Kerosene, Lime and Water.* "K-L is kerosene, lime and water, and the proportion of each in 50* gallons of different strengths, is as follows:—

"For 10%	K-L use	5	gals. kerosene,	20	lbs. lime,	44½	gals. water.
" 12½	"	6¼	"	25	"	43	"
" 15	"	7½	"	30	"	41½	"
" 17½	"	8¾	"	35	"	40	"
" 20	"	10	"	40	"	38½	"
" 25	"	12½	"	50	"	34½	"
" 30	"	15	"	60	"	30½	"

"The K-L-B is kerosene, lime and Bordeaux mixture. It is made exactly like the K-L except that the Bordeaux is used instead of water. We use the 4-4-50* Bordeaux formula. Four pounds of copper sulphate are dissolved and diluted with water to twenty-five gallons. Four pounds of stone lime are slaked and diluted with twenty-five gallons. Four or five pounds of hydrated lime or fresh; dry slaked lime are usually substituted for the stone lime. The copper solution is then poured into the milk of lime and the mixture is well stirred with a paddle.

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*Delaware Agricultural Expt. Sta., Bull. 73.

"The K-L-B-P is kerosene, lime, Bordeaux, and poison. It is made exactly like K-L-B except that poison is added to the Bordeaux. Paris green is about the most reliable poison, and one pound is used in seventy-five* gallons of Bordeaux."

Fresh lime is not conveniently obtainable in all parts of the Province. Dr. Frank T. Schutt, Chemist, at the Central Experimental Farm, Ottawa, has shown that flour may be used instead of lime with equally good results. With reference to the preparation, Dr. Shutt writes as follows:† "The preparation with flour is most simple. The requisite amount of kerosene is placed in the vessel (pail or barrel)—which is preferably dry—and flour added in the proportion stated, viz., eight ounces to the one quart, the whole thoroughly stirred and the water added, two gallons for every quart of kerosene. This is then vigorously churned. The time necessary to churn will vary from two to four minutes, according to the quantity to be emulsified, and the emulsion is then ready for use.

"When the emulsion is required for immediate use, the quantity of flour may be further reduced. It was found that as small a quantity as two ounces would emulsify one quart of kerosene, but that on standing a few hours a perceptible layer of kerosene had separated.

"It has, further, been found that by scalding the flour before adding the kerosene a less weight is required. An excellent emulsion, which showed not the slighted separation of kerosene after one week, was prepared by scalding two ounces of flour, mixing the resulting paste with one quart of kerosene and emulsifying with two gallons of water.

"The flour emulsion is smooth, readily and easily atomized, and does not clog the nozzle. Any separation into layers (no freeze kerosene will appear for several days, at least) may be readily overcome or remedied by simply stirring the mixture. It is equally effective as might be expected, as an insecticide as is the lime-formed emulsion, and amongst other advantages that may be claimed for it there is no perceptible whitening of the tree or foliage; and, further, in some places it may be found cheaper and easier to make than the lime emulsion. Its use is suggested as an alternative where good lime is unobtainable and also for making the emulsion when intended for ornamental trees, shrubs, etc., where the whitening of the foliage is objectionable. The flour emulsion can be added to Bordeaux mixture, or to Bordeaux and Paris green if desired."

Lubricating Oil Emulsions

The use of oil emulsions has long been practiced, kerosene oil emulsion having been introduced about 1870. Recently, beginning about 1925, the use of the lubricating oil fractions of crude petroleum for making emulsions has been attended by considerable success. The light, medium and heavy oils, running in specific gravity about 0.89, 0.90, and 0.91 respectively, can be readily emulsified with fish oil soap, preferably potash soap; the light and medium oils can even be emulsified with ordinary laundry soap, but the stock emulsion is not very lasting and, unless used right away, soon deteriorates sufficiently to become unusable. Of the above oils, the "light" variety or those oils running about 0.89 specific gravity, seem to be the most desirable for the purpose. The stock emulsion is prepared as follows:

Oil	2 gallons.
Water	1 gallon.
Potash fish oil soap	2 pounds.

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*Wine measure. One wine gallon is equal to 0.83 Imperial gallons.
†The Canadian Horticulturist, May, 1905.

The soap and water are mixed together until the soap is dissolved and then put into a kettle that can stand heat, together with the oil. The whole mixture is then heated to the boiling point, care being exercised to avoid frothing over and igniting, removed from the fire and, while still very hot, pumped back into itself with good force with a bucket pump, three or four times.

This stock emulsion is then diluted with water, or with Bordeaux mixture to give the so-called Bordeaux-oil emulsion, to any desired strength (1, 2, or 3% of oil in the finished spray) for direct application to the foliage. There is some tendency for the oil to separate out on top when this is done (unless, in the case of the water, the water be soft), but by reasonable agitation during the spraying this separated oil is kept sufficiently worked into the spray to insure uniform distribution. This tendency to separate is more marked in water than in Bordeaux, if the water is very hard; if the water is very hard the emulsion made with it can be stabilized by mixing with the water bluestone and hydrated lime at the rate of about ¼ lb. of each to 40 gallons before adding and working in the oil. This then makes it in reality a dilute Bordeaux and oil emulsion. Or the water can first be softened by any of the conventional methods, as the other alternative.

The Bordeaux-oil emulsion obviously will give the combined effect of both the oil and copper, and such a mixture is indicated where both are needed at the same time. And, in addition, the presence of the oil appears to improve the physical characteristics of the Bordeaux mixture, making it stay better suspended and to spread more uniformly.

Other ways of making these oil emulsions have also been devised, those of the most outstanding success being the cold mixes. The formulae are as follows:
Ingredients.

	Form 1	Form 2	Form 3	Form 4
Lubricating oil	2 gals.	1 gal.	2 gals.	2 gals.
Water	1 gal.	1 gal.	1 gal.	1 gal.
Bluestone, or green vitriol	¼ lb.	½ lb.	—	—
Kayso (calcium caseinate)	—	—	¼ lb.	—
Saponin (or extract from ½ lb. soap bark)	—	—	—	¼ lb.
Hydrated lime (100 mesh)	¼ lb.	½ lb.	—	—

In case of formulae 1 and 2 the copper or iron sulphates, respectively, are dissolved in one half the water, and the oil then added. Then to this the lime, worked up with the rest of the water, is added and the whole mixed and then pumped back and forth several times with a good bucket pump, using a fine Bordeaux nozzle. When Kayso is used, the water is slowly added to it, with stirring, until it is all thoroughly wetted and all the water is in, and then the oil is added and pumped as before. With saponin, the water is added, then the oil, and the mixture pumped.

The above treatments give the stock emulsions, and then these can be diluted to any strength desired for spraying, either with water or Bordeaux mixture.

Since no soap is present in the emulsions made this way by formulae 1 and 2, they can be mixed with lead arsenate or lime-sulphur to give combined sprays, and are also more stable with hard water.

If only small amounts of any of the stock emulsions of these lubricating oils are required, one can make them by using an ordinary egg beater instead of the bucket pump. Good effective agitation and perfect emulsification can, in this way, be secured if the beater is run vigorously for about five minutes.

Two very cheap and satisfactory lubricating oils for making these emulsions are those known, respectively, as "Red Engine Oil" and "Diamond Paraffin Oil". The former is more expensive but for certain insects, notably the pear psylla, it is superior to the lighter and thinner oil because it is more lasting on the surfaces on which placed. The specifications for these two oils in order that they be of satisfactory quality for control work should be about as follows:—

Grade of Oil	Viscosity Seconds	Specific Gravity Bé	Specific Gravity G. L.	Flash Point Fah.
Red Engine Oil....................	200	25	0.903	370°
Diamond Paraffin Oil..........	100	28	0.886	350°

The Soaps

These substances have been used in control work for many years. They are very effective against certain soft-bodied insects, such as plant lice, and against the scales. A very important and outstanding application of the soaps, however, is as emulsifiers for making the various oil emulsions and for use as spreaders and stickers. There action as insecticides is due chiefly to the toxic effect of the fatty acids contained in the fats and oils used in their manufacture, to their caustic action imparted by the alkali used in making them, and to their covering, clogging and glueing effect. There are two classes of soaps (1) the true soaps, or those made from the animal, fish and vegetable fats and oils and (2) the resin soaps or those made from various natural and artificial resins.

True Soaps.

The most effective soap is that made from whale oil. The term whale-oil soap may refer to a soap actually made from whale oil but usually it is merely a trade name for fish-oil soap in general, made with either potash or soda. The potash soaps, which are the best, because even stronger solutions remain liquid when they cool, are soft soaps. The soda soaps are hard. Of the two, the potash soaps are considered the best to use on vegetation, as well as being more convenient. Both kinds should always be dissolved in hot water.

If thought desirable, these soaps can be made at home; but it is very unpleasant and dirty work, and it is, besides, doubtful whether such good or cheap results can be secured as by buying from firms which make a special business of manufacturing soaps with only the required amount of moisture and the proper grade and amount of potash. It has been found that what is required for spraying purposes is a potash fish-oil soap, made with a fairly good quality of fish oil, and from which water has been eliminated by boiling, so that it does not exceed 25 or 30 per cent. of the weight of the soap. Soaps made with caustic soda instead of caustic potash are not so effective for spraying purposes. The late Dr. J. B. Smith (New Jersey Experiment Station), in his Circular No. 5, "Whale-oil Soap and Its Uses," says: "Whale-oil, or fish-oil soap is one of the most reliable materials for use against plant-lice, and generally against sucking insects which can be killed by contact insecticides. It kills by clogging the spiracles or breathing pores of the insects, and also to some extent by its corrosive action. The advantages of fish-oil over ordinary laundry soap lie in the greater penetrating power, in the fact that it remains liquid when cold, at much greater strengths, and that fish-oil itself seems to be more fatal to insect life than other animal fats. A good soap can be made as follows:—

Concentrated potash lye	3½	pounds.
Water	7½	gallons.
Fish-oil	1	gallon.

"Dissolve the lye in water, boil, and to the boiling solution add the fish-oil; continue to boil for two hours, and then allow to cool. Any grade of fish-oil will answer.

"Whale-oil soap may be applied in the strength of one pound in four gallons of water for brown or black plant-lice, and one pound in six gallons for green plant-lice; warm water should always be used when dissolving it.

"Soaps of all kinds are very useful in adding adhesiveness to liquid mixtures when it is necessary to apply these to such vegetation as cabbages, turnips, peas, etc., which have their leaves covered with a waxy secretion which prevents water from lying upon them. Any kind of soap will answer for this purpose, and it may be remembered that one quart of soft soap is about equal to one pound of hard soap."

Another method for making home-made fish-oil soap is given by Van Slyke and Urner, and is as follows:*

Caustic soda	6	pounds.
Water	1½	gallons.
Fish-oil	22	pounds.

"The caustic soda is completely dissolved in the given amount of water and the fish oil is added gradually under constant and vigorous stirring. The combination occurs readily at ordinary summer temperatures and the operation is soon completed. The mixing may be done in any receptacle sufficiently large to contain the whole amount of material. It would probably not be desirable to attempt to make more than twenty to forty pounds at a time, since the difficulty of thoroughly stirring a larger mass would tend to make a complete combination less sure, thus rendering liable the presence of too much free alkali. *Complete and thorough stirring is essential to success.* Caustic soda should be handled with precaution, since in concentrated form it easily injures the skin."

The above formula will produce about forty pounds of soap. This will be a hard soap since caustic soda is used. A better, but more expensive soap would be secured by using 8½ pounds of caustic potash instead of caustic soda in the above formula but otherwise proceeding in the same way in the preparation.

Resin Soaps.

The resin soaps were introduced about 1886 and specially employed against scale insects. They have been extensively used, usually mixed with the true soaps, as scalecides. They act by penetration of the tracheae and by clogging the spiracles through the separation out, in contact with the carbon dioxide of the air, of a resinous deposit.

These soaps, because of their resinous character, are useful as stickers. They also act as efficient spreaders because of their excellent wetting power.

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*New York Expt. Sta. Bull. 257, 1904.

The Tobacco Preparations

These materials have as their active principle the various alkaloids of the tobacco plant, the chief one of which is called nicotine, $C_{10}H_{14}N_2$. This compound is one of the most virulent of the vegetable alkaloids and applications carrying as little as .05% to .06% are exceedingly effective against all manner of insects. The action seems to be accomplished through paralysis and hence the tobacco preparations are spoken of as *paralyzants.* Plants do not seem to be adversely affected by the tobacco sprays even though strong preparations are used, hence the chief concern in their use is to assure that a sufficient strength is employed for destroying the pest. Therefore, when economy of material is not necessarily essential, preparations containing much more than .05% or .06% ought to be used.

Home-made Tobacco Extract.

Any one who has a supply of waste tobacco available (barn burnt, rejected, stalks, stems, refuse leaves, sweepings, and etc.) can, by simple steeping in water, make a decoction of excellent insecticidal value. Soaking in cold water, over a period of 24 hours, will extract approximately 75% of the nicotine; and infusing with hot water just nicely below the boiling point for 1 to 2 hours will withdraw 85 to 90% of the alkaloid.

The biggest difficulty in making and using these home-made extracts, however, is in the matter of gauging their strength. The nicotine content of tobacco materials varies all the way from 0.5% up to 5½% or more,—stalks and stems containing the least and leaves the most. Green tobacco and over-ripe tobacco will contain less nicotine than just mature tobacco, and barn-burned and moulded material less than well cured, sound material.

As a working basis it would probably be safe to assume that leaves contain 2½% and stalks and stems ½% of the alkaloid. Thus, if such be taken as a basis in making a cold water extract, then 100 lbs. of leaves would yield about 2 lbs. nicotine and 100 lbs. of stems or stalks about 2/5 lb. That is to say, if 100 lbs. of leaves were soaked for a 24 hour period with 400 gallons of cold water, an extract containing .05% of nicotine would be secured, and if 100 lbs. of stalks or stems were soaked for the same time with 80 gallons of cold water a decoction of the same strength would be obtained; and this strength is the minimum effective concentration for control work. In actual practice, therefore, unless one has to economize, it would be good business to increase this strength by at least half, that is, to either use 150 lbs. of tobacco or 2/3 as much water.

In actual procedure in making such extracts it is necessary to have the tobacco material ground or broken up into as fine a condition as possible—the finer the more completely will the nicotine be removed—and to now and again thoroughly stir up the soaking mass during the 24 hour extraction period.

To get the best results from these tobacco concoctions in spraying, soap solution or hydrated lime should be mixed with them. About 2 or 3 pounds of soap dissolved in water, or 4 or 5 pounds of fresh hydrated lime, to each 40 gallons will not only make the nicotine more effective but will also aid the spray to stick and spread.

Commercial Tobacco Preparations.

There are a number of commercial tobacco preparations on the market. Some of these have the nicotine in the form of the sulphate, ($C_{10}H_{14}N_2 . H_2SO_4$), and are quite highly concentrated, carrying as much as 40 per cent. of nicotine and coming on the market under such trade names as "Black Leaf 40," "Sulphate of Nicotine 40 per cent." etc. These remedies are very valuable for controlling soft-bodied insects such as aphids, and can be applied in strengths for good control which are not injurious to foliage.

These strong solutions are usually applied at the rate of half a pint per forty gallons of water, or one to one and a half teaspoonfuls per gallon. This gives a spray carrying about .05% or more of actual nicotine.

Since the tobacco remedies act as paralyzants, the vapour of the nicotine entering the body of the insect and paralyzing its nerves, it follows that the nicotine sulphate, which is non-volatile, would not be of the highest efficiency. It is therefore a good plan to add soap, hydrated lime, or some other alkaline material to aid in the liberation of free nicotine, which *is* volatile. A good formula for a soap wash to which to add the nicotine sulphate is:

Soap	2 or 3 pounds.
Water	40 gallons.

or about one ounce of soap per gallon of water. Soap also increases the spreading power.

Nicotine dusts are also now quite prominent, they being efficient, and can be applied faster than the sprays with less cost. In the dusts such carriers as kaolin, talc, kieselguhr, gypsum, sulphur, carbonate of lime, hydrated lime, etc., are used to hold the nicotine. Some of these are merely adsorbents and do not make the nicotine volatile enough to be efficient such as kaolin, gypsum and sulphur; whereas hydrated lime and carbonate of calcium are not only adsorbents for the nicotine solution, but also make the nicotine volatile and efficient. The best dusts, therefore, are those which contain an alkaline adsorbent but in this case the dust has to be kept in tightly sealed containers and if possible the containers kept full, else much of the nicotine vapour would be lost and the dust greatly weakened.

The nicotine sulphate and tobacco solutions lend themselves well to the making of combination sprays, they being compatible with almost all of the standard spray materials.

Derris or Tuba Root.

For many years past the people of the Phillipine Islands, Southern China and the Federated Malayan States, Borneo and Sumatra, have been using the roots of the low-growing shrub known as Derris elliptica for killing fish and insects and as the source of an arrow poison. Some ten or twelve years ago some of the root was brought to America for trial as a possible valuable insecticide and within the past four or five years has succeeded in proving to be a very effective poison for a considerable variety of insects. Green apple aphis and the nasturtium aphis can be effectively controlled by spraying with the ground root at the rate of one pound to 20 gallons of water. It destroys mosquito larvae when applied at the rate of one pound to each 1,000 gallons of the water in which the larvae are present. Many other insects are also amenable to the poison contained, but particularly fleas, lice, house flies and the larvae of the warble fly and it is for these latter that Derris is chiefly used at present.

The powder produced by grinding the roots is brown in color and contains as the active principle, a substance called "Rotenone," $C_{23}H_{22}O_6$, a name which is derived from the Japanese name for the derris plant (viz., Roten.).

No doubt Derris will become more widely used as it becomes better known and after it has received more extended trials as to its effectiveness against other insects.

It has already shown itself capable of destroying a great variety of insect life. Reasonable cost, ease of securing and ample supply will be the other factors which will determine to what extent it shall become utilized.

Several preparations are on the market under various trade names which contain extracts of derris as their active ingredient. *Pulvex* and *Derrisine* are examples of such.

Pyrethrum (Insect Powder, Buhach).

This powder is also called Dalmatian Insect Powder and Persian Insect Powder. It is also, like hellebore, obtained from plants, being the pulverized flowers of the botanical genus Pyrethrum. Value as an insecticide is due to the presence in it of substances exceedingly poisonous to most insects, but practically harmless to human beings and the higher animals. It can be used with impunity, therefore, and on account of this fact is of special value.

The compounds which impart the killing power (largely by contact with the body of the insect) are very easily disseminated into the surrounding atmosphere and thus lost. For this reason these powders must be fresh and have been kept in tightly sealed receptacles, else they will be ineffective.

Application can be made in a number of ways:

1. *In solution:* One ounce to three gallons of water.

2. *Dry:* Apply while dew is on in the morning or after a rain.

3. *Dry, with dilution:* Mix with some flour or other light powder to any extent desired. Apply as 2.

4. *In fumigation:* Dust over live coals; for dealing with mosquitoes and flies.

Corrosive Sublimate, $HgCl_2$.

This chemical, also known as mercuric chloride, is a white crystalline solid. One hundred parts of cold water will dissolve only seven parts of the compound, thus it is not very soluble. The rate and extent of solubility can be increased by using hot water, one hundred parts of the latter being able to dissolve fifty-four parts of the substance. Its water solutions are very corrosive on metallic vessels, such as iron, tin, zinc, aluminium, etc., and hence its name "corrosive sublimate," and for this reason solutions of it cannot be made or stored in such receptacles; wooden vessels only should be used.

It is an *extremely poisonous* compound and should be handled and used with greatest care. As a spray, on foliage, it is not used because of its corrosive action, although it would form a deadly poison to insects and fungi; but as a treatment for root maggots such as those of the onion, cabbage, cauliflower, radish, it is exceptionally satisfactory when used at the rate of one ounce to ten gallons of water and sprayed on the ground when fairly dry, just around the base of the stalk of the plant. It controls the maggots by contact action.

Carbolic Acid, Phenol C_6H_5OH.

This substance is an oxygen derivative of benzene, one of the members of the aromatic series of the carbon compounds. It has a permanent but characteristic and pleasant odour, which seems to be quite distasteful to many insects. In the undiluted form this acid is very active, and will burn and blister the flesh and cause much pain, but in the diluted form, as two parts to forty or fifty parts of water, it makes an important disinfectant that is extensively used in medicine. In the form of an emulsion with soap and water it is very useful in destroying the eggs and young maggots which infest onions, radishes, and similar garden crops.

The emulsion is made thus:

Carbolic acid	1 pint.
Hard soap	1 pound.
Water	1 gallon.

Dissolve the soap in the boiling water, and while boiling add the acid and continue the boiling for a few minutes, stirring thoroughly. Put the emulsion away in a tightly closed vessel and label "*Stock Solution of Carbolic Acid — Poison.*" Before using, dilute one part of the stock solution with fifty parts of water.

Carbolic acid is also used in the form of what is known as "Carbolized Plaster," in which case the acid is mixed with land plaster (gypsum), road dust, air-slaked lime or some other diluting medium, and is then sprinkled or dusted on in the dry state.

Carbolic acid	1 pint.
Diluent (land plaster, etc.)	50 pounds.

This mixture is very effective against flea beetles, cucumber beetles, etc.

FUMIGANTS.

These materials are either gases, or else materials which readily generate gases or vapours, which by virtue of a toxic, asphyxiating, paralyzing or corroding effect, kill the insect, or by means of an odour obnoxious to the pest cause it to leave.

Substances in this class are designed for getting at pests out of reach of the ordinary solid or fluid remedies.

Carbon Bisulphide, CS_2.

As the formula indicates, this compound is made up of carbon and sulphur, one atom of the former and two of the latter. In the pure form it is a clear liquid with a pleasant odour, but when impure it is somewhat coloured and possesses a highly disagreeable smell. It boils at 114°.8F., and thus volatilizes or changes to a vapour or gas very readily at ordinary temperatures. This gas ignites at a temperature of 248° F.

The vapours are very poisonous, and thus are very valuable in dealing with grain weevils, and the pea bug; and also for overcoming subterranean workers and household pests. Its use was first discovered in France, where it was and is employed against the grape phylloxera. The wine districts there were saved from complete annihilation by its introduction.

Since the vapour is 2.63 times heavier than air, it tends to work downward very rapidly, and will thus penetrate to some depths in the soil. In dealing with grain pests the liquid is placed in shallow dishes on top of the pile and then as the evaporation goes on, the vapour will work downward and penetrate the whole bulk.

Dosage: (1) for grain weevils, use one pint (one and a half pounds) for every 1,000 cubic feet of space. Place in shallow pans on top of the grain, using at least one pan in every twenty-five square feet of surface. Thus a bin of grain twenty-five feet long, by five feet wide, by eight feet deep, would require one pint to be distributed in five pans. Larger quantities would not be harmful and would be more effective; the fluid is cheap, therefore employ an overdose rather than an insufficient quantity.

(2) For pea bugs use one pint for every 100 bushels of peas.

(3) For subterranean workers (root maggots, ants, etc.,) inject small quantities into the soil around the base of the infested plant, or into the nest, two or three teaspoonfuls in a place.

(4) For household pests use from 4 to 8 lbs. (2½ to 5 pints) per 1000 cu. ft. of space.

All openings should be well sealed to prevent escape and waste of the fumes. Inhalation should also be avoided as much as possible, although small quantities breathed in will produce no harm except in case of a weak heart. Fresh air is the cure, and when one begins to feel a dizziness, it is wise to seek at once the open atmosphere. Before entering a room where it has been used, thorough ventilation should be given.

Precaution:— As one volume of carbon bisulphide vapour mixed with 14.3 volumes of air forms a highly *inflammable* and *explosive* mixture, *never allow a light or even a spark*, or a lighted pipe or cigar to be brought into or near rooms or buildings where fumigation with this material is being carried on.

Carbon tetrachloride, CCl_4

This is a colorless liquid, extensively used in a great variety of ways, industrially, as a solvent. It boils at 76.7°C. and thus, when exposed to the air, evaporates quite rapidly spontaneously. The vapour is pleasant smelling, and much heavier than air, and is both non-inflammable and non-explosive; indeed, this liquid is extensively used as a fire extinguisher under the name of "Pyrene."

The fumes of this substance are decidedly insecticidal in effect and because of the lack of fire and explosion hazard, carbon tetrachloride is used as a substitute for carbon bisulphide. It is applied in exactly the same way as the latter but being less efficient by two or three times, must be employed in proportionately greater amount. Fifteen to twenty pounds (1 to 1¼ gallons) per 1000 cu. ft. at a temperature of 70°F. for 24 hours, forms an effective dosage.

This fluid, given in capsule form, is considerably used as a treatment for certain alimentary parasites of sheep, dogs and foxes for which purpose it is very efficient. The vapours of carbon tetrachloride are practically harmless to human beings unless inhaled in large amounts.

Ethyl acetate — Carbon tetrachloride

Ethylene dichloride — Carbon tetrachloride.

These two fluids are mixtures, the first is composed of one volume of the pleasant smelling colorless liquid ethyl acetate ($CH_3COO\ C_2H_5$, B.P. 77°C.) and one and one-half volumes of carbon tetrachloride, and is specially recommended for the fumigation of grain in transit for which purpose it is used at the rate of 40-50 lbs. per carload. The second is composed of three volumes of the colorless liquid, ethylene dichloride ($C_2H_4Cl_2$, B.P. 83.7°C.), and one volume of carbon tetrachloride, and is particularly employed against household insects attacking upholstered furniture, clothing and stored products, the dosage used being about 4½ quarts or 14 lbs. for each 1000 cu. ft. of space.

Both of these fluids are non-inflammable, non-explosive, and of pleasing smell and their vapours are not very harmful to human beings, unless taken in excessive quantities. For this reason they are to be recommended as substitutes for carbon bisulphide where the fire or explosion hazard is present or where the vile smell of the latter is for any reason a handicap. Neither of them are as efficient as the bisulphide, but, like it, both evaporate spontaneously on exposure giving rise to heavy vapours which rapidly penetrate downward. They are thus employed in the same manner, i. e., poured into shallow pans and placed at the top of the enclosed space to be fumigated. Like all fumigants, the more active the insect at the time of fumigation the more perfect is the kill. Hence, these fluids give their best results at a temperature around 70° F.

Hydrocyanic Acid, HCN.

This insecticide, which is a colorless gas at ordinary temperature and pressure, is about seven-tenths as heavy as air and possessed of an almond-like odour. Its lightness brings about a rapid spreading, particularly upward, and in contrast to the heavy vapour of carbon bisulphide and such like substances, calls for the liberation of this gas at the lower reaches of the area being fumigated, instead of at the top. It is one of the most deadly poisons known and for this reason has to be handled with the greatest of care; and this applies to all of its salts, the *cyanides*, as well. It is very soluble in water, a 10% solution in this solvent being known as *prussic acid*, a very deadly fluid. The boiling point of HCN is 26.5°C. and it is thus evident that it could be easily condensed to the liquid form either by subjecting it to a low temperature, or to an increased pressure or to both. Indeed, it is now purchaseable in the liquid form in pressure cylinders for application in fumigating operations, a very convenient and inexpensive way of using it where one is carrying on the work on a comparatively extensive scale.

Hydrocyanic acid is used extensively in the fumigation of greenhouses and nursery stock. It is also employed in the destruction of scales on orchard trees and for ridding mills, granaries, storehouses, elevators and such like of grain and meal pests and rodents; and it is also very effective and suitable for destroying groundhogs, prairie dogs, ground squirrels, and other similar burrowing animals. It has its place, too, as a house fumigant for bed bugs, cockroaches, carpet beetles, clothes moths and other such pests that infest the human habitation. The applicability of this chemical as an insecticide was first demonstrated in California, in 1886, where it was found useful in combating the cushionary scale attacking citrus trees, but since that time has been found to possess the above extended applications. In fact there is no insect, using the term in its broadest sense, which is immune to the destructive effects of this gas, and where conditions are suitable it can be chosen as a remedy which will do a perfect job at a minimum outlay of time, labor and money.

One of the things to be remembered in respect to the successful utilization of this gas is that, like most other fumigants, it can only be used with success in inclosures. This is quite necessary because in a closed space only could a killing concentration be economically maintained over a sufficiently long period, a period which usually runs from 18 to 36 hours. This could not be done in the open as the vapour would dissipate rapidly and become completely lost in a very few minutes. The inclosures to be fumigated must be capable of being almost hermetically sealed in order that undue loss of the vapour through openings such as ventillators, chimney outlets, key holes, knot holes, cracks and such like, be practically entirely prevented. A minimum amount of water or watery fluids, and moist substances, should be present in the inclosure also, because water is a splendid solvent for the gas and, when present, rapidly removes it from the surrounding air and thus reduces the effectiveness. In household fumigation with this gas, it is essential to remember this because water, and all watery drinks and moist foods would in this way become poisoned. All such must be removed or protected while fumigating.

The gas is *extremely poisonous* and great care must be exercised when using it not to inhale more than very minute quantities; and before a room, or building or tent is entered after the operation a thorough airing must be given. It is not explosive nor does it possess a fire hazard.

Fumigation of trees is best done while in the dormant state; and if plants in foliage are present as in the home or in a greenhouse, night should be chosen as the time for action since sunlight has a very damaging effect on leaves for some time after they have been surrounded by the gas, especially when they are moist or wet. In fact, excess moisture in the air where plants are present must be carefully avoided even in darkness. In order to avoid a too moist condition, no hosing or watering should be done for a period of 24 hours before fumigation is started. To be most effective the temperature should be not lower than 55°F., preferably higher, as most insects become inactive at a temperature below 50°F. and are then much harder to kill. The aim should be to have a temperature around 70° F. and preferably rising rather than falling.

The gas can be obtained in the liquid form under pressure in pressure cylinders or prepared, as is more often the case, at the time of use, from one or other of the *cyanides.* The cyanide commonly used is either potassium cyanide (KCN), sodium cyanide $NaCN$), or Calcium cyanide ($Ca(CN)_2$). The last one is frequently referred to commercially as "Calcyanide" or "Cyanogas". All these are very poisonous and must be handled with every care. In the case of the potassium and sodium cyanides the gas is liberated by means of a mixture of sulphuric acid and water. Since this requires a vessel of some kind, such as an earthen crock, this is sometimes referred to as the "pot method" of fumigation. On the other hand, when calcium cyanide is used, all that is necessary to do is to spread the dry granules or powder out in thin layers on newspaper or such like and the moisture of the air causes the gas to be liberated. For this reason, since no acid or water is required, the generation of gas from this cyanide can be referred to as the "dry method" of fumigation, a method which is much simpler, and cheaper by 75%, than the pot method. Obviously calcium cyanide would be the most feasible one of the cyanides to use in destroying burrowing rodents. Also, in greenhouse fumigation, it has the advantage of maintaining a low concentration of gas over a long period of time giving a greater margin of safety to the plants. In the pot method the gas all comes off in one sudden rush and before it becomes spread by diffusion the area about the generator contains a dangerously high concentration. A concentration much above .007% becomes dangerous to plants.

In generating hydrocyanic acid from potassium or sodium cyanide it is very essential that the acid mixture used be neither too strong nor too dilute. If the acid is too strong the cyanide is apt to "freeze", a process which prevents a complete liberation of gas, or the hydrocyanic acid becomes destroyed by being converted into carbon monoxide and ammonium sulphate; if the acid is too dilute much of the gas is held in solution in the acid mixture and is thus prevented from escaping into the atmosphere. The best proportion of the three components in the pot method, is about as follows:—

(1) Where potassium cyanide is used:

Potassium cyanide	1 oz.
Sulphur acid, 1.84 S. G. (66° Bé)	1 fluid oz.
Water	3 fluid ozs.

(2) Where Sodium cyanide is used:—

Sodium cyanide	1 oz.
Sulphuric Acid, 1.84 S. G. (66° Bé)	1½ fluid ozs.
Water	2-3 fluid ozs.

The operation of mixing the above components is carried on by first of all pouring the acid slowly, and with stirring into the water in an earthenware dish (don't use a wooden, metal or glass dish) and then, when all is in readiness, dropping in the cyanide, preferably loosely wrapped in a thin paper bag. The operator then at once leaves the immediate vicinity. The cyanide should not be in large lumps. If lumpy, it should be broken up into pieces not bigger than walnuts.

In actual practice, the amount of cyanide to use varies with the case in hand. Using sodium cyanide the following amounts for the stated uses will give more or less standard dosages for each 1000 cu. ft. of space:—

(a) For greenhouses, with plants	3/16 oz.
(b) For nursery stock	10 "
(c) For mills, elevators, household, etc.	16 "
(d) For burrowing rodents, per opening	1 "

If potassium cyanide is used instead of sodium cyanide, approximately one-third more should be employed; and, if calcium cyanide is used one would need to weigh out approximately twice as much (as the commercial form is but 50% pure).

All residues left after fumigation is completed should be carefully gathered up and gotten rid of down a disposal drain, or by burying, and all enclosures under fumigation should be conspicuously placarded throughout the time the operation is under way. And in handling the sulphuric acid and the sulphuric acid-water mixture care should be observed to prevent spilling or splashing on clothes and flesh and on woodwork of the home. If spilling or splashing occurs, wash up quickly with water, or preferably with strong washing soda solution, and an operator would be well advised to carry a small bottle of ammonia with him to breathe occasionally in order to help counteract any gas fumes which he may inadvertently inhale from time to time.

Paradichlorbenzene, $C_6H_4Cl_2$.

This substance, sometimes called P-C benzene, along with some of its modifications (orthodichlorbenzene, etc.,), is a fumigant which has been specially introduced for controlling the peach tree borer, but can be used for other similar fumigation activities. It is also a very successful soil fumigant.

Paradichlorbenzene is a white crystalline powder, insoluble in water and which vaporizes slowly at ordinary temperatures, the gas or vapour being heavier than air. It is non-poisonous to man unless eaten, whereas its vapour is quite poisonous to insects. The vapour will also injure tender roots and young succulent growth of plants, but has no marked injurious effect on old growth.

In applying, weeds, grass, leaves, stones, sticks, etc., are removed from the base of the tree without disturbing the soil more than necessary and any gum excretions about borings are scraped off. Three-quarters to one ounce of the powder, which should be dry and fine enough to pass a ten-mesh sieve, are then evenly distributed in a continuous circular band about two inches from the trunk of the tree. Over this is placed four to six shovels of dirt free from grass, weeds, sticks, etc., and compacted, all without disturbing the crystals. Best results are obtained if the crystals are placed on a level with or above the highest borings, but this is not necessary if the dirt is piled high enough over the crystals and larvae within the tree.

The application should be made when the temperature of the soil is 60°F. or higher, a temperature of 55° to 60°F. requiring 14 to 21 days to kill the larvae, and a temperature of 70°F. requiring only 10 to 14 days. It is also not to be recommended on trees younger than six years without exercising care. Best results are obtained when the soil is dry, a wet soil requiring longer exposure. When the treatment is over the soil that has been piled around the tree should be pulled away.

The aplication is best made in the fall after the eggs have been hatched, as the larvae are then young and easy to kill.

Tobacco Punks.

Smouldering moistened tobacco stems, tobacco dusts, or paper impregnated with black leaf 40 or other strong tobacco infusions, or strong tobacco liquors painted on hot steam pipes are excellent fumigants in green house work.

In this work it is best to use the standard preparations, such as *Nicofume* or *Nikoteen* liquid, or *Nicoticide* papers both for the matter of convenience and effectiveness. Fumigation should be done at night and the atmosphere should be moistened by wetting down the walks but avoiding wetting the plants. This makes the fumes settle around the plants better. The house should be sealed as well as possible to prevent loss of the vapours and the temperature should not be higher than 60°F.

Chlorpicrin (or Nitrochloroform), CCl_3NO_2.

This substance was used during the late war as a tear gas and has since been found useful in fumigating flour and cereal mills, upholstered furniture and as a general household fumigant. When heated, it explodes. "It is a heavy, colorless, or slightly yellowish liquid (specific gravity 1.67 to 1.69) which volatilizes rather slowly. The gas formed is about five times heavier than air and where there is no interference to its movement it settles rapidly. That is, if there are low openings in a room or bin through which the gas can escape, it will flow out almost like water, but if the gas is confined it diffuses about equally throughout the entire space. On account of the heaviness of the chlorpicrin vapor, the stairways of a house being fumigated must be closed off or the concentration of the gas will not be maintained long enough on the upper floors to secure good results. In fumigating bins and elevator legs in a mill, the material should be applied at the top.

"Chlorpicrin adheres strongly to many dry materials. This is both an advantage and a disadvantage. Because of this adsorption and the heaviness of the vapor, it has a marked penetrating power and can reach many insects which are more or less protected from the action of some other fumigants. As a result chlorpicrin has been found to be especially effective against the larvae of the clothes moths working beneath the fabric of upholstered furniture, against the black carpet beetle larvae which like to dwell in cracks of floors where they are protected by dust and dirt, and against insects infesting stored food products. However, because of the adsorption of chlorpicrin, it is difficult to get rid of the gas after a fumigation, but it can be removed by thorough airing.

"The irritating effect of chlorpicrin on man is also an advantage. One unfamiliar with the odor of hydrocyanic acid might possibly stay long enough in a room in which the gas is present to be overcome and killed by it, but with chlorpicrin this would never happen. The effect on the eyes of even a low concentration warns a person long before there is any danger from breathing the fumes.

"In transferring chlorpicrin from large containers in which it is received from the factory or jobber to containers of more convenient size, and in filling atomizers or other equipment in which it is to be used, the operation should be carried on in the open air. This obviates any discomfort from small amounts which might be spilled and makes the use of a gas mask unnecessary. If a slight breeze is blowing and the person doing the work keeps on the windward side, the material can be handled with little or no inconvenience. Do not smell at the mouths of bottles or other containers in which the liquid may be stored, as air which is completely saturated with chlorpicrin is a powerful irritant when drawn into the lungs.

"Chlorpicrin evaporates very slowly, as indicated by its rather high boiling point, 112°C. (233.6°F.), in contrast with 76°C. (168.8°F.) for carbon tetrachloride and 46.2°C. (115°F.) for carbon disulphide. In order to overcome this low volatility and hasten the operation of getting the material from the liquid state into the gaseous state, Dr. R. N. Chapman of the Minnesota Agricultural Experiment Station, began the use of a mixture of chlorpicrin and carbon tetrachloride. It was found that the best results were obtained with a mixture of equal parts by volume of the two liquids. This mixture evidently has a higher vapor pressure than chlorpicrin alone and as a result evaporates faster. The advantage of using the mixture is increased many fold when it is to be applied with atomizing sprayers.

"It should be found out, when chlorpicrin is bought, whether it has been diluted with carbon tetrachloride. That fact should be borne in mind in connection with its use."*

Naphthalene, $C_{10}H_8$

This is a hydrocarbon which comes on the market as a white flaky solid, insoluble in water, but soluble in kerosene and other organic solvents and giving off an odor somewhat resembling that of camphor. It is obtained as a by-product in the manufacture of coal gas and coke, being recovered from the coal tar of which it makes up from 2 to 10%.

It is used as a repellant for insects since the vapor given off is not to their liking. In confined spaces, however, as in closets, chests, trunks, etc., this vapour becomes decidedly asphyxiating in character and many pests become effectively destroyed.

As a household remedy, it is widely used against clothes moths under the name of *Moth Camphor*, and for the same use, is the chief active principle of *moth balls*. The smell of this substance in the house or on clothing is not particularly relished but is quite harmless and rapidly disappears on aeration.

Flytox, Flit, Sapho "Fly X" and Similar Substances.

There are a number of preparations on the market under varying trade names, such as the above, which, when disseminated as fine sprays or mists, are effective fumigants. These are particularly useful in the home, or under like conditions. Most of these materials carry low boiling point petroleum oils, such as kerosene and gasoline, as their base, along with various flavours, like wintergreen, to make them pleasant smelling and thus not objectionable when used in living quarters. Pyrethrum, derris, and other insect poisons, or their extracts, are also sometimes present in certain amount in solution in the oil base.

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*University of Minn., Special Bull., 102.

Insecticides of Miscellaneous Application

Many of the contact insecticides included are also toxic in action and will function to a certain degree as food poisons. This is true particularly of pyrethrum and the tobacco preparations. However, for this purpose it is far better to rely upon the more active poisons, the arsenicals.

The food poisons will also exert some contact efficiency in that they are capable of stopping up the breathing pores of insects which crawl over or through them, either when in the wet state or dry state. It is far better to depend upon the regular contact remedies, nevertheless, because it is the corrosive action of a contact remedy which really makes it efficient, or the fact that it can be breathed in as a paralyzing, suffocating or poisonous gas. None of these properties are possessed to any extent by any of the regular food poisons.

FUNGICIDES

It has long been known that chemical compounds are useful in combating fungous diseases, for as early as 1807 it was discovered in France that copper sulphate would prevent the germination of the spores of corn smut. Sulphur has also been long used in the same country as a control, it having been found, in 1821, effective in the treatment of peach mildew, and later in 1848, for the powdery mildew of the grape.

Not much progress was made, however, in chemical control of fungi until 1882, at the time of the outbreak in the vineyards of France of the Downy Mildew. Soon after the outbreak of this serious pest, which threatened to annihilate the wine industry of Europe, a great effort was put forth in an endeavour to find a remedy and as a result, not only was that splendid and universally used material known as Bordeaux mixture evolved, but many other excellent remedies as well were discovered. Simultaneously with this advance it was also definitely established that chemical control of this class of pest was henceforth to be the most efficient and reliable line of attack. Since that time great advances have been made, not only in kinds of remedies, but also in what is even more important, the time of their employment.

To kill the fungus actual contact with the fungicide is usually essential. Ectophytes produce nearly all their tissue on the surface of the host whereas endophytes produce nearly all of their tissue within the host, only their spores and their fruiting bodies appearing on the outside. Hence, time of application of a remedy is all-important with the latter type of fungi since it is ordinarily impossible to introduce the controlling substances directly into the sap or blood of the host without doing the latter considerable harm.

The best time to kill any fungus, however, is in the spore stage, because then it is destroyed before it can do any harm to the host. And, in order to accomplish this it is necessary to have the poison distributed on the surfaces which are to be protected at the time the spores reach there; or on the surfaces where the spores are formed at the exact time that the fruiting bodies are being produced. Hence, life histories of these pests all have to be worked out in order to establish these dates.

As far as remedies are concerned, it has been found that the most generally useful and economical ones are the salts of copper, and sulphur and its compounds (the polysulphides.) But a number of other substances are used, among which are certain mercury compounds, carbolic acid and other phenols, and formaldehyde, these latter being particularly widely employed as controls for bacteria.

Copper-salt Fungicides

Bordeaux Mixture.

This substance which is a mixture of hydrated or slaked lime and copper sulphate, derives its name from the city of Bordeaux, in France, since it was in the vineyard district surrounding this place that it was first found useful as a fungicide by Millardet in 1882. Therefore the name gives no indication as to what ingredients are present.

The source of the copper in this fungicide is copper sulphate, or what is commonly known as "bluestone". Now copper sulphate is an "acid salt," or a salt whose solution in water shows an acid reaction, i.e., it will turn blue litmus paper red. This property of bluestone is due to the fact that it is a compound formed by the combination of a weak alkali, $Cu(OH)_2$, with a very strong acid, H_3SO_4, the outcome being that the acid property predominates. Being acid, copper sulphate therefore cannot be applied to foliage in sufficient strength to be active, because it exerts a burning or destroying influence. Like white arsenic, it must be changed to some other form, a form which will not be injurious. Bluestone can be applied to foliage in a diluted form without doing harm, but in such a highly dilute form that it is not very effective as a fungicide.

The material used to overcome the acid property just mentioned is calcium hydroxide (slaked lime, hydrated lime, milk of lime), and the resulting combination is known as Bordeaux mixture.

Provided enough lime has been used to act on all the copper sulphate, the latter will then be entirely in the form of copper hydrate,* a precipitate or sediment of a beautiful sky-blue colour, and which is practically insoluble in water. In this form, as a solid suspended in water, the copper sulphate is sprayed on the foliage without fear of doing any injury.

Being in a solid or insoluble form, copper hydrate, or Bordeaux, as it is called, is inert and will not act on the fungus. It must be changed to some form on the leaf which will be soluble in water. This change is brought about by carbon dioxide of the air and by that contained in dew and rain, and by that which comes from the leaf itself.

How to make the Bordeaux mixture.—The first thing to do in the manufacture of the Bordeaux mixture is to decide on some recommended formula. One which has long been advocated in Ontario is known as the 4-4-40 formula and is as follows:

$CuSO_4$ (crystallized copper sulphate or bluestone)	4 pounds.
CaO (quick lime)	4 pounds.
Water	40 gallons.

With good lime it only needs about one pound to act on all the copper; the excess given, three pounds, covers all danger which might arise from the use of a poor article. A large excess of lime is a disadvantage,—it causes the Bordeaux mixture to exert a slower and somewhat weaker fungicidal action, it is apt to cause the machinery to clog and to cause an uneven application, and the particles of lime offering more resistance to rain, will cause the mixture to be more rapidly washed from the trees. It may be an advantage, however, in a very wet season, by causing the Bordeaux to retain its efficiency longer and by allowing less injury to be done to foliage. Some orchardists are inclined to use a less proportion of lime, and recommend the following formula:

*In reality a much more complex reaction than the above occurs whereby a basic sulphate of copper is formed, the exact make up of which is governed by the proportion of copper sulphate and calcium hydrate used.

$CuSO_4$ (crystallized copper sulphate or bluestone)	6 pounds.
CaO (quick lime)	4 pounds.
Water	40 gallons.

The second thing to do after a formula has been decided on, is to slake the lime in a small amount of water, just enough to prevent it caking, and to dissolve the bluestone in another vessel (wood, copper or brass) also in a small amount of water.

As both copper sulphate and lime dissolve and slake, respectively, much quicker in hot water than cold, it is better to use heated water in order to save time. The very best lime obtainable is used, and if freshly burned, all the better. In slaking do not use an excess of water, but just enough to keep the lime moist. When the action is completed enough water is added to make a thin whitewash, and then the whole is strained through course sacking to remove any lumps which would clog the nozzle of the spray pump. This done, enough water is added to make the volume up to one-half of what the final mixture will amount to. The copper sulphate solution is diluted to the same extent. The two are now mixed by pouring each at the same time into the spray tank or some other third container, until the whole is brought together. In this way a precipitate is obtained so fine that it will remain in suspension with only occasional agitation. If mixing is done before dilution, a very coarse precipitate is formed which settles rapidly to the bottom of the spray tank and requires constant vigorous stirring.

If large quantities of spray mixture are going to be used, it is an excellent plan to make up "stock" solutions of the copper and lime. This can be done by dissolving at the rate of one pound of copper sulphate for each gallon of water used and making up a barrel full of it. Each gallon of the solution taken then represents one pound of bluestone. The bluestone can be conveniently dissolved by filling the barrel with water and then half suspending therein, enclosed in a canvas sack, the proper weight of the salt. Since the average barrel holds 40 gallons, this means that 40 lbs. of the copper sulphate would be used for making a barrel of "stock". The lime can be handled in the same way, being sure, of course, when later measuring out any of this lime stock, that the contents of the barrel are thoroughly stirred up immediately before dipping out any portion. Keep the barrels covered when not in use.

However, with the income of the ready slaked form of lime, or hydrated lime as it is called, a corresponding change in the above procedure for making the Bordeaux has resulted. In the first place it is not necessary to slake the lime and hence that part of the work is dispensed with, and in the second place the amount of lime to take is increased from four pounds to five and one-third pounds or about one-third more.

Furthermore, with spraying operations now on a much larger scale, and with more powerful spraying machinery available it has become customary to dissolve the copper sulphate, put it into the spray tank, dilute it to full volume, and then to throw in the hydrated lime, first sifted to remove grit and lumps. This is then mixed with the agitator, the latter's efficiency and power being depended upon to put the Bordeaux into the proper physical condition for efficient spraying.

Also, as time goes on, formulae change according to changing conditions and enlarged experience. The tendency at present is to use a much larger proportion of lime to copper sulphate and the most recent recommendation is:

Copper sulphate (bluestone)	4 pounds.
Hydrated lime	8-9 pounds.
Water	40 gallons.

The reason for this increase in proportion of lime over bluestone is an attempt to overcome the injury which Bordeaux tends to produce on foliage and fruit, such as russeting of leaves and fruit, yellowing and falling of leaves, cracking and malformation of fruit, the shot hole effect on injured tissue, etc.

Precautions to be Used in Making.

Before Bordeaux mixture is sprayed, it is absolutely necessary that all copper should be in the form of the sky-blue precipitate, i.e., enough lime must be used to act on all the bluestone. Formulae advocated by the experiment stations always contain enough lime to precipitate all the copper, but it may sometimes happen that such a very poor quality of lime is used or that some mistake is made in the weighing or measuring of the lime or bluestone that there will be some of the sulphate left unchanged. There are several simple ways by which one can tell when enough lime is present. Those who are very familiar with the reaction which occurs can tell by the colour of the precipitate, it having a greenish tinge when an insufficiency of lime is present instead of the deep sky-blue colour. However, those who are not familiar with the process must use more decided tests. Three simple ones can be employed, as follows:—

1. Take some of the clear solution which is left on top when the sediment settles and place in a white saucer. Add a few drops of a solution of potassium ferrocyanide (yellow prussiate of potash) to it. If a reddish brown precipitate or colouration appears, more lime is needed.

2. Take a portion of the clear fluid as before, and blow the breath gently over the surface. If a thin white pellicle or covering forms over the top, enough lime has been added.

3. Take a bright piece of steel, such as a knife blade, and hold it in the mixture for a minute or more. If it becomes coated with copper, more lime is required.

Test number one is the most reliable, and is the one recommended. The test solution, potassium ferrocyanide, can easily be made by anyone. One ounce of the salt is purchased at the drug store and this amount dissolved in ½ pint of pure, clean rain water. It is then ready to use.

In handling copper solutions use only wooden, brass or copper vessels as all other receptacles would be corroded and destroyed by them; besides the fungicide itself would be injured.

Copper compounds are *poisonous,* and therefore should not be left lying around where children or animals can get at them.

Combined with an Insecticide.

Bordeaux mixture is quite often combined with Paris green to impart to it an insecticidal value. In this case the mixture takes the place of water for holding the green in suspension. Other recommended arsenicals can be used for this also, such as calcium arsenate, lead arsenate and calcium arsenite. If soluble compounds of arsenic are used, such as sodium arsenite or white arsenic,* it would be necessary to increase the amount of lime used in making the original Bordeaux mixture. The use of soluble arsenicals, however, is not to be recommended.

Bordeaux Paste.

This substance is merely the ordinary Bordeaux mixture from which the excess of moisture has been removed. It, as a fungicide, is made on the same principle as lead arsenate paste. By the addition of water a spray of any desired strength can be made from it.

A sample which we analyzed contained 6.42 per cent. of copper oxide (CuO), an amount which is equal to 20.23 per cent. crystallized copper sulphate or bluestone ($CuSO_4$, $5H_2O$), and 19.85 per cent. of lime (CaO). Therefore, one pound of this paste would make two gallons of spray equal in strength to ordinary Bordeaux mixture. Its flocculent condition has been destroyed to a great extent, however, and it settles about ten times as rapidly in the spray tank as does freshly prepared Bordeaux.

Bordeaux Powder.

This material is the ordinary Bordeaux mixture reduced to the dry form by the removal of nearly all the water, and corresponds in principle to the powder arsenate of lead. By the addition of water a spray of any desired strength can be obtained.

It contains about 12½ per cent. of copper or enough copper, in other words, so that one pound to five gallons of water would make a spray approximately equivalent in strength to ordinary Bordeaux mixture. It is particularly designed for dusting operations. Some of these powders, however, may contain a greater or lesser amount of copper than stated above, and hence when making a spray from such it would be necessary to vary the amount of the water accordingly.

A type of Bordeaux powder on the market is one made by mixing together, in proper proportion, anhydrous bluestone, or blue stone heated until it has lost its blue color and has crumbled into a white powder, and well screened hydrated lime. This is probably just as safe to use as a powder made by reducing Bordeaux mixture to the dry form. It is white in color but turns to the regulation blue color when brought into contact with moisture, as on the leaf, or when mixed with water to make a spray.

Soda Bordeaux.

This fungicide is made from copper sulphate, just as the ordinary Bordeaux mixture. It differs, however, in that sodium carbonate is used to neutralize the acid property of the bluestone instead of lime; and that the final mixture contains sodium sulphate instead of calcium sulphate (gypsum). The resulting form of the copper is also different but seems to give excellent fungicidal control.

The main point in connection with this mixture is that sodium carbonate is an active alkali, and any amount of it added over and above that required to combine with all the copper will destroy foliage. Therefore, in making Soda Bordeaux, it is *important to add just the exact quantity of the soda required to change all the bluestone.* This is done by adding the soda solution slowly to the copper solution,

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*Agricultural Gazette, Jan. 1920, pp. 10-12.

mixing thoroughly after each addition, and testing for the neutral point with litmus paper. The moment the litmus paper takes on a faintly blue tinge is the time to stop adding. The copper is then all in the form of a sediment, and any more alkali added will be left in the free state.

The following tentative formula can be given:

Sodium carbonate (anhydrous)	4 to 5½	pounds.
Copper sulphate	4	pounds.
Hydrated lime	5	ounces.
Water	40	gallons.

In making, add three-quarters of the soda solution at once, mix thoroughly and then add the rest gradually, mixing and testing until the proper quantity is present. It may not require the whole amount recommended, and it may require more, depending upon the quality of the soda. When the alkaline value of a sample of soda is once ascertained, then one can proceed with much more rapidity. The small amount of lime is added to make the mixture decidedly alkaline, and, therefore, safe, and to cause the precipitate to remain blue instead of changing to dark brown or black, which it does after standing some time where an excess of soda is used.

Soda Bordeaux has an advantage over the ordinary Bordeaux in that it is just as good a fungicide, and, at the same time, is made without the labour of slaking and preparing of lime. There are disadvantages, however:

1. Care is necessary in the addition of the soda. Any added in excess is dangerous to foliage; an excess of lime is not harmful, although not advisable.

2. If soda is in excess, the addition of an arsenical to soda Bordeaux to impart to it an insecticidal power, is dangerous. Any free soda will act upon the arsenic compound and form sodium arsenite, which, being soluble, will scorch foliage.

This last difficulty has been experienced by some orchardists, and for this reason they may be prone to condemn Soda Bordeaux. However, if care enough is exercised, no harm can result from this source.

The Bordeaux made from "Blighty" is probably of this kind and has given good satisfaction in England. This type of Bordeaux is also sometimes called "Burgundy Mixture."

Woburn Bordeaux.

The Woburn Fruit Experiment Station* (England) have a method for making Bordeaux mixture which they claim gives a far superior spray to that obtained by the methods just mentioned. In their method lime-water is used in place of milk of lime, and also much less copper sulphate is used.

	Formula A.		Formula B.	
Copper sulphate (crystallized)	2	ounces.	1	ounce.
Lime water	13½	pints.	6¾	pints
Water (soft) to make	9½	gallons	9½	gallons.

Dissolve the copper sulphate in a little water and then pour the lime-water into it and mix thoroughly. After it stands and settles for a time take a little of the clear

*Eighth and Eleventh Reports of the Woburn Experimental Fruit Farm.

liquid from on top, put into a white saucer and add to it a few drops of potassium ferrocyanide solution. If a brown or red colour appears a little more lime-water must be added, and the operation of stirring, settling and testing repeated.

To Make Lime Water. Take one pound of good stone lime, slake it in a little water, and then add this to 40 gallons of soft water. (If hard water is used, use more lime.) Stir the lime and water up two or three times at intervals of several hours, and leave it to settle till the solution becomes quite clear. Run this clear liquid off and keep it covered from the air. The clear liquid is the lime water. (1 1/3 lb. of hydrated lime can be used in place of the 1 lb. of stone lime.)

Formula A gives a spray corresponding in strength with that of ordinary Bordeaux; Formula B gives a spray one-half as strong, and is the strength now recommended for spraying.

Copper Carbonate, $CuCO_3.Cu(OH)_2$

This valuable fungicide can be readily and easily made at home if one so desires but this is not necessary since there are several excellent commercial brands on the market. The following method of making is recommended: A barrel is partly filled with water and twenty-five pounds of copper sulphate are dissolved in it, and into this is poured a solution of thirty pounds of sodium carbonate (common washing soda). The copper is thrown down as a pale green precipitate of "basic" copper carbonate. This precipitate rapidly settles to the bottom, and after a time the clear solution above can be siphoned off. The barrel is filled with water again, the precipitate stirred up and allowed to settle, and the clear solution again drawn off. This washing removes the greater part of the impurities (sodium sulphate) and leaves behind about twelve pounds of basic copper carbonate. This can be removed from the barrel, and dried in the air, after which it is ready to use.

The following quantities can be used for spraying:

Copper carbonate	1 pound.
Water	40 gallons.

Copper carbonate has become quite prominent the past few years as a treatment for smut on seed grain, particularly for the bunt or stinking smut of wheat, and the flag smut of rye. Oats and barley, because of the hull, are not effectively treated by this material. The amount of dust to use is about 2 ozs. per bushel and one should see that every grain has a complete coating. Mixing the grain with the dust by the shovelling method is not effective and furthermore, if one uses this method, a gas mask has to be used since inhalation of the dust, although not deadly, will cause headache and vomiting. The way to dust the grain is to use some device similar to a rotating churn in which baffle boards are arranged.

Grain that has been dusted with copper carbonate is protected from the attack of mice and most of the common grain weevils and beetles, and germination is not affected adversely as is often the case with formaldehyde and bluestone treatments. Neither does the grain swell. But if much dust collects in the drill, it may set and cause the parts to work hard. This can be avoided by rocking the feed shaft gently with a wrench before starting the machine. After use the drill should be thoroughly washed out and oiled before put away.

A good copper dust should be light green in color, not blue, and should be fine and fluffy and free from any gritty particles, i.e., should feel smooth when rubbed between the fingers. It also should carry not less than 20% of copper.

Ammonical Copper Carbonate.

This spray is made from basic copper carbonate the preparation of which has just been outlined under "copper carbonate." When ammonia is added to this material, it dissolves to form a deep blue solution, and this solution diluted with the requisite quantity of water forms the well-known spraying compound.

This fungicide is of use in that it can be applied to trees when the fruit is well advanced in the stage of maturity without causing any disfigurement, such as would result from the employment of Bordeaux. This last material leaves a coating if sprayed just a short time before the fruit is picked, which does not enhance marketing qualities, and which, further, might cause poisoning.

Following are the quantities of material to use:

Copper carbonate	5 ounces.
Ammonia (sp. gr. 22° Baume or 0.90 G.L.)	3 pints.
Water	45 gallons.

Eau Celeste.

The name of this material indicates that it was originated in France, and it was there in 1885 it first came into use. It has decided action against fungi, but it exerts quite a caustic action on foliage, and for this reason cannot be much recommended. It is made in the following way:

Copper sulphate	1 pound.
Hot water	2 gallons.

When the crystals are dissolved and the liquid has cooled, add:

Ammonia (sp. gr. 22° Baume or 0.90 G.L.)	1½ pints.
Water, to make	25 gallons.

When the ammonia is first added a precipitation occurs, but on the addition of the excess this precipitate disappears and a deep blue solution results.

Copper Sulphate, Bluestone, $CuSO_4.5H_2O$.

As was stated when dealing with Bordeaux mixture, this compound can be used to combat fungous diseases on plants, but if used in solution concentrated enough to be of material benefit would destroy the foliage. Nevertheless, for dormant wood it can be used quite freely, and is recommended in the following strength:

Water	15-25 gallons.
Copper sulphate	1 pound.

In dealing with grain smuts, however, where the strength of the solution is not so necessarily guarded, this substance has beeen found to be decidedly beneficial. The Experimental Department of this College has done some extended work in dealing with smutted grain, and report the following results in connection with bluestone treatment with oats:*

(a) Copper sulphate	1 pound.
Water	25 gallons.

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*Ont. Agri. College Bulletin 140, pp. 14-15.

(b)	Copper sulphate	1 pound.
	Water	1 gallon.

In solution (a) smut affected grain was immersed for a period of twelve hours; and in (b) for a period of five minutes. After treatment the grain was dried and sown in test plots, along with a check plot of some left untreated. An average of three years trial gave these data:

	Percentage of smutted heads.
(a) Treatment	0.2
(b) Treatment	1.1
Untreated	7.0

These results show that bluestone has a very decided action in checking smut, and this is especially marked with treatment (a).

For making copper sulphate solutions for smut treatment, or for producing the various Bordeaux preparations, a special finely crushed form of the substance is now put on the market, to take the place of the large lump form. This pulverized form dissolves quickly and a great deal of time is saved by using it if one happens to be in a hurry. Otherwise it has no advantage over the lump form.

Also a special dehydrated or anhydrous form of copper sulphate is now available. This substance is a white, non-crystalline powder and is useful for dusting. It is especially prepared for mixing with hydrated lime in the proper proportion for making Bordeaux, and then either dusted on or mixed with the proper quantity of water and sprayed on. In this last case, i.e., when made into a spray, it turns into ordinary Bordeaux mixture.

Sulphur and Its Compounds.

Sulphur.

This substance has been described under contact poison insecticides and thus this aspect does not need further elaboration here. As was stated before, sulphur was early (1821 and 1848) found to be an efficient fungicide. It is not known exactly how its fungicidal action is produced, whether it be through its ability to volatilize (25 to 35°C.) and thus surround the organism with an atmosphere of sulphur vapour, or whether it combines with the oxygen of the air and thus produces some poisonous vapour, such as sulphur dioxide or pentathionic acid, or whether it acts by means of some other process or processes. But it is known that the more finely divided the sulphur is the more efficient it is; and also that the presence of oxygen seems to, in great part, determine its efficiency; and further, that in most cases, in order to exert control, it must be in direct contact with the pest.

Finely divided sulphur is used as a dust, or applied as a spray for fungicidal control. In making a spray, it is difficult to get the sulphur to mix with the water because it is hard to "wet". This has lead to the introduction of "wettable sulphur". The ingredient used to impart this wetting property is usually calcium caseinate, powdered glue, soap, dextrin, flour, or diatomaceous earth. Commercial forms of these wettable sulphurs usually contain 40-50% of fine sulphur, the rest being composed of water and one of the substances mentioned above, the whole being in the form of a paste. Such pastes are used at the rate of 4-10 lbs. per 40 gallons of water.

Sulphur is an excellent disinfectant for sick rooms and the like after infectious diseases. The fumes produced by burning it on hot coals are quite deadly to most disease organisms provided the air is well supplied with moisture. This latter can be obtained by sprinkling some water over hot coals or a hot iron or brick if no other method is available. The disadvantages of disinfecting with sulphur is that it bleaches colours badly, such as wall paper. Such coloured articles as cannot be removed, therefore, often become ruined.

The Polysulphides.

These substances include lime-sulphur, both the solution and dry forms, and also the self-boiled, the sodium and potassium sulphides or livers of sulphur (soluble sulphur), and B.T.S., and have previously been discussed under contact poison insecticides.

The advantage of using these forms of sulphur as fungicides, rather than the powdered elementary sulphur, is not only that they are readily soluble in water, and beside, are efficient contact insecticides, but that after they are applied they deposit the sulphur which they contain, by virtue of interaction with the atmosphere, in an extremely finely divided state and thus supply the sulphur in its most active fungicidal form.

The livers of sulphur are used to some extent for treating seed grain for smut. For this purpose about one pound of the substance is dissolved in 25 gallons of water and the seed treated with this solution.

The foliage or summer strength of the polysulphide forms of sulphur, or in other words, the strength used for fungus control on living plants, has in each case been given under the previous discussion when these substances were dealt with as insecticides. They must be used in a decidedly dilute form, both when used as a dust or as a spray, because of their high causticity. Even in the dilute form injury of foliage and fruit often ensues, and as mentioned before aluminum and ferrous sulphates are now recommended to be used in the sprays in order to reduce this.

Dry Mix Lime Sulphur.

Lime-sulphur as a summer fungicide, although cheap, effective and convenient, cannot be used with entire safety as a summer spray on peaches and other stone fruits, and often causes injury on apple and pear fruit and foliage. For this reason, self-boiled lime-sulphur was developed about 1905 as a substitute. This dry-mix sulphur lime is now being developed as a substitute for the self-boiled and is essentially a sulphur dust. Its efficacy will be largely controlled by the fineness of sulphur used in making the mix. It is the extreme fineness of sulphur as deposited on the leaves from an application of lime-sulphur solution which makes this latter spray so effective as a fungicide, and the nearer the ground sulphur used in making a dry-mix approaches that fineness, the nearer will it measure up in effectiveness. The formula for making it is as follows:

Sulphur (high grade, super fine)	8 lbs.
Hydrated lime (high grade, fresh, free from grit)	4 lbs.
Calcium caseinate (Kayso, Spreado, Spra-Spred)	8 ozs.

This is the amount to make 40 gallons of spray, but greater or smaller quantities can be mixed provided the same proportion of the ingredients are maintained. The Kayso makes the sulphur wettable and enables it to mix more readily with the water and at the same time imparts spreading and sticking qualities. Other things, such as glue, can be used in the mixture in place of Kayso.

Miscellaneous Fungicides

Mercury Compounds.

Solutions of mercuric chloride ($HgCl_2$), sometimes called corrosive sublimate, are used both for destroying fungi and bacteria. It is used both as a treatment for potato scab, and for disinfecting pruning tools when cutting out diseased wood such as in black knot, fire blight, etc. It is also widely used as a general disinfectant. For these purposes the following formula is very effective:

Corrosive sublimate	1 oz.
Water	6-8 gallons.

In making this solution a wooden vessel is used and the salt is tied in a muslin sack and suspended in the water near the top; or the salt is dumped into the water and stirred with a wooden paddle until dissolved. If the water is warm solution is effected more rapidly.

This substance is very poisonous and must be stored and handled with great care, and potatoes and other things that have been treated by it are also poisonous.

The properties of this compound were pointed out under contact poison insecticides.

A number of organic mercury compounds have been introduced from time to time as a treatment of seed grain for smut, and have been found very effective. Among these are *Semesan, Semesan Bel* and *Uspulun.* The active principle in these is hydroxy mercurichlorphenol.

Formaldehyde, CH_2O.

Formaldehyde is a gas, which under the influence of cold condenses to a clear mobile liquid that boils at —21° C. If this liquid be mixed with water until it forms 40 per cent. of the volume, we have a commercial article known as "formalin", and which is used and is valuable as a fungicide. It is especially useful as a treatment for grain smuts and potato scab.

Using the following strengths of formalin and method of treatment:

(a)	Formalin	½ pint.
	Water	21 gallons.

(Immersing for twenty minutes).

(b)	Formalin	½ pint.
	Water	5 gallons.

(sprinkling and stirring till thoroughly moistened,) the Department of Agronomy (Bull. 140, pp. 14-15) obtained the following results with oats, the figures giving the percentages of smutted heads in the crop obtained from the sowing of the treated grain:

(a)	.0 per cent.
(b)	.0 per cent.
Untreated	7.0 per cent.

These results show that both treatments with formalin entirely destroy the smut spores adhering to seed grain. These formulae will also serve for the treatment of wheat.

This aldehyde, in the form of either formalin, or as its solid modification "paraform," is also widely used as a disinfectant in hospitals and sick rooms after infectious diseases, and as a preservative.

Phenols.

Carbolic acid, the cresols (the basis of the creosote oils) and many other phenols are used as disinfectants. For this purpose 5% solutions are usually employed.

Hot Water.

Where conditions warrant its use, boiling hot water is a very useful agent for destroying all manner of troublesome organisms. It is a splendid sterilizer and can be used for cleansing containers and utensils of all kinds, dormant wood, etc. Live steam, if available, is a good and convenient substitute.

The hot water treatment is one of the most effective methods for destroying the loose smut of wheat. The details of this treatment are given in Circular No. 66 of the Dominion Experimental farms.

Bleaching Powder (Chloride of Lime).

This substance, which comes on the market as a white powder that emanates a strong irritating odour, due to chlorine gas coming off, is widely used as a disinfectant (and as a bleach, from which it gets its name). Its active principle is available chlorine of which it should contain 33% to be of standard efficiency.

One of the leading uses to which it has been put as a germicide is for the purification of water for domestic use, particularly in large city and town water systems where the water is necessarily often drawn from contaminated sources, such as a lake or river. In such cases the process of purification is conducted on the large scale and the method gives no hint as to how one on the farm or elsewhere might proceed to treat water on the small scale, where necessary. The following directions* serve to indicate how this can be done:

1. Mix ½ pound of chloride of lime (33 per cent. available chlorine) with 1 pint of water.

2. Then add sufficient water to make 1 gallon.

3. Dissolve 13 ozs. of washing soda crystals in 2 quarters of lukewarm water.

4. Add sufficient water to make 1 gallon.

5. Mix these two solutions in a barrel or crock and allow the milky solution to settle over night.

6. Pour off the clear liquid from the white sediment into a jug and fill into bottles, well stoppered, and keep cool in a dark place. This "stock hypochlorite" will contain approximately the equivalent of three per cent. of chloride of lime or one per cent. of available chlorine.

Application. Mix one ounce of this stock solution to five gallons of water that is to be used for drinking purposes. After mixing allow to stand for half an hour before use.

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*Ont. Dept. of Agr., Bull. 330, p. 73, see also p. 76.

The solution may be added in small quantities to water after it has been drawn from the well or the quantity of water in the well may be estimated and the necessary amount of solution poured direct into the well and stirred in.

However, chloride of lime is not confined, by any means, to water purification (in which case, in large municipal plants, it is now largely being substituted by liquid chlorine), but is also widely used and useful for general disinfection. Dairy utensils, for instance, can be effectively cleansed by means of it. For such purposes, the stock solution as made up for water purification would be eminently satisfactory.

HERBICIDES

For destroying plants not wanted a number of chemicals are available. Among these the most widely used are sodium arsenite, ferrous sulphate (green vitrol), copper sulphate (blue stone or blue vitrol), bleaching powder or chloride of lime, calcium chlorate, spent gas lime, sodium chlorate and sodium chloride (salt).

The application of this method for destroying weeds is usually only possible where all plant life is to be destroyed, as along walks and driveways, railway tracks, or on non-grass tennis courts, along ditches, and the like. However, some success has attended the use of at least copper sulphate and ferrous sulphate in destroying mustard, dandelion and other rough, broad leafed plants growing in grain or grass crops.

Chemicals of various kinds are also used to check certain types of plants by virtue of producing in the soil an unsuitable medium from the standpoint of soil reaction. Some types of plants do best in an acid soil and others in an alkaline soil, and if the reaction is changed to that which is unsuitable the plant or plants in question die out. Sheep sorrel is a sign of an acid soil, and hydrated lime would tend to destroy it by making the soil alkaline. Clovers thrive best in a slightly alkaline soil and the application of sulphate of ammonia, the continuous use of which tends to make the soil acid in reaction, would eventually result in the driving out of these legumes.

When using copper sulphate, ferrous sulphate sodium arsenite, sodium chlorate and calcium chlorate as herbicides usually about 10% solutions in water are used, i.e., about 1 lb. to each gallon of water. And the plants to be destroyed are sprayed until well soaked, possibly at about the rate of 100 gallons to the acre. Gas lime is usually spread over the area to be treated; and salt and bleaching powder distributed about the base of the plant to be destroyed, good heavy applications being given in such cases. However, these latter two might be put on as sprays also, the salt as a strong solution and the bleaching powder as a strong suspension (it is insoluble in water).

Some of the above chemicals are sold as herbicides under trade names, such as "Bortox—the Chemical hoe", "Weed Cop" etc.

COMBINATION SPRAYS AND DUSTS

It very often happens that a plant is attacked by more than one enemy at the same time so that more than one kind of combative treatment or material has necessarily to be utilized. For instance, it frequently occurs that a fungus disease and some insect, either biting or sucking, attack together. In such cases it is desirable that a combined application of a fungicide and insecticide should be given if such a combination is possible for in doing so the labour of putting each one on separately is dispensed with. In other cases, still, it sometimes happens that a biting and sucking insect are preying on a plant at the same time, and if a food poison and a contact poison can be mixed together and applied in one operation a big item of expense, namely, labour, is proportionately curtailed.

Unfortunately, it is not possible to combine indiscriminately the various substances which are available; but nevertheless many combinations are possible and entirely satisfacory in every way and the practice of using combined treatments is now quite well developed.

The need and desirability of adopting combined treatments was early recognized and began to be carried out a number of years ago; and manufacturers of spray materials have, from time to time, put out desirable combinations. Such a combination is illustrated by "Pyrox," a mixture of Bordeaux paste and lead arsenate paste, i.e., a combined fungicide and food poison. It would evidently fulfill collectively the same functions as its two ingredients would each accomplish singly, and its use has been attended with very satisfactory results.

Following is the analysis of samples of this remedy which we have examined from time to time:

Water	63.05	per cent.
Lead oxide (PbO)	17.88	"
Copper oxide (CuO)	4.58	"
Arsenic oxide (As_2O_5)	7.55	"
Sulphur trioxide (SO_3)	0.46	"
Calcium oxide (CaO)	1.23	"
Undetermined material	5.25	"
	100.00	"

It will be seen that pyrox contains arsenic equivalent to 30 per cent. of neutral lead arsenate; and enough copper so that one pound of the paste would produce about one gallon of spray equal to ordinary Bordeaux.

However, pyrox is only one example among many others. Among others might we mention the following:

(a) *Sprayide*—a combination of arsenate of lime and Bordeaux mixture in a dry powdered form, a combined food poison and fungicide suitable for either dusting or spraying.

(b) *J—C Bordo-Arsenate*—a combination of Bordeaux and calcium arsenate, the same as the above, and has the same uses.

(c) *Bug-o-cide*—a blend of Paris green and other arsenicals in order to get the quick and vigorous action of the former combined with the slower and prolonged action of the latter.

The above examples do not nearly exhaust the list of prepared combinations, but will serve to illustrate the principle. A whole host of combinations are possible and many of them can be, and are, made by the user himself, e.g., lime-sulphur and lead arsenate, Bordeaux mixture and Paris green, nicotine sulphate and soap wash, Paris green and lead arsenate, and so on.

The main things to keep in mind in making combination spray materials are (1) What the mixture is to be used for so as to make the proper choice of suitable ingredients; and (2) Not to mix any ingredients which will harm the effectiveness of each other or produce products which will harm the plant or other host on which it is placed. In other words only efficient and compatible things are to be mixed and made into combination spray substances.

As a guide to those things which ordinarily can or cannot be safely mixed to form combinations, the following table is given. Only the more commonly utilized materials are included:

TABLE SHOWING MIXTURES WHICH ARE SUITABLE AND THOSE WHICH ARE OBJECTIONABLE OR QUESTIONABLE.

Material	Gives suitable combinations with:	Gives objectionable or questionable combination with:
Paris Green	Tobacco Preparations Bordeaux mixture Lead Arsenate Calcium Arsenate Sulphur.	Lime sulphur and all of the polysulphides. Oil Emulsions Soaps Soda Bordeaux
Calcium Arsenate	Paris Green Bordeaux mixture Lime Sulphur when used with three or more **parts of** hydrated lime. Tobacco Preparations Sulphur	The Livers of Sulphur (soluble sulphur) Oil Emulsions Soaps Soda Bordeaux
Lead Arsenate	Paris Green Bordeaux mixture Lime sulphur when used with three or more parts of hydrated lime. Tobacco Preparations Sulphur	Oil Emulsions Soaps The Livers of Sulphur (soluble sulphur) Soda Bordeaux
Bordeaux mixture	Lead Arsenate Calcium Arsenate Paris Green Tobacco Preparations Oil Emulsions made with bluestone.	Oil Emulsion made with soap Soap
Lime Sulphur	Calcium arsenate or Lead arsenate when mixed with three or more parts of hydrated lime. Tobacco Preparations	Paris Green Oil Emulsions Soaps
Tobacco Preparations	All commonly used materials.	
Oil Emulsions	Soaps, if the emulsifier in the emulsion is soap.	All commonly used materials.
Soaps	Tobacco Preparations Oil Emulsions containing soap as the emulsifier. Livers of Sulphur (soluble sulphur) Sulphur	All materials carrying heavy metals, i. e., Copper, Lead, Calcium, Zinc, Mercury, etc.

A GOOD POISON BAIT.

Ruggles and Parker in Circular 17 of the Agricultural Extension Division of the University of Minnesota give the following method of making a poison bran bait for grasshoppers. It is also a bait that will be found quite satisfactory for other purposes such as for cut worms or army worms, but for these latter the poison (i.e., the white arsenic, Paris green or sodium arsenite) might be reduced by one half and the amyl acetate, salt, and even the molasses could be omitted:

"Coarse wheat bran (free from shorts)	100 pounds.
Crude white arsenic	5 pounds.
Salt	5 pounds.
Amyl acetate (technical grade)	3 ounces.
Molasses (low grade)	1-2/3 gallons.
Water	8 to 10 gallons.

Discussion of Materials

Bran—Use only coarse wheat bran, free from shorts. Shorts causes the mixture to stick together in balls, greatly increasing the labour of mixing. When scattered, poisoned bran mash containing shorts has a tendency to fall in lumps which are not readily eaten by the grasshoppers and which are dangerous to birds and livestock. If bran is high in price and sawdust can be had for the hauling, a 50-50 mixture of the two can be used with good results.

Arsenic—Finely powdered crude white arsenic is both cheap and effective. Paris green can be substituted for it, pound for pound, but is much more expensive. Sodium arsenite can also be used and in the "wet method" of mixing has some advantages over either crude white arsenic or Paris green. This material is sold in liquid form for killing weeds and as a dry powder. For killing grasshoppers, use one quart of the liquid or 2 pounds of the power in place of the 5 pounds of crude white arsenic recommended in the standard formula.

Salt.—Any salt that will dissolve quickly will be satisfactory.

Amyl acetate.—Insist on amyl acetate "technical". So-called "banana oil" and "bronzing liquids" should be avoided as they usually contain only a small amount of amyl acetate. *Never use more than the formula calls for.*

Molasses.—Sugar-beet or other low-grade molasses is recommended. If only high grade expensive molasses is available, the amount used may be reduced one half without noticeably reducing the effectivenes of the bait.

How to Mix Poisoned Bran Mash

Dry Method — (1) Thoroughly mix 100 pounds of coarse wheat bran and 5 pounds of crude white arsenic, or Paris green. This can be done by working the bran and arsenic back and forth with a scoop shovel on a tight floor or in a wagon box, grain tank, or galvanized watering trough. It is extremely important that every flake of bran be coated with the poison.

(2) Dissolve 5 pounds of salt in 10 gallons of water in a galvanized tub and add 1 2/3 gallons of cheap molasses. Stir until all the ingredients are well dissolved.

(3) Work the liquid materials into the bran and arsenic by adding a little at a time and turning with a scoop shovel or rake until no dry bran remains. A good mixture will be uniformly moist and yet will scatter into small flakes when broadcasted from the hand.

Wet Method. — When large amounts are to be prepared, mixing in 500-pound lots by the wet method is more rapid than by the dry method and no irritation of the skin follows as is often the case when the dry method is used.

(1) Spread 500 pounds of bran so that it lies about six inches deep on a tight floor.

(2) Stir 25 pounds of the crude arsenic or the proper amount of either one of the other two poisons, to a thin paste in 8 or 10 gallons of water in an ordinary galvanized tub.

(3) In a second tub dissolve 25 pounds of salt in 5 gallons of water. Then add 8 gallons of molasses and 15 ounces of amyl acetate and stir until well mixed.

(4) Pour the two wet mixtures at the same time into a 40 gallon barrel and add enough water to fill the barrel to within 8 inches of the top. Detail a man to stir the mixture in the barrel constantly, with a long paddle, and impress upon him that if he fails to keep the material well mixed, poor results will follow. White arsenic or Paris green are very heavy and if the mixture is not constantly stirred, will settle to the bottom, resulting in a very poor distribution of the poison throughout the bran. The use of sodium arsenite, which quickly dissolves in cold water, in place of crude arsenic or Paris green, does away with this difficulty.

(5) Wet the entire surface of the spread-out bran by scattering the wet mixture from buckets. About one-fourth of this entire mixture should be used in the first wetting, after which the bran should be well worked by raking from each end of the pile. After each part of the bran is raked it should be gathered into a pile so that when the first raking is completed there will be two nearly equal piles. These should then be turned with scoop shovels, and spread out in the same way as at the beginning. By adding the rest of the mixture in three installments and raking and shoveling each time, the poison is very well distributed. At the last application, 3 or 4 gallons of water should be added to the barrel to wash out the small amounts of arsenic that usually remain in the barrel in spite of constant stirring.

(6) The prepared mash should now be sacked and is ready for immediate distribution or may be kept in the sacks for several days. In the latter case it should be plainly marked "POISON" and kept where stock can not reach it."

Smaller quantities of this bait, compounded by either method, may be made by reducing the materials as required, but maintaining them in the same proportion.

For grasshoppers about 20 pounds per acre would be a suitable application, for which purpose it is broadcasted much as one would sow seed. In case of bad infestation, heavier dosage could be given or the dose repeated in a few days. For cutworms, where whole areas are affected it would be distributed as for grasshoppers; but where individual plants, such as tomato or tobacco, are being attacked, about ½ teaspoonful is placed near the base, but not touching, each plant. Also, for cutworms, it is preferable that the bait be distributed late in the evening in order that it be fresh and moist when the cutworms become active.

Since baits of this class are extremely poisonous to all animals and man, they must be handled, stored and used with all due precaution. When thinly scattered in the field, however, there is usually no danger, even to poultry or birds, if the bait has been made of the proper kind of bran so that it is granular and does not fall in large lumps. Where distributed in little heaps or masses, on the contrary, it is a dangerous source of trouble and all animals should be kept away. This drawback of poison baits may some day be partly or wholly overcome by the introduction of some substance equally poisonous to worms but less so to higher animals. The fluorides and silicofluorides seem to be useful in this respect but as yet their substitution for the arsenicals cannot be advised.

GUARANTEES.

According to "The Agricultural Pests' Control Act," of the Dominion of Canada, the guaranteed analysis of materials sold for control work must have the active ingredients stated on the packages or containers. This is for the purpose of safeguarding the purchasing public against fraud and against the use of weak, inefficient and harmful remedies. It also protects the manufacturer against fraudulent dealers and at the same time standardizes the quality and utility of the material and develops a spirit of confidence and co-operation between the manufacturer and the consumer.

Following are the standards which have been set up:

(a) All metallic poisons shall have the percentage by weight of the active substances present and the minimum percentages of each metal present stated.

(b) Where arsenic is present the maximum percentage of water soluble arsenic expressed as metallic arsenic shall be stated.

(c) All sulphur or compounds of sulphur shall have the percentage of sulphur present stated in terms of atomic sulphur.

(d) In the case of lime-sulphur compounds the guaranteed analysis shall be stated in terms of: (a) Total sulphur
(b) Polysulphide sulphur
(c) Density in Baume degrees.

(e) Phosphorus, chlorine, iodine, fluorine, antimony, or any other active element not otherwise mentioned shall be stated in its atomic form.

(f) In the case of oil emulsions, and soap emulsions, the total percentage of oils and the total percentage of soap present shall be stated.

(g) In the case of phenols, lysol, and other similar poisons the phenol coefficient shall be stated.

(h) In the case of strychnine or strychnine preparations the actual percentage of the alkaloid or of its sulphate, if in sulphate form, present shall be stated.

(i) In the case of cyanides the guaranteed analysis shall be in terms of Hydrocyanic Acid HCN.

(j) In the case of tobacco extracts and tobacco preparations the percentage of nicotine shall be stated as nicotine base ($C_{10}H_{14}N_2$).

(k) In the case of all repellant and attractant substances the percentage shall be stated as volatile oils or repellent or attractant ingredients.

(l) In the case of all other organic substances the actual name and percentage of the material shall be declared.

(m) In the case of bacterial cultures for extermination of animal pests, the date after which the material shall not be guaranteed effective shall be stated.

POISONS — THEIR TREATMENT AND ANTIDOTES.

Since practically all of the chemicals used in control work are poisonous to man and beast, great care has to be exercised at all times in their use and storage. However, under the best of management mistake or accident will sometimes occur. In such instances emergency procedure must always be adopted because every moment becomes exceedingly precious, and while the doctor is on his way, much can be done, if one knows how, that will usually spell the difference between life and death. For this reason all packages containing poison must show conspicuously on the outside the usual symbol of such, together with the word POISON plainly marked. As well as this, the antidote and treatment for such poison or poisons present must be given.

Following is a list of the common poisons and their respective antidotes as given in the regulations:—

(1) *Mineral Acids.* Sulphuric, hydrochloric, nitric and acetic acids. *Antidote.* No emetic. Give very concentrated lime water, chalk, calcined magnesia, soap suds. Afterward raw eggs, milk, sweet oil.

(2) *Acid Oxalic. Antidote.* No emetics. Give concentrated lime water, wall plaster in paste with water, chalk, afterwards castor oil.

(3) *Alkalis.* Lye, sodium hydroxide, potassium hydroxide, ammonia water, etc. *Antidote.* Vinegar, dilute citric or tartaric acids, lemon or orange juice, then raw eggs, sweet oil, barley water, stimulants.

(4) *Arsenic and all compounds containing arsenic. Antidote.* Emetic promptly, syphon tube cautiously inserted, milk, and emetic of mustard water, hydrated ferric oxide; followed by raw eggs, milk, mucilageneous drinks.

(5) *Barium.* All compounds of Barium. *Antidote.* Emetic, epsom salts, glauber salts, any alkaline sulphate.

(6) *Cyanides.* All compounds of hydrocyanic or prussic acid. *Antidote.* Syphon tube or emetics, cold applications to head and neck, aromatic spirits of ammonia, smelling salts, artificial respiration, brandy (per rectum), prevent asleep.

(7) *Copper.* All compounds of copper. *Antidote.* Emetics, baking soda, then white of eggs, milk, sweet oil.

(8) *Fluorides.* All compounds containing fluorine. *Antidote.* Calcium compounds, preferably 1% solution of calcium chloride, lime water.

(9) *Formaldehyde.* Formalin, etc. *Antidote.* Ammonium acetate solution, or well-diluted ammonia water.

(10) *Hellebore. Antidote.* Syphon tube or mild emetics, warmth, stimulants, artificial respiration, if necessary.

(11) *Iodine. Antidote.* Emetics aided by demulcent drinks, starch and flour paste, raw eggs.

(12) *Lead.* All compounds of lead. *Antidote.* Emetic, epsom salts in large doses, stimulating drinks, potassium iodide.

(13) *Mercury.* All compounds of mercury except corrosive sublimate. *Antidote.* immediate emetic, then white of raw eggs, milk, gruel, barley water, flour and water. Give patient all he can swallow.

(14) *Corrosive Sublimate.* No emetic. Give white of raw eggs and milk in large quantities.

(15) *Phosphorus. Antidote.* Stomach tube, emetics, copper sulphate both as antidote and emetic (3 grains in water every five minutes till vomiting is induced) half-ounce of epsom salts, no fats or oils.

(16) *Phenols, Carbolic acid, etc. Antidote.* Cautious insertions of syphon tube and wash out stomach with epsom salts solution afterwards, olive oil, milk, castor oil, brandy, and warmth.

(17) *Stychnine.* All compounds. *Antidote.* Emetics, strong tea, potassium bromide; keep patient still, give chloroform to prevent spasms.

(18) *Sulphides.* Carbon disulphide. potassium and sodium sulphide, etc. *Antidote.* Syphon tube and wash out stomach, or 3 grains of copper sulphate in water as emetic. Afterwards milk, eggs, warmth, artificial respiration, if necessary. Alcoholic stimulants per rectum.

(19) *Tobacco.* Extracts of tobacco, nicotine, etc. *Antidote.* Syphon tube or emetic, prone position, strong coffee or tea, warmth to extremities.

(20) *Turpentine. Antidote.* Emetic, milk.

(21) *Zinc.* All compounds of zinc. *Antidote.* No emetic, large doses of baking soda or washing soda dissolved in warm water, milk and eggs freely, strong tea.

SPRAY CALENDAR

No matter how carefully one may choose the treatment for any given pest, it is entirely ineffective if improperly employed. A remedy must be applied thoroughly, in the correct fashion, and, above all, at the proper time.

Further, one may apply a remedy exactly according as it should be done and at exactly the right time, and still get no result because of wrong choice of remedy.

For these reasons, a "Spray Calendar" should always be consulted and followed. Such a calendar is designed to show the correct choice, time and manner of employment of remedies for the more common enemies.

Two Spray Calendars are published by the Ontario Department of Agriculture, one for "Apples" and one for "Pears, Stone Fruits and Bush Fruits." These are revised annually and it is strongly advised that any one employing remedies on the above plants should secure these and follow the directions therein given. Copies may be obtained by request either by writing to the Ontario Department of Agriculture, Parliament Buildings, Toronto, or to the President, Ontario Agricultural College, Guelph. Advice for controlling pests not covered by these calendars may be had by writing the Ontario Agricultural College.

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Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

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POTATOES

By

W. J. SQUIRRELL
A. H. MACLENNAN
J. A. CARROLL

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ONTARIO AGRICULTURAL COLLEGE

GUELPH, ONTARIO

POTATOES

by

W. J. Squirrell, A. H. MacLennan and J. A. Carroll.

IMPORTANCE OF THE CROP.

The importance of the potato is not always generally realized either by the producer or the consumer. This crop ranks second only to wheat as a human food. No single crop either in New or Old Ontario is grown on a greater number of farms than potatoes. In the average of the five year period, 1925 to 1929,

A Field of Irish Cobblers, Grown from Certified Seed.

inclusive, there were 161,361 acres of potatoes grown in Ontario with an average total production of 16,327,664 bushels, which was valued at approximately $15,799,227. Potatoes provide one of the cheapest forms of human food and are used in Ontario almost as extensively as bread. At the present time Japan, whose chief food product is rice, is spending large sums of money investigating the growing of the potato for Japanese conditions.

Composition and Uses.

Potatoes are rich in starch and form one of the chief commercial sources of this product. When used alone they form an unbalanced ration but in conjunction with foods rich in protein, such as meat, fish, etc., they become an important factor in a well balanced diet. Chemical analysis show that cooked potatoes (peeled) contain 75.5 per cent. water; 2.5 per cent. protein; 20.9 per cent. carbohydrates; .1 per cent. fat; and 1.0 per cent. ash. An analysis of raw potatoes (peeled) showed a slightly higher water content and a slightly less carbohydrate content than cooked potatoes, peeled. The carbohydrates are made up chiefly of starch, sugar and a small amount of crude fibre. The analysis made by the Chemical Department of the Ontario Agricultural College of eighty-one lots of potatoes of different varieties from different soils and localities in Ontario and New Brunswick showed there was a variation in percentage of dry matter from 16.4 to 26.6; of protein from 1.5 to 2.9; and of starch from 9.6 to 20.7. The average amount of starch in potatoes grown on sandy loam and on light sandy loams was 16.0 per cent., and on heavy clay loams 16.1 per cent. The results, therefore, showed little difference in starch content of potatoes grown on light and heavy types of soil. A test of a number of different varieties of potatoes grown under similar conditions of soil and climate showed wide differences in chemical composition. In experiments conducted by the Department of Field Husbandry over a period of several years to determine the table quality of potatoes, results showed that the table quality was more influenced by variety than by locality, soil or climate. A high percentage of carbohydrates or starch causes potatoes to be dry or mealy, a high percentage of protein to be waxy and a high percentage of water to be wet and soggy.

In the Province of Ontario an average crop of potatoes removes from an acre of land approximately 25 pounds of nitrogen, 37 pounds of potash, and 8 pounds of phosphoric acid. An average crop of potatoes removes less of the fertilizing constituents from the soil than an average crop of mangels or corn.

The chief use of potatoes in the Province of Ontario is for the production of human food. These potatoes are prepared and used in many ways. In the process of peeling raw potatoes lose approximately 20 per cent. of their weight. Potatoes fed to farm stock in Ontario are confined largely to peelings, culls and the surplus of old potatoes on hand, except when prices are low, then a considerable percentage of the crop is fed. As the result of experiments in feeding hogs Fjord of Denmark found that 400 pounds of cooked potatoes equalled 100 pounds of mixed grains; Henry of Wisconsin, that 442 pounds of cooked potatoes equalled 100 pounds of corn meal; and Potter of Oregon, that 360 pounds of steamed or 552 pounds of raw potatoes equalled 100 pounds of barley. German economists estimate that 40 per cent. of their potato crop is fed to stock; 28 per cent. is used for human consumption; 12 per cent. for seed; 6 per cent. in the manufacture of alcohol; 4 per cent. in the manufacture of starch and related products and 10 per cent. decay. It is likely that in future a larger percentage of the Ontario potato crop will be fed to stock and used in the manufacture of commercial products.

Climate and Soil.

The potato thrives best in a rather cool climate where there is a sufficient supply of moisture for its development. Wet summers and extremely hot weather are detrimental to the best development of the potato. In each of the past thirty years meteorological records have been taken by the Department of Physics of the Ontario Agricultural College. These records show the total amount of precipitation in each of the five growing months, May to September, 1929, and for the average of the past thirty year period in the table given below:

Period	May	June	July	Aug.	Sept.	Total
	Inches	Inches	Inches	Inches	Inches	Inches
1929 (1 year)	3.72	1.22	3.68	1.14	.83	10.59
1900-1929 (30 years)	3.03	2.89	3.72	3.06	2.69	15.39

Extensive investigations carried out in the United States indicate that the best potato growing areas have a precipitation of twelve to eighteen inches during the period between planting and harvesting late potatoes. It will be noticed in the above table that the amount of rainfall in the five growing months at Guelph comes within the limits of precipitation which indicate the possibility of maximum yield. The average total precipitation at Guelph for this period does not vary greatly from that of a large part of the Province of Ontario. It should be remembered that good cultivation is one of the best agencies for conserving and regulating the soil moisture supply.

Potatoes are grown on many types of soil but give their best results on rich sandy loams, where there is a good moisture supply. The greatest yields of potatoes should not be expected on very light sandy or very heavy clay soils, poorly drained soils or on soils lacking in fertility or organic matter.

Rotation.

In considering a rotation for the potato crop the grower should not only consider the needs of this crop but also the requirements of the other crops following potatoes. The success attained by the farmer in all lines of crop production is largely measured by the choice of crops in his rotation. In those sections where potatoes are extensively grown a three to five year rotation is generally practised and here legumes play an important part. The common rotation in many parts of Ontario is potatoes, grain and clover. The first crop of clover is usually cut for hay and the second crop ploughed under in the late summer or early autumn. In rotations lasting four or five years the clover is used for hay for one or two years or pasture for a year or two. A three year rotation consisting of potatoes, grain and sweet clover or alfalfa has been successfully used in a number of the principal potato growing sections of the Province. Potatoes require a large amount of organic matter in the soil and it is of first importance that a good legume be one of the crops in the rotation. Rotation experiments at Guelph indicate that red clover, sweet clover and alfalfa sod form an excellent preparation for the potato crop. The potato is one of the very best of cleaning crops and thorough cultivation of the soil during the growing of the crop leaves the land in excellent condition for the crop which follows.

Few plants suffer more from virus diseases than potatoes and the growing of this crop in a definite rotation is one of the best means of minimizing the injury from these diseases.

Manure and Fertilizers.

Barnyard manure is one of the most valuable sources of plant food. It should be remembered, however, that it is quite variable in composition depending on whether it is horse, cow, sheep, hog or poultry manure and also on the care taken to conserve the liquid and solid excrement. An application of twenty tons per acre of good barnyard manure would add approximately 200 pounds of nitrogen, 100 pounds of phosphoric acid and 200 pounds of potash to the soil. If all this were available for the growing potato crop it would be more than sufficient to produce a three hundred bushel yield per acre.

When fresh stable manure is used it may be applied to the land after it has been fall ploughed and cultivated. After spreading the manure the land is thrown into ridges about thirty inches apart with a double mould board plough. The manure contained in the ridges is protected over winter and the land left in this condition until time for preparing the seed-bed in the spring. Leaving the soil in the ridges over winter exposes the largest amount of surface to the action of the elements and provides the best possible surface drainage in the spring. Some potato growers apply barnyard manure on sod land during summer, autumn, winter or in spring and plough the land just before planting time. When the manure is applied to land in the spring unless it is well rotted it has a tendency to increase the amount of scab. Because of this many growers prefer applying barnyard manure to the crop preceding potatoes. Barnyard manure in addition to being a valuable source of soil fertility is also one of the chief sources of organic matter.

Except in the case of two or three highly specialized crops no cultivated crop receives more artificial fertilizers than the potato and few crops respond more readily to their application.

The nitrogen in artificial fertilizers promotes the vegetative growth of the plant and a good supply of this element is usually indicated by a deep green color in the foliage of plants. A deficiency of nitrogen in the soil is indicated by the stunted growth of the plant. A too liberal use of nitrogen produces an excess of top and delays maturity.

The phosphates in artificial fertilizers stimulate root growth and hasten maturity.

Potash is an important element in artificial fertilizers because it produces an abundance of carbohydrates such as starch, and the potato crop is dependent on a large supply of this element.

A sufficient supply of all of the above elements in an available form is necessary for maximum production of the potato crop. Whether the soil is deficient in one or all of the above elements can only be determined by field trials.

To use artificial or commercial fertilizers most intelligently the farmer should study his own soil needs through simple plot tests and obtain the general information available on the subject of fertilizers in the annual reports of the Ontario Agricultural and Experimental Union and the bulletins of the Department of Chemistry of the Ontario Agricultural College.

The Department of Chemistry of the Ontario Agricultural College in experiments conducted on sandy loam types of soil in a number of the potato growing districts of Ontario found a fertilizer combination of 4-12-4 or 3-10-5 gave good results where no barnyard manure was used or clover ploughed under; a 2-12-6 where some barnyard manure was used; and a 0-12-5 where a good application of barnyard manure was given and a clover sod ploughed under. Results showed that it was economical to apply 500 to 600 pounds per acre of these fertilizer combinations where conditions warranted it. Under some conditions as much as 1000 pounds per acre may be used with profit.

It is always well to remember that the problem presented by each type of soil varies and the potato grower should modify the quantities of fertilizers and manure to suit his requirements. Manuring and fertilizing is secondary to soil and climate and when these are particularly unfavorable no skill in adding manures and fertilizers will insure a maximum yield. The use of fertilizers and manures will not amend the results of poor seed-bed preparation and poor cultivation.

Preparation of the Soil.

Fall ploughing is recommended for the potato crop. Where this is followed in the late autumn by ridging, it insures the most complete decay of the sod and exposes the soil to the agencies causing disintegration. The depth of ploughing will vary with the type of soil, depth of surface soil and character of the subsoil. Where the surface soil is deep it is ploughed to a greater depth than where it is shallow. On soils well adapted to potato growing the depth of ploughing should be from five to seven inches. The spring preparation of the soil where the land has been left in ridges over winter consists of thoroughly cultivating and harrowing the land. It is a common practice with some farmers to apply manure in the late winter or early spring and spring plough the land. This requires a more thorough spring preparation of the seed-bed than where the land has been fall ploughed. The aim in soil preparation should be to provide for the potato a deep mellow seed-bed and as far as possible have the organic matter well decomposed befor planting.

Seed Potatoes.

The selection of the best potato seed stock is just as important as the selection of the best seed of different varieties of grain.

Experiments at Guelph indicate that immature potatoes have a greater seed value than matured potatoes.

In the average of an experiment conducted for a period of four years with two early, two medium and two late maturing varieties of potatoes it was found that potatoes planted on the average date of July 12th and the next year used for seed produced 219.5 bushels as compared with potatoes planted on the average date of May 31st and the next year used for seed which produced 192.4

bushels of potatoes per acre. The value of immature potatoes for seed is further evidenced in the results presented in the following table:—

Source of Seed	Average Yield of Potatoes per Acre (Bushels)										
	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	Ave.
Northern Ontario.........	292.6	168.1	187.2	195.3	209.3	169.7	217.1	189.6	233.2	183.3	204.5
Southern Ontario.........	279.8	163.9	183.2	187.7	198.8	162.4	198.8	185.4	230.4	172.1	196.3

The average figures in this table summarized the results of co-operative experiments on 642 farms, most of them in Old Ontario. It will be noticed that in every one of the ten years the Northern grown seed produced a higher yield per acre than seed which was grown in Southern Ontario, the average difference

Uniform and Vigorous Growth from Seed of Selected Hills.

for the whole period being 8.2 bushels per acre. In each of the years in which the experiment was conducted both the Northern and Southern grown seed was obtained from inspected fields and was comparatively free from disease of all kinds.

Farmers, especially when potatoes are a good price, sometimes use small potatoes for seed. If these are selected indiscriminately from the potato seed bin this is not a good practice. These small potatoes may have come from hills which had few and only small potatoes or the small size may have been due to disease. The farmer can do much to improve the yield, quality and uniformity of his crop if, when the plants are in bloom, he stakes enough good hills to provide seed for the following year. These hills should be dug and the potatoes stored separately from the general crop. In an experiment conducted for a period of fifteen years (1913 to 1927 inclusive) potatoes of the Davies' Warrior variety from the outstanding selected hills produced yields as follows:—No. 5 Hill, 217.4 bushels; No. 2 Hill, 192.1 bushels; No. 1 Hill, 180.6 bushels; and No. 8 Hill, 178.0 bushels per acre. These selected hills all produced greater yields per acre and a higher percentage of marketable potatoes than the ordinary run of seed stock of the same variety.

The potato is not a seed but a tuber and usually requires more frequent change of planting material than is the case with most other crops. It will often be found advisable to obtain certified seed of the best varieties where these latter have been produced under conditions which provide immaturity of seed and contain the minimum of disease.

VARIETIES.

One of the most important questions for the potato grower to decide is the choice of variety to grow. In choosing the variety the grower should keep in mind yield, quality, adaptability to growing in the district, and suitability for the market.

A Well Selected Lot of Green Mountain Potatoes.

The most desirable type for the market at present is a smooth white potato of fair size (not too large) with two diameters nearly equal and the third dimension considerably less (flat round).

There are still too many varieties of potatoes grown on the farms of Ontario. It is not possible to obtain maximum yield, the best quality and a uniform product for market when a large number of varieties are grown in a district.

In all 445 varieties of potatoes have been under experiment at the College. Most of these varieties have been grown for at least 5, some for 10, 15, 20 and even 30 years. It is not the purpose of this bulletin to discuss in detail the results obtained from testing this large number of varieties but only three which have proven to be of greatest economic importance in the Province of Ontario. These are the Green Mountain, Rural New Yorker and Irish Cobbler varieties.

Green Mountain. The tubers are moderately to distinctly oblong, usually broad, flattened; skin a dull cream or light russet color, frequently having russet brown splashes toward the seed end. The sprouts are usually white occasionally tinted with magenta, while the leaf scales and the tips are tinged with lilac to magenta. The flowers are white.

In variety tests in the experimental field at Guelph covering a long period of time the Green Mountain variety was one of the best yielders. In experiments to determine table quality and which considered mealiness, flavor and appearance, this variety ranked among the best. The eyes of the Green Mountain are fairly shallow and the variety seems to possess only medium disease resistance. In co-operative experiments covering a ten year period, this variety, tested by 1162 farmers in all the counties and districts of the Province of Ontario, gave an average yield of 203.9 bushels, compared with the Irish Cobbler, 173.3 bushels per acre. The percentage of small potatoes (potatoes less than 1½ inches in dia-

A Good Selection of the Dooley Variety.

meter) of the Green Mountain variety was 9.6 and of the Irish Cobbler 12.7. The results of these co-operative tests run in the same direction as those conducted in the experimental plots at Guelph and show that the Green Mountain produces a somewhat higher percentage of marketable potatoes than the Irish Cobbler variety. The Green Mountain is a medium late maturing variety.

Varieties of the Green Mountain group are:—Green Mountain, Bethel Beauty, Blightless Wonder, Carman No. 1, Clyde, Delaware, Empire State, Farmer, Freeman, Gold Coin, Green Mountain Jr., Gurney's White Harvest, Keystone, Late Blightless, Long Island Wonder, Norcross, Pride, Snow, State of Maine, Uncle Sam, White Mountain.

Rural New Yorker. The most common variety of this type in Ontario is the Dooley. The tubers are broadly round flattened to short oblong, or distinctly oblong flattened; skin creamy white or deep russet; sprouts at the base dull white in color; leaf scales and tips violet purple to pansy purple. The central part of the corolla of the flower is deep violet in color with the purple growing lighter toward the outer sections; five points of the corolla are white or nearly so.

In the average results of the experiments at the College and in the co-operative expriments over Ontario the Rural New Yorker has not yielded quite as well per acre as the Green Mountain variety. It seems, however, to be well adapted to those sections of the Province where the summers are the warmest. The quality of the Rural New Yorker variety is good. The Rural New Yorker is medium late in maturing and has shallow eyes. This variety proved to be one of the best in disease resistance of the varieties tested at Guelph. The Rural type produces its tubers after the plants are well grown.

Varieties of the Rural New Yorker group are:—Rural New Yorker, Arcadia, Carman No. 3, Dooley, Great Divide, Jackson White, Late Vicktor, Lily White, Million Dollar, Noxall, No. 9, Ohio Wonder, Peerless (Bresee's No. 6) or Boston,

A Good Selection of the Irish Cobbler Variety.

Prosperity, Rhind's Hybrid, Rural New Yorker No. 2, Sir Walter Raleigh, White Giant, White Swan, Late Petoskey (Rural Russet), Russet (Dibble's), Roxbury.

Irish Cobbler. The tubers of this variety are roundish to roundish flattened or slightly oblong flattened; the stem end is usually deeply notched and the tuber has a shouldered appearance at the base. The tips of the sprouts are slightly or distinctly tinged with reddish violet or magenta. In some cases the color is absent. Flowers are a light rose purple and under hot summer conditions may become almost white. The Irish Cobbler is one of the best early maturing varieties tested at Guelph and in the co-operative experiments over Ontario. This variety which possesses fairly deep eyes is one of the most resistant against disease. Its table quality is good and it is one of the best keepers of the early maturing potatoes. Experiments in the storage of potatoes show that it keeps as well as most of the late maturing varieties.

Varieties of the Irish Cobbler group are:—Irish Cobbler, Early Dixie, Early Eureka, Early Petoskey, Early Standard, Early Vicktor, Extra Early Eureka, Flourball, Potentate, Bells Deposit.

Note—Description of Varieties and Group Classifications from "The Potato" by Wm. Stuart.

Time of Planting.

The time at which potatoes should be planted is controlled by a number of factors, climatic conditions at planting time being one of the chief of these. In the main it may be said that potatoes for early market should be planted just as soon as danger from late spring frosts is passed. The following table gives the average results of planting the Irish Cobbler, an early maturing, and the Green Mountain, a late maturing variety, on each of five different dates for a period of seven years:—

Variety	Average Results, 7 Years, 1918-1924		
	Date of Planting	Yield per Acre (Bushels)	
		Marketable	Total
Irish Cobbler	May 6th	197.5	227.4
	" 20th	182.2	211.8
	June 3rd	165.4	190.0
	" 17th	151.7	179.1
	July 1st	101.5	129.2
	" 15th	53.7	81.4
Green Mountain	May 6th	233.3	272.1
	" 20th	215.6	250.2
	June 3rd	194.3	224.1
	" 17th	177.1	213.2
	July 1st	98.8	130.9
	" 15th	24.3	46.7

This experiment was conducted in duplicate and is the average of using both Northern and Southern grown seed of each variety. The greater part of the late or main crop potatoes are planted in Ontario between the 15th of May and the 1st of June. The results of this experiment would indicate, where the season and labor conditions permit, that larger yields per acre would be obtained if the main crop potatoes were planted somewhat earlier than is the usual practice. The best table quality was obtained from earliest plantings, when the potatoes were matured at time of harvest.

Seed Potatoes Exposed in Different Ways for Three Weeks Before Planting.

An experiment was conducted for five years in succession in which potatoes were evenly divided into different lots and placed in varying degrees of light and heat for three weeks before they were planted. Some were placed in a dark cellar, others in the window of the cellar, others on the barn floor, others in the greenhouse immediately under the glass and others in the open air. Two varieties were used in the experiment. The different lots of each variety were made up of the same weight and the same number of tubers. Potatoes exposed in a dark cellar grew long, tender, light colored sprouts, while those in a warmer temperature and in the light produced short, green colored sprouts. One-half of the potatoes kept in the dark cellar were planted with the sprouts removed and the other half with the sprouts still attached to the tubers. The table below gives the average percentage marketable and the yield of marketable as well as the total yield for the ten tests in the five years for each of the six treatments:—

Places where Potatoes were kept for twenty-one days before planting	Average Percentage Marketable	Average Bushels per Acre per Annum	
		Marketable	Total Yield
1. In barn in light (sprouts on)	77.9	187.1	221.1
2. In root cellar in light (sprouts on)	74.4	173.8	210.6
3. In root cellar in dark (sprouts on)	74.1	169.4	206.0
4. In greenhouse in light (sprouts on)	59.8	134.6	189.3
5. In root cellar in dark (sprouts off)	63.1	130.5	177.3
6. In open air (sprouts on)	58.2	62.9	107.3

Late potatoes which were placed on the barn floor in the latter part of May and allowed to remain there for three weeks after which they were planted whole with the short sprouts attached gave better results than tubers submitted to any other exposure in total yield and in yield of marketable potatoes. The potatoes which were kept for three weeks in a dark root cellar and which were carefully planted with the tender sprouts attached gave an average yield of 28.7 bushels more than similar potatoes from which the sprouts had been removed. These results show that seed potatoes from which sprouts have been removed in the spring before planting are considerably weakened for crop production. The results also show that if seed potatoes are allowed to sprout in the spring their value depends principally upon the conditions under which the sprouts are allowed to develop before the time of planting. Tubers which were exposed to the open air were injured considerably by changes in temperature.

When the whole potato is exposed to the light a very few of the eyes start to grow and these are generally situated at or near the seed end. The total resources of the potato are largely devoted to the development of the few sprouts which start first and many of the eyes thus remain in a dormant condition. In the early stages of growth the food material of the young sprouts seems to be drawn from that part of the tuber which is the greatest distance away from the new growth.

Seed potatoes placed in shallow trays and stored for a short period before planting in a room moderately warm, well ventilated and lighted have given excellent results. By this process the sprouts produced will be short, dense, full of color and strong enough to withstand handling at planting time. The young sprouts will develop buds near the potatoes which probably accounts for the increase in productiveness. Sprouted tubers hasten the season of growth producing strong healthy plants which are often likely to escape the worst attacks of blight.

The sprouting method mentioned above is used principally in growing the extra early potato crop.

Planting Sets of Different Sizes With One Eye in Each Set.

This experiment consisted of six separate plots in which potato sets of 1/16, 1/8, 1/4, 1/2, 1 ounce and 2 ounces in weight were planted under similar conditions. No set contained more than one eye. The sets were planted one foot apart in the row. There was thus exactly the same number of sets used in each of the plots. The experiment was conducted in duplicate in each of five years, two varieties being used each season. The potato sets were planted to a depth of about four inches and flat cultivation was used throughout. The following table gives the average of five years' results in testing potato sets of six different sizes:—

Size of Sets Planted	Eyes per Set	Amount of seed used per Acre (bushels)	Average results for 5 years (10 tests)			
			Percentage of crop marketable	Yield per Acre (Bushels)		
				Marketable	Total	Total less Seed used
One-sixteenth oz........	1	1.3	61.0	36.8	47.5	46.2
One-eighth oz..........	1	2.6	88.6	78.8	89.7	87.1
One-quarter oz.........	1	5.2	89.7	98.4	111.1	105.9
One-half oz............	1	10.3	88.7	109.4	129.0	118.7
One oz................	1	20.6	89.5	129.9	148.4	127.8
Two ozs...............	1	41.2	87.6	149.7	173.9	132.7

The results show that the size of set planted has a very marked influence on the yield produced. Under exactly the same conditions there was a variation of from 47.5 to 173.9 bushels of potatoes per acre per annum due to the difference in size of the potato sets planted. It will be noticed that in the yield of marketable potatoes the differences were almost as great as in total yield per acre.

Planting Potato Sets of Equal Size with a Varying Number of Eyes in Each Set.

There is much difference of opinion as to how many eyes each potato set should contain. As the size of the potato set itself has a marked influence on the yield of potatoes it is important to use sets of uniform size if definite results from using a different number of eyes are to be obtained. An experiment was conducted in the experimental plots in which every set was cut to weigh one ounce and in which the number of eyes in the different sets varied from one to five. The experiment was conducted in duplicate each year by using two varieties of potatoes and was continued for five years in succession. The conditions of planting were the same as those given in the preceding experiment. The table below gives the average results for five years' experiments in planting one ounce potato sets containing from one to five eyes each:—

Number of Eyes in ounce sets	Average Results for five years		
	Weight of 30 Largest Potatoes per Plot (pounds)	Percentage of Crop Marketable	Yield of Potatoes per Acre per annum (bushels)
Each Set containing 1 oz. and 1 eye......	9.8	86.2	139.8
" " " 1 " " 2 "	9.2	84.6	151.3
" " " 1 " " 3 "	9.0	82.6	153.9
" " " 1 " " 4 "	8.6	81.2	161.3
" " " 1 " " 5 "	8.5	83.3	165.1

The potato sets of one ounce in weight, which contained one eye each, produced the largest potatoes and the highest percentage of marketable tubers but the lowest yield per acre. With one slight exception as the number of eyes increased from one to five in the potato sets there was a decrease in the size of the largest potatoes, a decrease in the percentage of crop marketable and an increase in the average total yield of potatoes per acre per annum. The results of this experiment show that the number of eyes in potato sets have a distinct bearing on the yield per acre.

Many potato growers are of the opinion that potato sets should be planted with the cut surface downward and the eyes facing upward. In an experiment conducted at the College every set in one plot was placed with the eyes downward and every set in the other plot with the eyes upward. This experiment was conducted in duplicate and the average yields per acre for the two methods were practically identical. It would seem that there is little to be gained from having the eyes in the potato sets pointed in any special direction.

Planting Single Eyes from Different Parts of the Seed Tuber.

In each of five years an experiment was conducted by planting single eyes from different parts of the tubers. As will be seen from preceding experiments the yield of potatoes varies with size of sets planted, great care was therefore taken to have sets planted of exactly the same weight. The experiment, therefore, tests the comparative value of the eyes from different parts of the tuber and is not influenced by the difference in the size of the sets planted. This experiment was conducted with two varieties of potatoes each year. The results are the average of ten separate tests. The cultural methods were similar to those in the two preceding experiments. The following table gives the average results for five years in testing single eyed sets taken from different parts of the tubers:—

Potato Sets of uniform weight, and containing single eyes taken from different parts of the tubers	Average Results for five years		
	Weight of 30 Largest Potatoes per Plot (pounds)	Percentage of Crop Marketable (4 years)	Yield of Potatoes per Acre per annum (bushels)
Middle portion	12.4	85.3	174.8
Stem end	11.5	82.1	167.7
Seed end	11.9	84.2	162.0

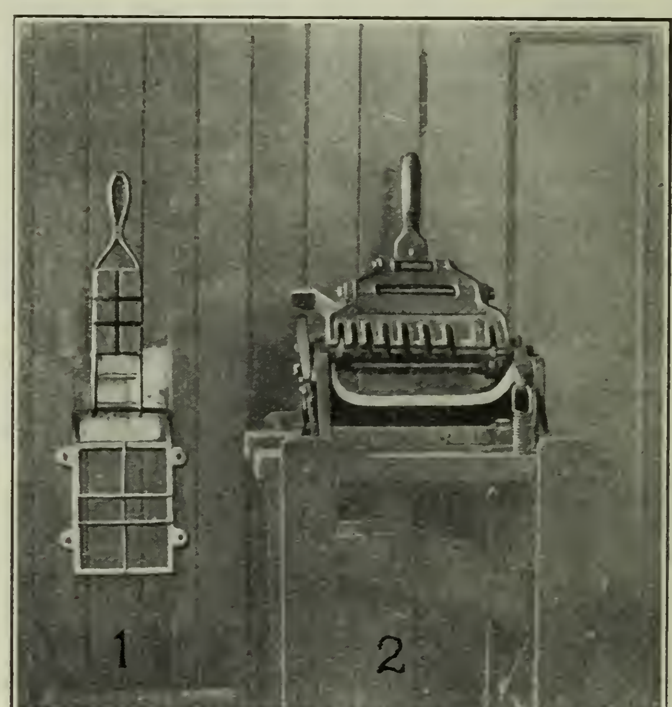
In four out of five years the eyes taken from the central or middle portion of the potatoes produced the highest yields per acre. In the other year the eyes taken from the seed ends of the potatoes were most productive. The sets from the middle portion of the potatoes produced the highest marketable yield per acre, there being a difference of 1.3 bushels per acre over sets taken from the seed end of the potato.

Planting Potato Sets at Different Times After Cutting.

Some potato growers are of the opinion that it is best to cut seed potatoes from three to five days before they are planted. An experiment was conducted at the College for a period of eight years with the object of securing information on this point. Two varieties were used in the experiment each year. Two lots of potatoes each containing the same number and the same weight of tubers were used, one lot of each variety of potatoes was cut from four to five days before planting time and the other lot of each variety was cut and planted on the same day. The cultural methods were uniform throughout and were the same as reported in previous experiments. The table below gives the average of sixteen separate tests conducted for a period of eight years from planting potatoes at different times after cutting:—

Time of Cutting and of Planting Seed Potatoes.	Percentage of Crop Marketable Average 8 years	Yield of Potatoes per Acre (Bushels) Average 8years
Potatoes cut and planted on the same day.	77.4	170.1
Potatoes cut four or five days before planting.	76.3	162.3

In the average results of the experiment conducted for eight years potatoes which were cut and planted on the same day gave a yield of 7.8 bushels per acre per annum more than those which were cut from four to five days



Machines for Cutting Potatoes for Planting.
(1) *Small machine;* (2) *Large machine.*

before they were planted. Not only was the yield per acre greater but the percentage of marketable potatoes produced from the seed tubers which were cut and planted immediately was also higher.

In a co-operative experiment conducted throughout Ontario for a number of years potatoes which were cut and planted immediately gave an increased yield of 16.6 bushels over potatoes which were cut four, five and six days before planting. This co-operative experiment was the average of over three hundred tests conducted on as many farms in Ontario.

Influence of Plaster and Lime Sprinkled on Freshly Cut Seed Potatoes.

In order to obtain information which would be a guide in the treatment of freshly cut seed tubers an experiment was conducted for five years in succession in which freshly cut seed potatoes were sprinkled with plaster or with lime or were left untreated before planting. In order to secure the most accurate data on this subject from four to six separate tests were made each year. In the five year period a total of twenty-two tests in all were made. Finely ground land plaster and slaked lime were used. The planting took place in the latter part of May or the first week of June each year and equal amounts of seed were used in the different plots. The cultural methods were the same as those mentioned in previous experiments. The table below gives the average of the twenty-two tests conducted for five years in treating freshly cut seed in different ways before planting:—

Treatment of Freshly Cut Seed Potatoes	Weight of 30 Largest Potatoes per Plot (pounds) Ave. 5 years	Percentage of Crop Marketable Average 4 years	Yield per Acre (bushels) Average 5 years
Coated with Ground Plaster..........	13.9	81.1	214.4
Coated with Slaked Lime.............	13.6	78.9	200.6
Not Treated........................	12.8	78.8	190.8

The results show that freshly cut seed potatoes which were coated with land plaster gave 23.6 bushels per acre per annum over potatoes left untreated. The seed treated with lime occupied an intermediate position between those treated with land plaster and those left untreated. In four out of the five separate years potatoes treated with land plaster produced the highest total yield per acre and also the highest percentage of marketable potatoes.

In an experiment which was conducted for seven years in succession and in duplicate in which finely ground brick and road dust were used for coating freshly cut seed potatoes in comparison with land plaster, results were as follows:—Untreated, 179.4; Road Dust, 186.0; Ground Brick, 189.5; and Land Plaster, 191.1 bushels per acre.

In a co-operative experiment conducted for a period of five years in which ninety-seven farmers tested freshly cut potato sets coated with land plaster and freshly cut sets untreated the yields were as follows:—Freshly cut sets coated with Land Plaster, 187.7; Untreated Seed, 177.6 bushels per acre.

Depth of Planting.

The depth at which potatoes are planted will depend upon the type of soil, the method of cultivation, climatic conditions likely to prevail during the growth of the plant, and whether the potatoes are grown for early market or as a late or main crop. It is usual to plant early potatoes rather shallow. On heavy cold soils potatoes should not be planted to a greater depth than from three to four inches, while on light loam soils which may be lacking in moisture they are often planted to a depth of five inches. The soil in the experimental plots at the College is an average clay loam. On this type of soil potatoes were planted at depths of 1, 3, 5 and 7 inches in each of seven years. From two to four varieties were used in the experiment each year. Potatoes were planted in the latter half of May or the first week of June depending on the season. Level cultivation was used throughout. The following table gives the average results of tests conducted for seven years in planting potatoes at four different depths:—

Depth of Planting	Depth of new Potatoes below surface (inches) Average 3 years	Yield per Acre (Bushels)	
		Marketable Potatoes Average 5 years	Total Crop Average 7 years
One inch	1.7	177.4	192.4
Three inches	3.0	188.9	202.8
Five inches	4.0	188.6	206.2
Seven inches	4.9	164.1	189.6

It will be seen that the greatest average total yield per acre was obtained by planting potatoes at a depth of five inches. The results, however, varied in different years, the largest yield per acre in one year being obtained where potatoes were planted to a depth of seven inches and another year where the planting depth was one inch. Deep planting gave the highest returns in dry seasons and shallow planting when there were frequent rains. When total yield, yield of marketable and percentage of potatoes sunburned as well as general quality of potatoes were taken into consideration there was little difference from planting potatoes at depths of three to five inches on this type of soil.

Distance Apart of Rows and Potatoes in Rows.

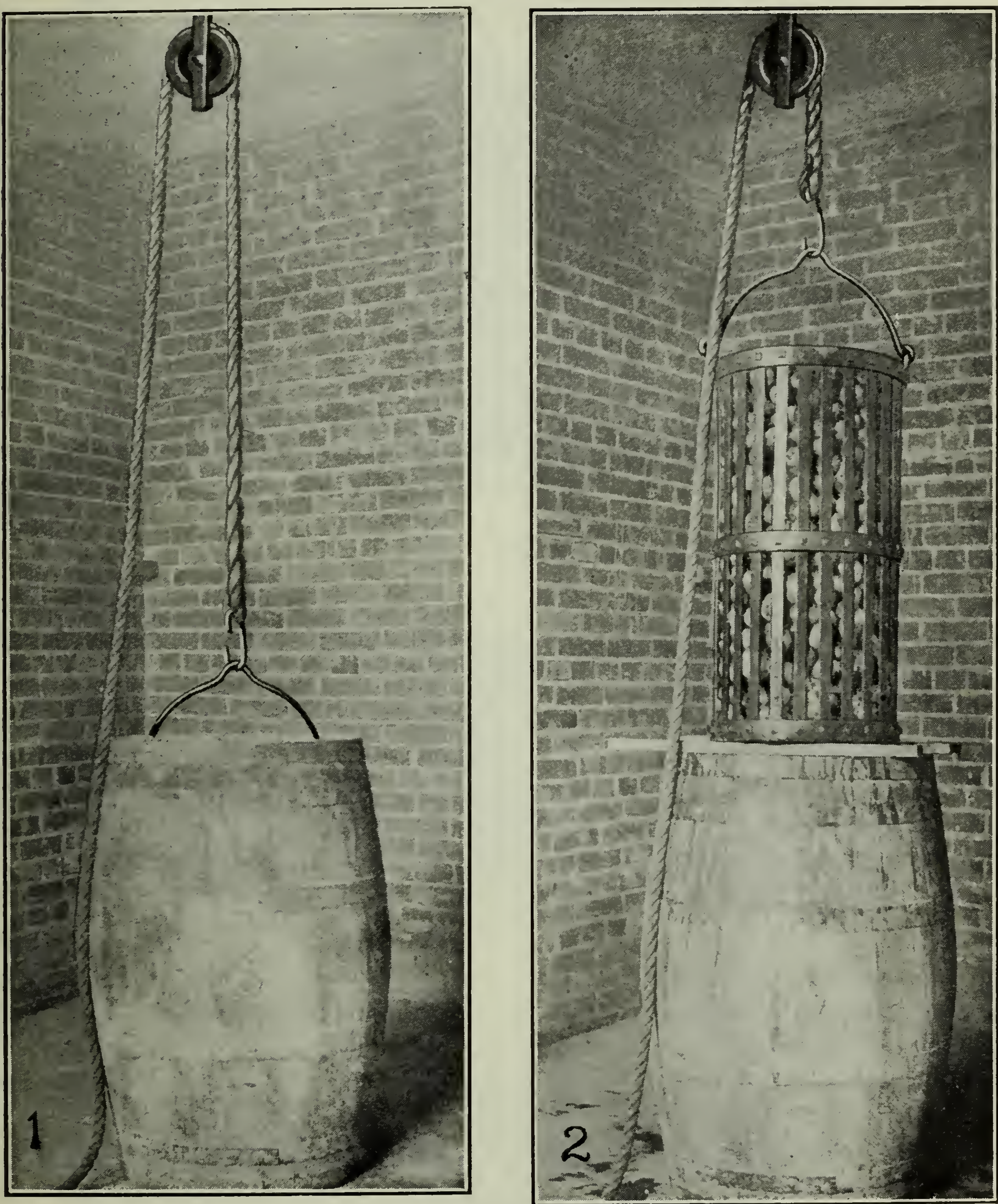
The distance apart of rows and potatoes in the row will depend on the variety grown, the available plant food in the soil, rainfall and soil drainage and the size of potato sets planted. The results of experiments at Guelph and the experience of many successful potato growers indicate that for the most economic production potato rows or drills should be spaced about thirty to thirty-three inches apart and the potato sets dropped at distances of ten to fourteen inches. The Rural New Yorker type of potato produces its tubers directly under the stalks and in a close bunch and it is not necessary to plant the sets of this variety as far apart as those of the Green Mountain whose tubers in growing spread quite widely in the soil. For early market potatoes are often planted at a distance of nine inches in the rows as the crop is usually dug before it is matured.

Rate of Planting.

The amount of seed required to plant an acre depends chiefly on the method of planting and size of set. In the principal potato growing districts of Ontario growers use from fifteen to twenty-five bushels of seed tubers to plant an acre.

Treatment for Potato Scab.

This disease manifests itself in the form of rough, corky, brown spots on the surface of the potatoes. Botanical investigators have shown that the organism of common scab may be conveyed to the soil with farmyard manure as well as



Method of Treating Potatoes for Scab by Immersion in Formalin Solution. (1) *Potatoes being immersed for two hours;* (2) *Potatoes draining after immersion.*

carried on the potato seed tubers and that the organism will live in the land for several years and still have the power of causing the disease. The organism thrives best in soils which are slightly alkali. The amount of scab seems to increase with the quantity of vegetable matter in the soil especially where there are fresh applications of barnyard manure.

The two substances commonly used for the prevention of scab are corrosive sublimate and formalin and both of these are effective in reducing the amount of scab if used in the right proportions.

An experiment was conducted at the Ontario Agricultural College for a period of ten years in treating potatoes for scab. Potatoes in one plot were left untreated and those in another plot were treated with corrosive sublimate (mercuric bichloride), a substance very poisonous to animals and human beings. The corrosive sublimate treatment consisted of dissolving two and one-quarter ounces of this material in two gallons of hot water and after an interval of ten to twelve hours diluting with thirteen gallons of water. The whole potatoes were immersed in this solution for one and one-half hours, then spread out to dry and cut and planted in the usual manner in comparison with others which had been left untreated.

Another experiment was conducted for five years in treating potatoes for scab by the formalin method. This consisted of soaking seed potatoes for two hours in a solution of formalin (40% formaldehyde) made by mixing one pint of the formalin with thirty gallons of water. Both this experiment and the one with corrosive sublimate were conducted in duplicate, two varieties of potatoes being used in each of the separate tests.

No increased yield of potatoes per acre was obtained from using either of these seed disinfectants but the amount of scab in most years was very considerably reduced.

In order to grow the best quality of potatoes as free from scab as possible, the crop should be grown in a definite rotation. Where possible the use of fresh barnyard manure should be avoided and only manure which is free from the scab organism used. The use of fertilizers having an alkaline action such as wood ashes and lime should also be avoided.

The grower should treat seed even though the potatoes seem to be comparatively free of scab. Both the treatments mentioned are comparatively simple and inexpensive. After potatoes have been treated care should be taken that they are not again contaminated with the organism from contact with dirty bags, boxes, baskets, etc. As previously mentioned, corrosive sublimate is a deadly poison and all treated potatoes should be planted, or if not used in this way, destroyed. The use of corrosive sublimate also reduces the amount of rhizoctonia and black leg.

Level vs. Ridged Culture.

Two systems are commonly used in the growing of potatoes in Ontario, level and ridged. The results of experiments conducted for several years at the College and co-operative experiments by farmers over Ontario showed little practical difference in the use of these two methods. In cool, rather wet, seasons results were in favor of hill culture while in hot dry summers results favored level culture.

Cultivation After Planting.

Potatoes after planting should receive thorough cultivation. Only in this way will the soil moisture be conserved, plant food liberated, potato ground kept in a loose friable condition and weeds destroyed.

Spraying Potatoes in different years in the Experimental grounds at the Ontario Agricultural College.

After potatoes have been planted and before they are above ground many weeds which have germinated will be destroyed by using a weeder or a light harrow. This treatment may be continued until plants have reached a height of two to three inches. Soon after the rows can be distinguished the cultivator may be used for the first time. The cultivator should be used throughout the season as often as is necessary to destroy weeds and keep the soil in a loose friable condition. Cultivation is usually continued until the potato tops have almost closed in the rows. Slightly moulding the rows at the last cultivation will tend to cover any potatoes which might be above the surface of the ground and prevent greening.

Spraying Potatoes.

The object in spraying is to protect the foliage from injury caused by the attacks of fungus diseases and insects.

In the two following paragraphs will be found the joint recommendations of J. E. Howitt, Professor of Botany, and L. Caesar, Professor of Entomology, of the Ontario Agricultural College, for spraying for late blight and rot and to control potato beetles.

Commence spraying when the potato beetle eggs are just hatching which will usually be when the potato plants are from five to eight inches high, and keep the foliage covered throughout the season with the Bordeaux, taking special precautions to see that it is well covered during wet weather. Never put off spraying because it looks like rain, for once dry the spray mixture will withstand rain and be on at the critical time.

For the first application use Bordeaux—four pounds copper sulphate, six to eight pounds hydrated lime, and forty gallons of water, with two pounds of arsenate of lime to each forty gallons. Repeat the spraying often enough to keep the foliage well covered. Add the arsenate of lime to the Bordeaux only when required for beetles. No stated number of sprayings of the Bordeaux can be recommended. The number depends on the weather. The wetter the weather the larger the number. If the season is favorable for blight and rot, continue spraying until the plants have finished their growth and died. It is important to use plenty of Bordeaux at each application. Forty gallons may be sufficient to cover an acre when the plants are small, but when the plants are large from eighty to one hundred gallons or more will be required for each acre. It is often found necessary to spray each row twice at each application when the plants are large. It should be borne in mind that spraying only pays when it is thoroughly done.

An insecticide that has proven quite effective in killing potato bugs is one made up of 8 ounces of Paris Green, 1½ pounds of Arsenate of Lead and 40 gallons of water. This treatment, however, is more expensive than using the arsenate of lime treatment. A large number of tests made by the Department of Field Husbandry and by other Departments at the College show that the use of Bordeaux mixture prolongs the life of the potato plants, increases the yield per acre, the percentage of marketable potatoes and lessens the amount of damage from rot.

The Importance of Roguing Potato Fields.

A thorough roguing of the crop will enable the grower to remove and destroy those plants which show signs of such diseases as Rhizoctonia, Black Leg, Fusarium Wilt, Spindling-sprout, Mosaic, Curly Dwarf and Leaf Roll and thus lessen the injury to the growing crop as well as to the future seed crop. The grower at the same time is able to remove the plants of other potato varieties from his field and purify his variety.

Digging.

Potatoes grown for early market are usually dug when the vines are still green, the potatoes at this time being about two-thirds matured. At this stage of maturity the skin of the potato is easily broken and great care is necessary in handling. For this reason early potatoes, especially on small areas, are usually harvested with the potato fork. Late maturing or main crop potatoes are usually harvested ten days to two weeks after the tops are dead. Potatoes possess the best table quality when they are well matured. When potatoes are grown in long rows and on considerable areas they are harvested with the ordinary plow, or the double mould-board plough when special forked attachments are used to free the tubers of dirt and spread them on the surface of the ground. In many of the specialized potato growing districts of Ontario potato diggers are now commonly used. The Elevator potato digger which is operated by two or four horses and has a harvesting capacity of three or four acres or five hundred to twelve hundred bushels per day is a type now in common use.

Sorting and Grading.

The sorting of potatoes for early market usually takes place in the field, tubers of the right size and shape for market or home use being picked immediately after digging. Both early and late maturing potatoes should not be allowed to lie long in the hot sun and if possible should be harvested in dry weather. When the late or main crop consists of several acres it is a good plan to run the potatoes through a potato grader. This machine sorts according to size and may be operated in the field at the time of harvesting or at some convenient place before the potatoes are stored for the winter. During the operation of the potato grader the unsound, misshapen and diseased tubers may be removed by hand. There are several makes of potato graders on the market which do efficient work. The proper grading of potatoes is necessary in putting a uniform product on the market.

Storing.

Bearing in mind that a potato is at all times active physiologically, i.e., a living organism, conditions must be provided which will prevent severe losses in storage. Above all, it should be borne in mind that the tender skin of a freshly harvested tuber is easily scratched or broken, that diggers or implements may cause cuts or bruises, which prove disastrous when such potatoes are placed into unsuitable storage. Moist tubers, especially when cut and bruised, are the first to succumb. Therefore, avoid all bruises, cuts, etc., and, if at all possible, the placing of potatoes into any kind of storage until perfectly dry. The proper temperature at which potatoes should be stored is 35 to 37°F. It is absolutely essential that potatoes while in storage should be kept as dry as possible, and the best method to obtain this result would be to store them in crates, providing means for the free circulation of air among the crates throughout the entire storage period. Bin storage requires less space and is less expensive, but one objectionable feature is that it is very difficult to prevent the tubers from sweating. If, however, bin storage is resorted to, care should be taken to avoid piling the tubers against the wall or directly on the floor, a practice which does not permit of sufficient ventilation, especially where a large quantity is piled. A suitable means of ventilation can be provided by constructing a false wall of slats nailed sufficiently close together to retain the potatoes and about 6 inches distant from the main wall. In addition a temporary floor should be laid down about 6 inches above the other floor, having sufficient space between the boards to ensure free circulation of air under and around the pile. In the case of large piles, ventilators made of wooden slats should be provided at regular intervals, in addition, both vertical and horizontal throughout the pile.

Growing Certified Seed Potatoes.

During the past few years it has been amply demonstrated that Certified seed potatoes can be depended upon to give higher yields of better quality potatoes than potatoes which will not meet certification requirements.

Few field crops are attacked by as many diseases as the potato. Some diseases are recognizable only on or in the tuber; others can be distinguished only in the field while the plants are growing. Disease-free seed potatoes cannot be recognized merely by an examination of the tubers, for apparent soundness is no guarantee of freedom from disease, and notwithstanding good appearance, they may carry diseases which may prove very destructive. For instance, there are a few diseases which more adversely affect the yield than "Leaf Roll" and "Mosaic"; yet neither of these diseases is recognizable in the seed tuber.

The elimination of disease is the first principle in obtaining good seed potatoes. Careful inspection of the individual growing plants at various stages of their growth is essential to detect diseases and lack of vigour; just as essential as is field inspection generally in order to detect poor stands, mixtures, etc.

Meaning of Certification.

Certification is a means of recording seed stock that is of good type, from vigorous plants, and relatively free from serious diseases. When potatoes have been inspected in the field and after harvest by an officer of the Dominion Department of Agriculture, and have been found to be vigorous and to conform to certain standards of freedom from serious diseases and of purity of variety, they may be certified. Official tags are issued for such seed stocks, and all potatoes sold as Certified seed must have the official tag attached to each container of potatoes.

It is an indictable offense under the Destructive Insect and Pest Act to use any other kind of tag likely to mislead an unsuspecting public. Growers and associations are permitted, however, to attach their own tags or brand, or mark any container with any special description, but such must only be done when the official tag is present on the container.

Steps Necessary to Obtain Certification.

Early in spring an application form should be obtained from the Dominion Botanist, Central Experimental Farm, Ottawa, or from the nearest district inspector. This form should be filled in and returned in a stamped envelope to the nearest district inspector. All applications must be made on or before June 15, on which date the lists are closed. No inspection can be guaranteed after this date. Application forms received after June 15 will be returned to the sender with a note advising him that the lists are closed and his application is cancelled, unless exceptional conditions warrant an extension.

Regulations Governing Certification.

1. The seed used in planting the crop for which certification is desired must have been taken from stock which passed both field and tuber inspections the previous year. Seed should be of desirable type for the variety entered, and should be as free as possible from scab and Rhizoctonia, or be treated before planting.

Any variety, however, which is correctly named may be certified after passing all inspections for two years in succession.

2. Potatoes intended for inspection and certification should be planted at least 200 feet from other potatoes. This is to avoid possible infection. Disregard of this ruling has led to the rejection of many fields.

3. No fields which upon first field inspection have more diseases than are permitted in the standard, or show insufficient growth and vigour, will be given a second inspection or further consideration for certification.

4. Fields should be kept well cultivated and sprayed for blight and insects. Weedy, poorly cultivated fields, and those showing many plants stripped by insects, will be disqualified.

5. Seed potatoes must be dug and handled with the greatest care to prevent unnecessary bruising or they will go down in storage. They must be kept from danger of frost injury. Tubers exposed to frost injury will not be certified.

6. First field inspection will commence about six or seven weeks after the average planting date for the district. Second inspection will follow in from two to four weeks.

After field inspections are completed, growers will be notified by card if their fields have passed. The return of the card to the district inspector will ensure their receiving tuber inspection. In the case of a field failing to pass the field inspection the grower is notified of this fact by letter and the crop is not considered further for certification. Tuber inspection will be given at digging time, or as soon after digging as possible, and continue until all who apply for tuber inspection have been visited.

Certified Seed Potatoes—Inspection Standards.

Field.	Inspection 1st %	Inspection 2nd %
Blackleg	3	1
Leaf Roll, Curly Dwarf	2	1
Mosaic	2	1
Wilts	3	2
Foreign	1	½
Misses (if due to roguing)	2	—

Providing that in no case shall a total of more than 6 per cent. disease be allowed on first inspection or more than 3 per cent. on second inspection.

TUBER.

Tags to be issued by inspector only on the express understanding that tubers must conform to the following standard when shipped:

	%
Wet rot (Bacterial)	½
Late blight and dry rot	1
Scabs or rhizoctonia—	
Slight	10
Severe	5
Necrosis, wilts, and internal discolorations other than due to variety	5

Providing that in no case shall a total of more than 7 per cent. be allowed except in the case of slight scab or Rhizoctonia.

Not more than 1 per cent. of powdery scab allowed under scabs.

Not more than 2 per cent. of the tubers to be malformed, or spindly, or badly damaged by sunburn, cuts, cracks, bruises, insects, etc.

No frost injury or foreign tubers shall be allowed.

Not more than 5 per cent. by weight of the tubers shall be below 3 ounces or above 12 ounces.

At fall bin-inspection, if more than 3 per cent. late blight be found in bin, grower will not be allowed to grade for fall shipment, but may hold for spring shipment, subject to re-inspection.

7. Growers should allow at least ten days in storage before attempting to grade.

8. Potatoes must not be sold as Certified Extra No. 1 seed potatoes unless they have the official certification tags attached to the containers. Certification is not complete until that time.

9. Seed stocks improperly stored as indicated by excessive sprouting or shrivelling will be refused certification.

10. Any person found guilty of misusing certification tags will be liable upon conviction to the penalty or penalties imposed or set under The Destructive Insects and Pest Act.

POTATO MARKETING.

Potatoes, like bread, are used in every home. The demand varies slightly because of price fluctuations, but is fairly constant. There is a great variation in acreage and this, coupled with weather, disease, and other factors affecting production, causes violent fluctuations in price.

Under present trade conditions the basic price in Ontario depends upon the size of the North American crop. It is estimated that the 1929 crop in North America, which was about 25% less than the 1928 crop, will yield a farm revenue nearly double that received for the enormous crop of 1928. The 1928 U.S. crop was about 30% higher than that of 1925, but the total value was 59% less.

These violent fluctuations in price are the curse of the potato industry. Farmers received too little for their crop in 1928, because they were paid too much in previous years. This stimulated an increase in planting and with favorable weather conditions, a surplus resulted. This problem was discussed at a National Potato Conference in Chicago in December, 1928, and since that time a National Potato Institute has been organized. The hope is that the industry may be so organized that this price fluctuation may be moderated. Whatever the outcome may be growers would be well advised to guard against extending their acreage because of extremely high prices in any one year. It is a much safer policy to concentrate on increasing the production of quality potatoes per acre and thereby reduce the cost per bushel. The only Ontario farmers who had any chance for a profit in 1928 were those who had a high yield per acre.

The Consumer Chooses.

Potatoes are perishable and heavy but modern storage and transportation facilities permit long distance shipping, and consumers are not confined in their choice to local production. Ontario produced a surplus of potatoes in 1928, but they were imported by the train-load from other provinces. There came into the city of Toronto alone, nearly 700 cars. These were sold at a premium over Ontario stocks, the amount of which equalled the price that some Ontario farmers were offered at shipping points. In modern commerce the consumer is supreme and the producer must give him what he wants, packaged to suit his convenience and delivered as required.

The Ontario potato industry has not followed these principles in a comprehensive organized way. This province has grown good potatoes, but they were not all good and the best lost their identity in the mass. The consumer has sometimes received a mixture of varieties poorly graded sometimes diseased and lacking identification in any systematic way. Little attention has been paid to packages. Eastern stocks were more uniform in variety, type and grade and were put up in clean sacks. The industry in these other provinces was organized to supply a steady volume of dependable quality product.

What can be done about potato marketing in Ontario? This prompts the question "Where does marketing commence"? In the face of present day competition it is futile to attempt to gain the best market with a poor product. Moreover, if yields are low and the cost per bushel or bag is high, no marketing system can assure a profit except in years when prices are abnormally high.

Essentials of Successful Marketing.

To successfully market Ontario potatoes attention should be given to the following points:

1. Production of high quality stock.
4. Brand name.
2. Proper grading.
3. Attractive packages.
5. Steady volume.
6. Advertising.
7. Organization.

To offer a quality product it is necessary that there be uniformity in type. Community selection of a variety is essential. Attention must also be paid to those other cultural practices which have been found effective and which have been detailed in the production section of this bulletin.

Grading is perhaps the most needed reform. Some growers like to sell "Field run". "Everything goes" they say, but is it sold? When small, diseased, cut, bruised or other undesirable potatoes are put in a sack for sale, the farmer is merely paying transportation and other costs on culls to some city garbage can. The Root Vegetables Act administered by the Dominion Department of Agriculture requires that all potatoes in closed packages be sold by Grade. A definition of grades and terms is included at the end of this section.

All packages should be clean, uniform and attractive. If sacks are used they should at least be clean and strong. Many sales of car lots are lost because the cars, when opened, are so detractive, on account of poor socks which are unsightly and often leaky after the usual shunting.

To avoid shifting of bags and to lessen frost injury loaders should follow a plan which will bind the load and allow circulation of air. By courtesy of the Canadian National Railways a diagram is included which illustrates a satisfactory method.

Consumers have become accustomed to buying by Brand. This is advantageous in the marketing of potatoes. Sacks may be stamped with a brand name which will be easily remembered and has an appeal. Branding is useless unless the seller is prepared to offer a product of high quality and is ready to stand behind it. Good potatoes may be identified in this manner and distinguished from the average run of Ontario stocks.

Methods of retailing have so changed in recent years that we have several large firms in Ontario who buy not by the car load, but by car loads per week or month. To trade with organizations of this kind, it is necessary to have a steady and dependable volume in order that contracts may be made for the marketing season.

Publicity is required to educate consumers to the fact that Ontario grows good potatoes and to advise how they may be procured. Then too, potatoes have been receiving too much adverse criticism, particularly by those promoting the sale of other foods. The potato in a balanced diet is not unduly fattening and has health virtues which should be featured.

In order that these essentials may be applied in the successful marketing of Ontario potatoes organization is necessary. The present system requires modification and in some respects re-organization. Co-operative marketing is suggested as a solution particularly in heavy producing areas not adjacent to large consuming centers.

RULES AND REGULATIONS REGARDING THE SALE OF COMMERCIAL POTATOES AS ADMINISTERED BY THE FRUIT BRANCH.

(*a*) Canada, No. 1, shall include only potatoes of similar varietal characteristics, which are reasonably mature, firm and practically free from dirt or other foreign matter, freezing injury, sunburn, abnormal growth, growth cracks, hollow heart, cut, scab, blight rot, soft rot, dry rot or damage caused by disease, insects, or mechanical or other means. In this grade the diameter of the potatoes of the round varieties shall be not less than 1⅞ inches and of potatoes of the long varieties 1¾ inches.

In order to allow for variations incident to commercial grading and handling not more than 5 per cent. by weight of any lot may be below the prescribed size. In addition not more than 5 per cent. by weight may be affected with hollow heart, and not more than 6 per cent. may be below the remaining requirements of this grade; but not more than 1/6 of such 6 per cent., that is, not more than 1 per cent. by weight of the entire lot may have the flesh affected by soft rot.

(*b*) Canada, No. 2, shall include only potatoes of similar varietal characteristics which are reasonably mature, practically free from dirt or other foreign matter, frost injury, soft rot, blight or dry rot and sunburn, and which are free from serious damage caused by abnormal growth, growth cracks, cuts, scab or other disease, insects or mechanical or other means. The diameter of the potatoes of this grade shall be not less than 1½ inches.

In order to allow for variations incident to commercial grading and handling not more than 5 per cent. by weight of any lot may be under the prescribed size and in addition not more than 6 per cent. by weight of any lot may be below the remaining requirements of this grade, but not more than 1/6 of such 6 per cent., that is, not more than 1 per cent. by weight of the entire lot may have the flesh affected by soft rot.

(*c*) Canada, No. 3, shall consist of potatoes which do not conform to any of the foregoing grades, but the minimum diameter shall be not less than 1½ inches.

(*d*) Canada Fancy, shall include only potatoes of one variety which are reasonably mature, firm, bright, well shaped, free from freezing injury, soft rot, dirt or other foreign matter, sunburn, second growth, growth cracks, hollow hearts, cuts, scab, blight rot, dry rot, disease, insects, or mechanical injury and other defects. In this grade the diameter of the potatoes shall be not less than 2¼ inches.

In order to allow for variations incident to commercial grading and handling not more than 5 per cent. by weight of any lot may be below the prescribed size and in addition not more than 6 per cent. by weight of any lot may be below the remaining requirements of the grade; but not more than 1/6 of such 6 per cent., that is, not more than 1 per cent. by weight of the entire lot may have the flesh affected by soft rot.

Definitions of Terms for Grading.

(*a*) "Reasonably mature" means that the outer skin does not loosen or feather readily during the ordinary methods of handling.

(*b*) "Bright" means free from dirt or other foreign matter, damage or discoloration from any cause, so that the outer skin has the attractive color normal for the variety.

(*c*) "Well shaped" means the typical shape for the variety in the district where grown, and free from pointed or excessively elongated and other ill-formed specimens.

(*d*) "Soft rot" means any soft, mushy condition of the tissue from whatever cause.

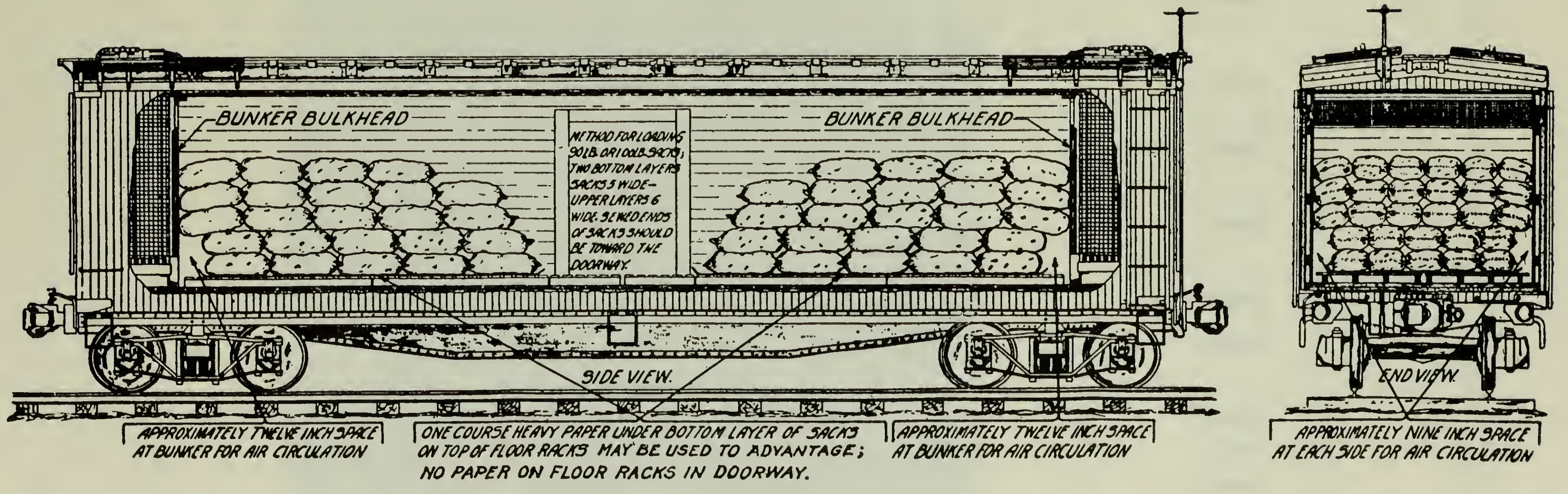
(*e*) "Diameter" means the greatest diameter at right angles to the longitudinal axis.

(*f*) "Practically free" means that the appearance shall not be injured to an extent readily apparent upon examination of the lot and that any damage from the causes mentioned can be removed in the ordinary process of paring without appreciable increase in waste over that which would occur if the potatoes were perfect.

(*g*) "Free from serious damage" means that any damage from the causes mentioned can be removed by the ordinary process of paring without a waste of more than 10 per cent. of the total weight of the potato. Scab shall be considered to cause serious damage when more than 25 per cent. of the surface of the potato in the aggregate is affected.

(*h*) "Abnormal growth" means excessive or second growth or any growth which materially changes the potato from its normal shape.

RECOMMENDED METHOD FOR LOADING SACKED POTATOES
IN REFRIGERATOR CARS



By Courtesy Canadian National Railways

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Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE
GUELPH, ONTARIO

ROSE CULTURE

by

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1. A view of the Experimental Rose Beds at the Ontario Agricultural College.

The outdoor culture of roses in Ontario, in fact, throughout most of Canada, is by no means the difficult task many would have us believe. When we consider that rose bushes do well at such northern points as Fort William and Port Arthur, Sudbury, North Bay and Sault Ste. Marie, as well as in any part of the Province south of these municipalities, we may readily believe that difficulties encountered in outdoor rose growing are products of the imagination rather than of fact! The main difficulty lies, not with the climate nor the plant, but with the individual; and conscientious effort plus common sense will result satisfactorily in the main.

ROSE CLASSES.

For greater clarity the following abbreviated and informal classification is given; detailed charts and descriptions may be found elsewhere in the many publications on this subject.

ROSA RUGOSA.

Rosa rugosa, the Japanese rose, with its many hybrids, is the only commonly grown rose which winters satisfactorily in Ontario without protection, and so is mentioned first. It is conspicuous not only because of its hardiness, but also for its attractive and disease-resistant foliage; its lovely sweet-scented blooms; its vigour; and its shrub-like habit of growth.

HYBRID PERPETUALS.

The Hybrid Perpetuals (mis-named for they are not, as a class, perpetual blooming), are probably second to the rugosas in point of vigour; and are characterized also by attractive dark green foliage, having five or seven leaflets to the leaf; by fine blooms of large size, good colour and exquisite fragrance; and by their lack of bloom after the end of July.

HYBRID TEA AND PERNETIANA.

These two classes, for convenience and because they are given exactly similar cultural treatment, may be considered here as one. They provide attractive and recurrent bloom throughout the entire summer; and are neither as vigorous nor as hardy as the Hybrid Perpetuals. Hybrid Teas are characterized chiefly by fine foliage of a lighter green than the previous class, having—practically invariably—only five leaflets to the leaf; and all the colours in the rose kingdom, save only true yellow, are represented in the blooms of this class. Pernetianas, on the other hand, provide the only true yellow-blooming bush roses of our gardens, and may also be recognized by their very light glossy green leaves, and the numerous short prickles on the stems. This type may produce either five or seven leaflets to the leaf; and the blooms always show some yellow.

DWARF POLYANTHA.

The members of this class are commonly called Baby Ramblers or Pompons, and are chiefly valuable because of the remarkable frequency with which they flower. They form low growing bushes; and, as a class, bear clusters of small brightly coloured blooms. The Polyanthas of more recent introduction bear larger individual flowers than their predecessors, and with equal profusion. This is a class of rose bushes receiving considerably more neglect than it deserves, in Ontario.

CLIMBING ROSES.

This type is divided, ordinarily, into four sections, viz.: Climbers, Ramblers, Pillars and Climbing H.P.'s and H.T.'s.

Climbers include those varieties which naturally attain a height of twelve feet or more, the main growth being upright in character; while Rambler roses, as the name indicates, have a spreading habit of growth and are useful for covering ground. The latter type has been developed mainly from the species R. Wichuraiana (Wich), and resembles it in having minute shiny leaves.

Pillar roses are those which grow upright naturally, but only reach a height of seven to ten feet; and Climbing H. P.'s and H. T.'s are merely vigorous "sports" of varieties of Hybrid Perpetuals and Hybrid Teas already in commerce. That is, they are unusually vigorous bush roses which have acquired the definite habit of developing abnormally tall growths. With proper attention, particularly as regards pruning, these plants may be maintained in the garden as Climbers.

(It is interesting to observe contradictions and palpable misnomers in connection with Climbing roses, for instance: American Pillar is a Climber; Crimson Rambler is a Climber; and Paul's Scarlet Climber is a Pillar! The variety Dorothy Perkins is an excellent example of a true Rambler rose.)

"TREE" ROSES.

Standard and half-standard or, commonly, "tree" roses, are rose varieties grafted at heights of, respectively, six and three feet, to an understock (usually of R. rugosa). They have a certain definite place in the rose garden and deserve more attention than they receive in this Province, and are not too difficult if given proper attention.

Many other types of roses are in commerce but space precludes dealing with any other than the above, all of which are usual types in Ontario.

BUDDED vs. OWN-ROOT ROSES.

Most bush roses planted outdoors in Ontario are budded or grafted; that is, they have been propagated by grafting a leaf-bud from a commercial rose variety to a species or "wild" rose. With all usual rose classes except Japanese roses, Climbers and the very vigorous bush roses, this system is apparently wisest, for it seems that all save the very strongest bushes have difficulty in establishing both root and top growth simultaneously. That is, hard-wood stem cuttings of most bush roses will not develop into satisfactory plants for garden use; and, even if they do develop somewhat, they are less vigorous, smaller and less prolific than budded rose bushes of the same age. To those, then, who would plant rose bushes outdoors we would advise the purchasing of budded, two-year old, field grown bushes.

PLANTING.

WHEN TO PLANT.

The correct time to plant rose bushes in Ontario has long been a controversial matter; we have ardent supporters of both fall and spring planting, with the latter in greater favour.

The following experiment, with its results, will give some idea as to our experience with fall planting:

TABLE No. 1.

FALL PLANTED ROSE BUSHES.

Variety	Number Planted	When Planted	Number Winter Killed	Percentage Living Over First Winter
Frau Karl Druschki	4	Oct. 21/26	4	0
La Tosca	4	Oct. 21/26	3	25
Gruss an Teplitz	4	Oct. 21/26	3	25
Frau Karl Druschki	6	Nov. 5/27	4	33
La Tosca	6	Nov. 5/27	6	0
Gruss an Teplitz	6	Nov. 5/27	3	50
Frau Karl Druschki	6	Oct. 15/28	3	50
La Tosca	6	Oct. 15/28	4	33
Gruss an Teplitz	6	Oct. 15/28	3	50
	48		33	31.25

These bushes were ordered for fall delivery at the discretion of the nurserymen and, when received, were in full leaf. They were pruned in the regular manner, planted well in a good situation, and given adequate winter protection. However, the fact that the plants were in leaf when shipped nullifies the value of the experiment insofar as fall planting of dormant bushes is concerned. It was definitely established, though, that fall planting of immature bushes must be avoided.

Fall planting in 1928, with 44.45% of the bushes set out living over the first winter, resulted comparatively well because the winter weather of 1928-29 was conducive to successful wintering of all tender plants.

2. Rose Bushes heeled in and later covered with soil—held for spring planting after fall delivery.

There is a common belief that, if dormant rose bushes may be planted before the final freeze-up, there is little danger of any high percentage of loss; but, in ordinary years it is extremely difficult for most of us in Ontario to receive dormant bushes in time for such planting. We would prefer to receive the plants in the fall and bury them, placed in a twelve-inch deep trench at an angle of forty-five degrees, in soil in some section of the garden where snow lies, than to try very late fall planting. Until, then, it is established as fact, and not theory, that dormant bushes will do well with fall planting, we would advise rose growers in this Province to plant their rose bushes in the spring, and as early as possible.

The reason we advise fall delivery of rose bushes is simply because we want to have them on hand for planting as soon as the frost is out of the ground. If we can plant them in February (though this is not often possible) so much the better; the later they are planted, the poorer the results will be during the first blooming season. Spring delivery is often delayed, either through the fault of the shipper or the transportation company, and this delay is not only aggravating, but deeply disappointing, to the purchaser.

WHERE TO PLANT.

Possibly the most important consideration in choosing a site for a rose garden, or even for a rose bed, is that the soil must be well drained. While it is quite true that rose bushes appreciate a cool soil, and one that is retentive of moisture, it is equally true that they do not like and will not thrive in soil which will puddle or remain continually wet.

An ideal site is one where the ground slopes to the south; while an ideal soil is a well-drained—naturally, or otherwise,—clay loam soil. If such a site is protected to the north by a windbreak of trees or buildings, success is practically assured.

Rose bushes, however, are not nearly as particular with regard to site and soil as many writers would have us believe. The conditions mentioned above are ideal, but it is not possible for all rose lovers to secure them. A lighter soil—even a sandy soil—if enriched by annual applications of nitrogenous fertilizers, will do very well for Climbing Roses, Hybrid Teas, Dwarf Polyanthas and Pernetianas.

Then, too, many varieties do well in comparatively shady positions, though not as well, naturally, as when more sunlight will reach them. One advantage of a rose bed shaded from sunshine during the hottest part of the day, is that the roses fade less quickly and remain fresh longer; this, on the other hand, is offset by the increase in disease and decrease in number of blooms in shady spots. Ordinarily, a position in full sunshine is desirable, but it is not essential.

PREPARATION OF SOIL.

Rose beds should be dug over thoroughly before any bushes are planted and, for early spring planting, this work should be done the fall previous. If fall planting is the rule, the rose bed should be prepared at least one month prior to planting so that the soil may settle well first.

We do not agree with the rosarians who advise trenching the garden to a depth of three feet prior to setting out the plants; under ordinary Ontario conditions, such preparation is not at all necessary. Bush roses, on the average, do not send their roots down into the soil for a distance greater than twenty inches; and, therefore, deeper trenching is unnecessary. If drainage is not naturally good it must be supplied—either through the use of tile, or by placing rocks, broken bricks and other roughage at this twenty inch depth.

Plentiful supplies of thoroughly decayed manure, and bonemeal, may be mixed with the soil when making the rose bed.

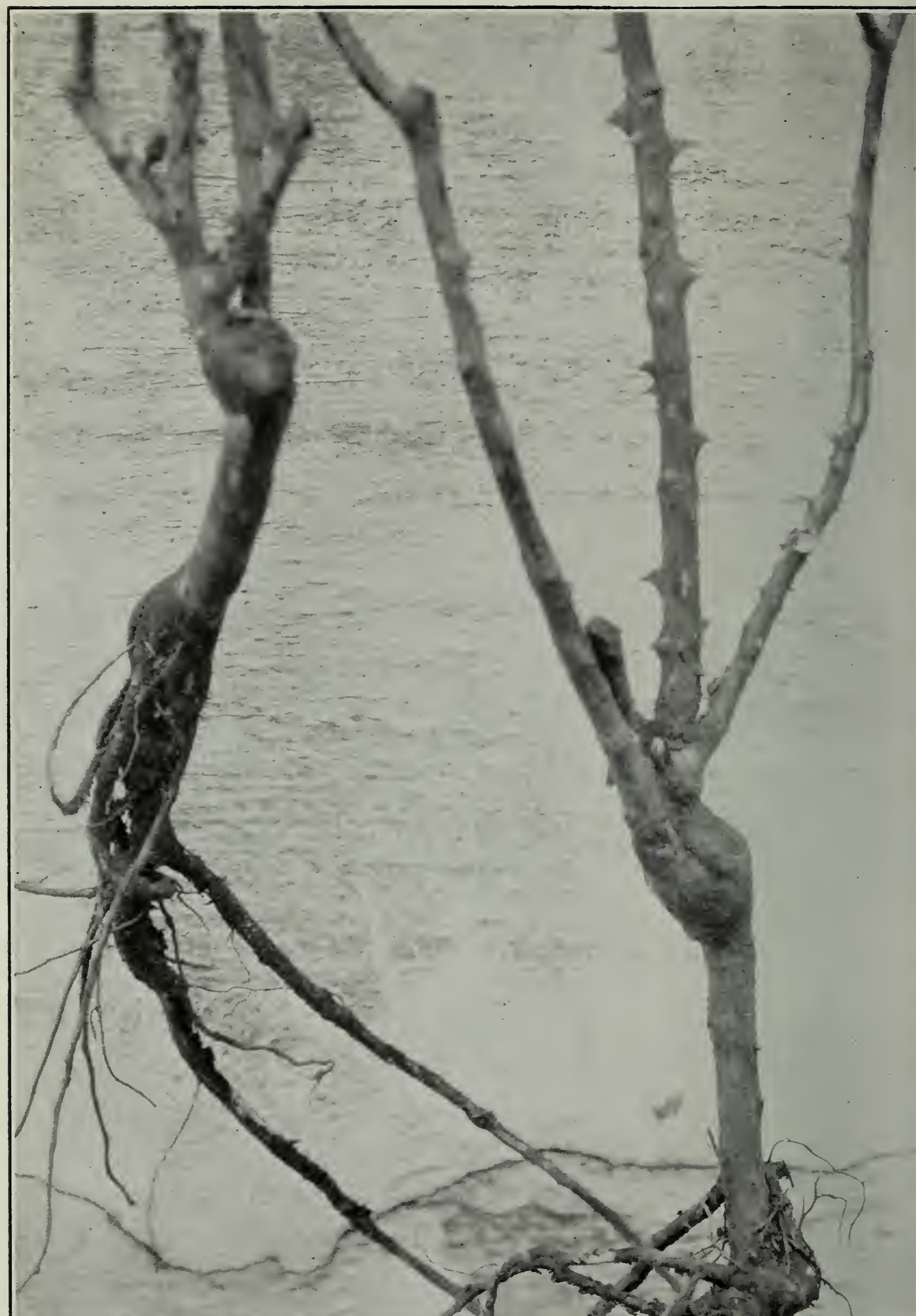
HOW TO PLANT.

Proper planting is the first essential for success in rose growing; we believe that, if rose bushes are planted correctly and given good winter protection, they may be cultivated successfully by any Ontario gardener.

When the bushes arrive from the nursery all wrappings should be removed and, if the plants seem to be withered or dried out they should be placed in a tub of water for at least twelve hours before they are planted.

Care must be taken to protect the roots from sun and drying winds; and at no time should they be left exposed to these elements.

In planting, a hole deep enough to accommodate the root system comfortably should be dug, and the bush must be planted upright. Long tap roots, awkward roots, and about one-third of the top growth should be removed to permit the bush to become established more readily. When the bush is set properly soil should be filled in around it, and pressed firmly with the foot. If the soil is not thoroughly firmed air pockets may be left and, if a root enters an air pocket it will cease to function properly.



3. Typical Rose plants as received from the nursery. The swollen area at the base of the stem denotes that point where the plant was grafted.

The bush should be set deeply enough to permit the point where the plant was grafted (see illustration 3), to be two inches below the soil surface. This must be done to protect that union from adverse climatic conditions for, if the bush is killed out at this point, all flowering wood is lost, and the plant must be replaced.

After the bush is in place and the surface soil around it has been loosened, give it a pail of water and leave it alone.

PLANTING DISTANCES.

The planting distances usually recommended for rose bushes appear to us to be too great; vacant spaces being too prominent, when the plants are set two to five feet apart. As previously mentioned, rose bushes appreciate a cool soil, and closer planting permits the bushes themselves to provide satisfactory root shade for each other. We believe, too, in planting as many bushes as possible in the space available so that maximum pleasure may be derived from the rose bed. It might be said, however, with regard to the planting distances recommended below, that within the various classes there are unusually vigorous varieties which require more room, and these measurements must be considered only as average distances for the different types.

Rosa rugosa (and Hybrid rugosas): Three to four feet.
Hybrid Perpetual: Twenty-four to thirty inches.
Hybrid Tea and Pernetiana: Eighteen to twenty-four inches.
Dwarf Polyantha: Twelve to fifteen inches.
Climbing Roses (all types): Five to six feet.
"Tree" Roses (both types): At least five feet.

CARE DURING FIRST SEASON.

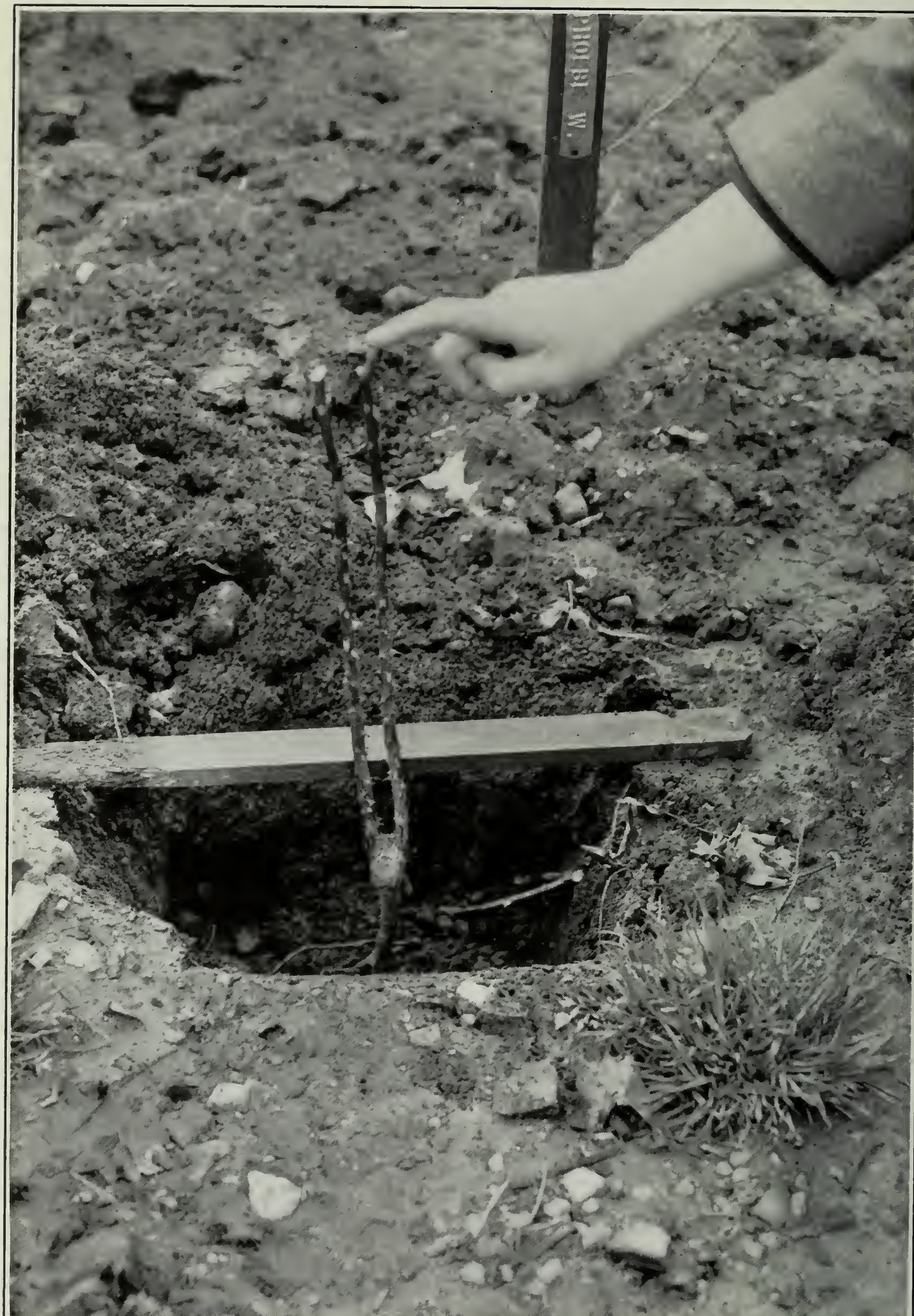
Not only during the first summer, but every year, the rose beds need cultivation; the soil should be stirred up at least once a week, and all weeds must be removed. The precautions for the control of insects and diseases, as recommended elsewhere in this publication, must be observed; as may also the directions for fertilizers as given below.

We must, however, try to induce strong, vigorous growth during the first season so that the bushes may become well established before entering their first winter in our garden. To do this, it is frequently advisable to keep the plants free of bloom; that is, to remove all flower buds which may form, so that all the strength of the plant will be used to develop a good root system and vigorous top growth. If the bushes are apparently growing strongly this precaution is not necessary; and personal opinion must very largely be the controlling factor; we must, however, remember that the prime essential is to have our bushes thoroughly prepared for their first winter with us and to secure this is our chief aim during that first season.

WINTER PROTECTION.

As previously suggested, this problem, coupled with that of planting, forms the most important question in the whole process of successful outdoor rose culture. While we in Ontario do not suffer the very severe winters frequently attributed to Canada by residents of other countries, we do need to exercise particular caution if we expect our rose bushes to winter over year after year.

The rose grower would do well to remember, in the first place, that most rose bushes are not killed by severe cold; but that alternate freezing and thawing in the late winter or early spring does most of the damage. This



4. Planting depth, with "graft" below soil surface. Have hole large enough to accommodate the root system comfortably.

fact is the result of the following reactions. A mild spell may cause the snow to disappear and the frost to leave the ground, and immediately sap starts to flow in the cell tissue of the rose bushes. (Some authorities claim that root action occurs even before the frost action ceases). Then, after two or three days—or more—of mild weather, comes severe frost; the sap ceases to flow, freezes, expands and bursts the cell walls; thus killing the tissue.

It should be remembered, too, that some rose varieties are constitutionally weak, and are not strong enough to winter without extra protection; that some bushes, when purchased, are so weak that the possibility of their living even through the first season is problematical; and that rose bushes are not naturally long-lived. We know, of course, of bushes of the more vigorous types which have done well in one position in an Ontario garden for ten or twelve years, but this is the exception rather than the rule; most rose bushes not living in the garden more than four or five years, on the average.

When all these factors are considered we understand why an annual loss of five per cent., or less, is highly satisfactory to most rose growers.

5. Soil mounded around rose bushes for protection over winter. Note Climber at left of illustration. The boards are used to hold snow where continued heavy snow-fall is not usual.

Many rosarians, of course, frequently bring their rose bushes through the winter without a loss.

We would advise those interested in winter protection of rose bushes to refer to the items, in this Bulletin, dealing with pruning and fertilizers; because, in both instances, certain precautions are advocated which, if practised, will render successful wintering more probable.

It will be remembered, also, that Rosa rugosa and its hybrids need no winter protection in Ontario.

PROTECTION OF BUSH ROSES.

(1) In Districts Where Continued Heavy Snowfall is the Rule.

In northern sections of the Province, where the ground is frozen early in December, and where deep snow may be expected from early winter until spring is actually at hand, it is a comparatively easy matter to carry bush roses through the winter in good condition. The snow in itself supplies an effective form of winter protection, and the absence of alternate freezing and thawing in the spring months is a further aid to success. In districts, then, such as this, the only protective material which needs to be added is soil; which should be mounded around the bases of the bushes to a height of eight or ten inches. Care must be taken not to expose the root system and, if the bushes are planted rather closely, it may be necessary to bring soil or sand from another part of the garden for this purpose. This operation should be performed after several frosts, but before winter actually sets in.

(2) In Districts Where Late Winter Thaws are the Rule.

In the southern sections of the Province, along the lake shores, and in that portion generally known as "Old" Ontario, the process of winter protection is somewhat different, and entails more thought and work.

Mounding of the soil around the bushes, of course, is advisable in these districts; but additional covering to hold what snow may fall, and to keep

6. The Rose Garden, part of which is shown in illustration number 5, covered with snow. Note the mounds over the hilled-up bushes.

the frost in the ground as long as possible, is necessary. This extra material should consist of evergreen boughs, though straw makes a satisfactory substitute. Manure or leaf mould must never be used to cover rose bushes; and we believe that leaves, too, must usually be avoided. The former substances form either a wet smothering blanket or a sheet of ice around the bushes, and do incalculable harm; while the latter may form a dense heavy mass which is not porous and so holds too much moisture around the plants. Litter, or strawy manure, may be placed on the soil, between the bushes, after winter has definitely set in, but is not necessary.

This additional protective material must be removed in good time in the spring, or the bushes will mould and may rot away. It should be taken away when all danger of really sharp, and continued, frosts are passed. Some growers remove this material on bright warm days, replacing it at night; while others uncover the bushes gradually—a little each week—as spring advances; either system is satisfactory.

PROTECTION OF CLIMBING ROSES.

Many growers give their climbing roses, no matter what type, absolutely no winter protection; but we cannot agree with this practice, even if it does seem easier and quite satisfactory. All types of climbers, save only Climbing H.P.'s and H.T.'s, produce considerable, if not all, of their bloom on wood one year old; therefore it is imperative, if maximum bloom is to be obtained yearly, to save all the wood possible; and we know no section of Ontario where climbing roses winter without some loss of wood, if unprotected. In fact, in any section of the Province, we have occasional winters which kill climbers back very severely.

The method used may be the same in any section of the Province, and that is to make bundles of the canes in late fall, and support them

7. A Climbing Rose, showing injury done by mice or rabbits during winter. Girdling by these animals frequently does more harm than weather conditions.

on stakes some six inches to a foot from the ground so that the wood may ripen; after several frosts, but before winter is at hand, lay the bundled canes on the ground and cover them with three or four inches of soil. No further protection is necessary. In the milder districts evergreen boughs, or straw held in place with branches, is just as satisfactory. With the latter system, however, mice sometimes make their winter headquarters under the protective material, and eat the bark of the Climbers during the winter, frequently doing more harm than weather would have done. This trouble may be partially, if not wholly, avoided by delaying in covering the bushes until just before winter sets in; in this case, the mice will probably have already found their new homes and will not bother the rose garden. Poison bait, too, may be used; but this is not satisfactory where there are pet animals.

Occasionally Climbing roses develop unusually vigorous growth which is difficult to cover satisfactorily in the above mentioned manner; though naturally, this is not likely to occur if proper pruning has been the rule. However, any gardener who has such bushes may protect them by wrapping gunny-sacking or canvas around them.

"TREE" ROSES.

This class of rose is not easy to carry over winter intact; but success may be obtained by carefully removing the soil from three sides of the plant, bending it over to the ground on the fourth side, and covering it over entirely with soil. Some growers dig them up and bury them completely in a trench dug for the purpose. They must be lifted and replanted in the spring before the wood becomes mouldy from contact with wet warm soil.

PRUNING.

Pruning probably worries the amateur rose grower more than any other phase of garden activity, yet it is not an unusually difficult problem. Lack of space forbids detailed instructions on this subject, but a few general principles may be dealt with first, after which more specific directions may be given for each rose class.

Pruning is necessary for the health of the bush, and to secure either fine blooms of large size or smaller flowers in greater quantity. Unpruned rose bushes naturally assist themselves by losing, annually, old growths which are replaced by vigorous new shoots, but better results may be obtained by properly assisting them to make these natural changes. The habit of the rose bush is not tree-like, and it will not naturally, no matter how favourable conditions may be, assume any other than a bush or shrub-like habit of growth.

In pruning we remove all dead or diseased wood; open up the centre of the bush to permit a ready access of air and sunlight; determine the future shape of the bush, and induce a more vigorous growth which results in stronger plants.

Sharp instruments should always be used, and all cuts should be clean, leaving no ragged edges or split canes; if the cut is made at a sharp angle the wound will heal more quickly. All cuts, except, of course, when the shoot is removed entirely, should be made just above a bud on the outside of the cane—that is, a bud pointing away from the centre of the bush. This is done to prevent new growth crowding into the centre of the bush and forming a dense growth which makes an admirable breeding ground for insects and diseases.

The severity of the pruning depends largely on the type of bush and the results desired but, in general, we advocate rather severe cutting back. The expression, by an English rosarian, that "after pruning, the rose garden should resemble an uninhabited city," is very apt.

The theory that pruning promotes growth is generally accepted, and is directly responsible for the following principle: The more vigorous the bush, the less it is pruned. To illustrate—Hybrid Perpetuals, as a class, are stronger than Hybrid Teas, and consequently do not require as severe pruning.

In general, too, it is believed that very severe pruning of bush roses will produce stronger growth, with fewer blooms which are of high quality and are suited for the exhibition table; while more moderate pruning will produce more flowers which will be of poorer quality, but of great value in garden decoration. Thus, the result desired may be secured by the rose grower, if pruning is properly done.

ROSA RUGOSA AND ITS HYBRIDS.

Bushes of this class should be pruned in the early spring, and all that is necessary is to thin out dead or diseased wood; in other words, this class seldom requires pruning. These bushes may be cut back severely in spring to secure a gorgeous burst of bloom during the summer months; but such treatment delays the blooming period.

8. A Hybrid Perpetual Rose badly in need of pruning. The centre should be opened up to admit sunlight and air.

9. The Hybrid Perpetual Rose shown in illustration number 8—after pruning.

HYBRID PERPETUALS.

This class is naturally quite vigorous, and, as stated above, does not require particularly severe pruning. All dead wood should be cut out at its base and six to twelve strong shoots, twelve to fifteen inches in length may be left; as well as strong laterals (side-shoots) carrying three to six buds. If roses for exhibition are desired leave four to eight canes eight to ten inches high, with strong laterals carrying only two or three buds. Pruning, with this class, should be done in the spring, shortly after winter protection has been removed.

HYBRID TEAS AND PERNETIANAS.

Spring is also the proper time for pruning these classes, but it is safe to wait two weeks or more, after they are uncovered, before cutting them

10. A Hybrid Tea Rose, just uncovered in spring, and needing pruning.

back. In pruning these types, leave four or five strong shoots eight to ten inches long, with short strong laterals bearing three or four buds; for production of exhibition bloom, only two or three canes four to seven inches long should be left, and laterals may be treated at the grower's discretion.

It must be remembered that great variations in habit of growth occur within these, as well as all other classes of bush roses, and severity of pruning must be guided accordingly. With Hybrid Teas, most varieties producing blooms in quantity do not bear flowers of exhibition calibre and consequently require comparatively light pruning. Most varieties bearing single roses seem to react more favourably also with less severe cutting back.

11. The Hybrid Tea Rose shown in illustration number 10, after pruning.

DWARF POLYANTHAS.

The only pruning necessary with bushes in this class is to remove, in early spring, all dead, diseased and superfluous wood.

CLIMBING ROSES.

The pruning of climbing roses is an entirely different and more puzzling task than it is with the bush types, and, incidentally, variations in the correct methods to be used occur with the various types in this class.

CLIMBERS.

As mentioned previously, Crimson Rambler is a good example of this type and pruning should be done to it (and the other multiflora roses) in August or early September. All wood more than two years old should be cut out, and laterals on two-year-old wood only should be left (these laterals may be cut back the desired distance in the spring). Roses of this type bloom on the strong growing one-year-old canes, and on the laterals of two-year-old wood; so care in pruning must be exercised.

RAMBLERS.

Each season the Ramblers produce strong lengthy canes and it is on this new wood that most of the bloom is produced in the succeeding year. This type, then, should be pruned immediately after the blooming season is over; when all old, weak and unnecessary wood should be removed.

PILLARS.

The only pruning needed by roses of this type is the removal of unnecessary wood in the fall, and a light heading back in the spring; and the same is true of Climbing Hybrid Perpetuals and (Climbing) Hybrid Teas. With the latter severe pruning may result in a reversal of type, and your Climber may become a bush rose.

"TREE" ROSES.

With this class, it is advisable to prune according to the instructions given for bush roses of the same variety, keeping in mind that standards ("Tree" roses) must be well shaped. If this is kept in mind, and pruning is not too severe, results should be satisfactory.

12. Typical appearance of climbing roses (in this case, Crimson Rambler) after pruning. Leave five or six canes of one and two-year-old wood.

SUMMER PRUNING.

To secure recurrent bloom on bush roses, all flowers should be removed —either as cut roses, or when full blown; if the bloom is left the tendency of the plant is to form seed, which is not wanted, and which deprives the grower of further bloom. Cutting roses or spent blooms constitutes a form of pruning and, when doing this in the early part of the season, it is usual to cut far back. This practice is known as summer pruning; and should be done with more discretion than is usually the case.

We know that pruning, no matter what type, promotes new growth; and that the greater the amount of wood removed, the more vigorous the resultant growth will be. Understanding this, we do not condemn cutting roses with long stems, or removing full blown flowers with considerable wood; but we do advise, emphatically, cutting with shorter stems as the season advances. The object of our summer's work is not only to have an attractive garden and to secure plenty of bloom; it is also important that we try to prepare our bushes as thoroughly as possible for inevitable winter. We know that the wood should be ripe, or mature, before winter if best results are desired; and lighter summer pruning as the season advances aids in securing this maturity.

(Another way to hasten the ripening process is to pack the ground firmly, by trampling, around the bushes in late September, and stop cultivating the beds.)

SUCKER GROWTH.

Sucker growth appears only on plants which have been grafted, and comes from the root system; or, in other words, from below that point where the grafting was done. (Technically, from below the union of stock and scion). It is usually rampant growth which utilizes most of the strength of the plant to its own advantage.

Many people do not recognize sucker growth when they see it; while many others cling to their belief in the antiquated and incorrect "seven-leaves" idea; that is, "all growth which carries seven leaves is sucker growth." Such a statement is indeed ridiculous and is not borne out by fact. Many bush and Climbing roses bear seven leaflets to the leaf.

Any grower may definitely decide whether or not sucker growth is present by tracing any branches of which he is suspicious to their point of origin. If they emanate from below the swollen area which denotes the point at which the bush was grafted they are suckers and should be cut away and destroyed; otherwise they may be left.

13. Rosa Canina, (Dog or Briar Rose). Commonly used as an understock by British Nurserymen. Very satisfactory here. (Original).

In order to familiarize ourselves with the general appearance of sucker growths which may appear on rose bushes, the following brief and non-technical descriptions of the more popularly used understocks are given:

R. canina is native to England and is used in Great Britain—and in Canada—more than any other understock. It is characterized by scattered, hooked prickles; bright green wood (save where browned by the sun); and smooth leaves. The pink blooms are single.

R. multiflora is a native of Japan and is used largely as an understock in the Eastern United States, though to a lesser degree in Canada. It has five to seven leaflets to the leaf and bears small, double, fragrant, white blooms. The thorns always appear in pairs and are few in number.

14. Manetti. Used under glass and for Hybrid Perpetuals as an understock. Not recommended; short-lived, suckers freely. (Original).

15. Rosa multiflora. Used largely in Eastern United States, and also as an understock for Climbers of the Multiflora type. Satisfactory. (Original.)

Manetti is not a species rose but, according to Pemberton, was "raised from seed by Signor Manetti of the Botanic Garden, Monza, Italy." The general habit of this understock resembles very closely that of the Hybrid Perpetuals, and must be watched for. The prickles are few, the growth strong; and the light green stems are frequently sun-bronzed.

16. Rosa Odorata. Used mainly under glass as an understock. Too tender to be recommended for outdoor plantings. (Original).

R. rugosa, commonly known as the Japanese rose, bears thick, wrinkled, dark green leaves, and the stems are thickly covered with sharp straight prickles. The large single flowers are fine, while the fruit is smooth, large and red.

17. Rosa rugosa. (Japanese Rose). Commonly used in Northern Europe as an understock for all types of roses. Not recommended as it suckers too freely. (Original).

R. indica odorata, another rose species imported, originally, from China, is used extensively for roses under glass; and to some extent for field-grown rose bushes propagated in nurseries in the United States. It is characterized by five to seven leaflets to the leaf, scattered hooked prickles, solitary light coloured flowers and leaves which are sharply serrated.

FERTILIZERS.

Most of the plant food necessary for proper growth and bloom with rose bushes is supplied naturally, but three elements must be added annually to those present; nitrogen, phosphorus and potash. We prefer to apply nitrogen in the spring and early summer, with applications of phosphorus and potash being supplied in the fall.

Liberal quantities of well decayed manure may be dug in to the rose bed in the early spring; or blood or liquid manure may be supplied generously every ten days to two weeks until flower buds are formed. We must frown upon the usual practice of applying nitrogenous fertilizers throughout the summer months because, simply, nitrogen promotes succulent growth which cannot mature before winter if the applications are continued. A little thought in this matter of nitrogenous fertilizers (coupled with the consideration of summer pruning recommended above), will go far in ensuring satisfactory wintering of rose bushes.

Phosphorus, in the form of bonemeal, and potash, which may be found in wood ashes, may be applied at the rate of two to four ounces of each per plant in early fall. Commercial preparations containing both these elements are offered for sale, and are readily procurable; though we would advise applying them to the rose bed later in the fall, or in spring, because they are more soluble than bonemeal and wood ashes.

18. H. T. Mme. Butterfly. The most popular florists' rose in Canada. Fine in the garden. The form and substance of this rose is splendid, and the variety is worthy of a place in any rose garden. A real improvement of its parent: Ophelia.

ROSE VARIETIES.

Records are taken annually in our gardens of the behaviour of all rose bushes planted, with particular attention being paid to the reactions, not only of the variety, but of each individual bush, to our climatic conditions. Definite and accurate notes are taken every week throughout the growing season on such items as, Vigour, Hardiness, Disease Resistance, and Number of Blooms. From these records the following tables have been compiled, and the results shown may be accepted as correctly descriptive of the behaviour of the different varieties in this district.

Before discussing the various items in the tables separately, we offer the following summary of weather conditions during the three years the bushes were under test. These weather records date from November 1st, 1926, to October 31st, 1929.

TABLE No. II.

WEATHER RECORDS, O.A.C., GUELPH, ONT.

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
						MONTHLY PRECIPITATION							
1926	......	......	......	......	......	......	......	......	......	......	3.97″	1.88″	......
1927	2.00″	1.50″	2.72″	1.81″	4.54″	2.92″	8.81″	1.13″	1.53″	2.58″	4.32	3.19	37.05″
1928	2.13	1.17	2.72	2.48	1.88	4.57	4.53	3.13	3.40	3.45	3.65	1.14	34.25
1929	4.58	1.0	3.08	5.29	3.72	1.22	3.68	1.14	.83	2.84	......	......	......
						MEAN MONTHLY TEMPERATURES							
1926	......	......	......	......	......	......	......	......	......	......	34.1°	19.9°	......
1927	17.6°	23.4°	34.1°	42.4°	51.0°	59.2°	65.5°	62.2°	61.9°	51.7°	39.55	25.7	44.52°
1928	21.0	21.3	26.94	40.5	52.8	59.7	67.15	68.16	56.1	49.3	37.8	28.3	44.09
1929	19.6	17.0	35.05	43.8	50.3	61.4	66.8	62.55	60.4	45.5	......	......	......
						MAXIMUM TEMPERATURE FOR EACH MONTH, WITH DATE							
1926	......	......	......	......	......	......	......	......	......	......	63° (on 15th)	42° (on 13th)	......
1927	40° (on 30th)	43° (on 24th)	61° (on 17th)	77° (on 19th)	81° (on 23rd)	90° (on 30th)	90° (on 1st)	83° (on 8th)	86° (on 15th)	78° (on 3rd)	71 (on 1st)	54 (on 13th)	......
1928	41 (on 19th)	41 (on 8th)	67 (on 25th)	71 (on 7th)	82 (on 4th)	81 (on 13th)	88 (on 9th)	88 (on 15th)	84 (on 10th)	80 (on 11th)	64 (on 15th)	46 (on 13th)	......
1929	43 (on 6th)	44 (on 26th)	64 (on 24th)	77 (on 7th)	87 (on 30th)	87 (on 18th)	91 (on 28th)	87 (on 26th)	91 (on 3rd)	71 (on 20th)	......	......	......
						MINIMUM TEMPERATURE FOR EACH MONTH, WITH DATE							
1926	......	......	......	......	......	......	......	......	......	......	14° (on 28th)	−8° (on 7th)	......
1927	−16° (on 27th)	−1° (on 22nd)	7° (on 1st)	22° (on 8th)	32° (on 28th)	35° (on 6th)	39° (on 4th)	39° (on 25th)	30° (on 24th)	28° (on 15th)	16 (on 19th)	−3 (on 24th)	......
1928	−20 (on 30th)	−6 (on 25th)	−2 (on 10th)	18 (on 16th)	26 (on 13th)	33 (on 3rd)	45 (on 29th)	47 (on 31st)	31 (on 26th)	15 (on 30th)	14 (on 26th)	2 (on 22nd)	......
1929	−7 (on 14th)	−22 (on 20th)	3 (on 9th)	18 (on 2nd)	28 (on 10th)	32 (on 6th)	40 (on 20th)	40 (on 30th)	29 (on 20th)	21 (on 18th)	......	......	......
						NORMAL MONTHLY PRECIPITATION, FOR 41 YEARS							
	2.08″	1.68″	1.82″	2.19″	2.76″	2.96″	3.32″	2.83″	2.59″	2.38″	2.39″	1.898″	28.898″
						NORMAL MONTHLY PRECIPITATION, FOR 41 YEARS							
	19.27°	19.01°	27.91°	41.76°	53.05°	63.0°	67.92°	66.14°	59.19°	47.51°	35.94°	24.46°	43.76°

It may be seen from this table that during each of the three winters heavy frosts succeeded mild weather during the months of January and February; and it is weather conditions such as these which result in so called "winter" killing.

It is noticeable, also, that the precipitation during the summer months of 1927 and 1928 was unusually heavy, so that the complaints regarding mildew and black spot may be laid, very largely, at the door of the weatherman—rather than on the varieties cultivated. Similarly, too, the very dry conditions of the summer of 1929 were conducive to insect attacks (very notable in the case of the green aphis) and to a reduction in the severity of the damage caused by fungus diseases.

In wet weather satisfactory methods may be adopted to combat disease; while in dry weather insects may be controlled; but, if little or nothing is done to offset these attacks, much more damage will be caused by disease in wet seasons and by insects in dry summers.

With direct reference to our system of records we might say that, soon after the bushes are uncovered in spring, a note is made as to the condition of each bush in the garden. Thus we determine the hardiness of the varieties concerned.

When the bushes start to bloom, a record is kept of all the blooms borne on each bush; these records are taken every week during the summer season. Also during this weekly observation trip, notes are taken with regard to diseases; ten points is perfect—that is, disease free—and the bushes are looked over closely for evidence of disease. If the bush is apparently only slightly bothered, it is scored as 10% affected; if half of it seems to be diseased, it is 50% affected; and these percentages, because the plants are gone over every week, may be lowered or raised as the season advances and results warrant such alterations.

Colour descriptions and a record of fragrance are taken with each variety new to our plantation; and a note on the general health and vigour of each bush is taken at the end of the season. With regard to fragrance we might say that the symbol XXX means unusual fragrance, while XX means that fragrance is pronounced.

TABLE No. III.

HYBRID TEAS: RESULTS OF THREE-YEAR TESTS.

VARIETY	Number Tested	Number Winter Killed	Number Died Out	% Black Spot	% Mildew	Blooms per Plant per Season	Fragrance	Principal Colour Effect
Admiral Ward	4	0	1	16	0	25	XX	Crimson
Admiration	9	4	2	10	0	12	X	Cream-shaded orange
America	10	7	1	15	0	5	X	Light-pink
Angele Pernet	6	2	2	23	0	4	....	Orange
Annie Laurie	3	1	1	20	0	11	X	White, flushed pink
Arthur R. Goodwin	3	2	1	10	10	6	XX	Orange, flushed pink
Aspirant Marcel Rouyer	10	2	8	37	0	3	X	Salmon-apricot
Augustus Hartmann	6	2	0	17	0	23	X	Red
Avoca	6	0	0	10	10	16	X	Crimson
Barbara Robinson	2	0	1	10	0	13	X	Deep cream
Beauté de Lyon	3	0	3	68	0	7	X	Orange
Belle Cuivrée	2	1	1	60	0	11	X	Coppery orange
Bertha Turner	2	1	1	35	0	7	....	Shell pink
Bessie Chaplin	3	2	1	43	0	8	X	Rose pink
Betty Hulton	4	1	2	20	0	18	XX	Creamy yellow
Betty Uprichard	16	7	0	14	0	29	X	Pink

TABLE No. III.—(Continued).

HYBRID TEAS: RESULTS OF THREE-YEAR TESTS.

VARIETY	Number Tested	Number Winter Killed	Number Died Out	% Black Spot	% Mildew	Blooms per Plant per Season	Fragrance	Principal Colour Effect
British Queen	7	0	0	7	2	30	X	White
Capt. F. S. Harvey Cant	3	1	0	13	0	14	X	Palest pink
Captain Kilbee-Stuart	4	1	2	47	0	8	....	Crimson
Chas. K. Douglas	6	2	0	13	0	23	....	Scarlet
Christine	5	2	1	10	0	15	....	Bright yellow
Christine Prior	5	1	1	40	0	15	X	Delicate pink
Clarice Goodacre	5	2	2	12	0	6	X	Cream
Colleen	7	5	2	20	0	4	X	Light pink
Colonel Oswald Fitzgerald	3	0	2	17	0	20	X	Scarlet
Columbia	3	1	0	38	0	15	X	Pink
Countess of Elgin	2	0	1	28	0	13	....	Satiny rose
Courage	10	2	3	33	0	16	X	Scarlet
Courtney Page	3	0	0	7	18	15	X	Crimson
Covent Garden	3	1	0	33	0	10	X	Crimson
Crimson Chatenay	3	0	2	20	0	13	X	Crimson
Crimson Emblem	7	1	1	8	0	33	....	Deep crimson
David Gilmore	3	0	0	8	0	24	....	Bright pink
Dean Hole	2	0	0	9	0	29	XX	Carmine
Diadem	8	3	2	22	0	11	....	Light pink with orange tinge
Dorothy Page Roberts	4	0	0	7	0	8	X	Salmon pink
Duchess of Wellington	4	1	2	23	0	12	X	Orange
Dwarf Bedding Tea	2	0	1	18	0	26	....	Light pink
Edel	6	3	0	20	0	16	X	White
Edith Cavell	3	1	0	24	0	21	X	White
Edward Bohane	6	0	3	17	2	13	X	Rose pink
Eldorado	3	0	3	66	0	8	XX	Golden yellow
Elsie Beckwith	2	1	0	20	0	19	X	Rose pink
Elvira Aramayo	3	0	1	30	0	17	....	Reddish copper
Empire Queen	2	0	0	13	0	16	....	Bright rosy pink
Etoile de Hollande	7	2	0	7	0	15	X	Crimson scarlet
Evelyn Murland	3	0	1	31	0	19	X	Crimson
E. Ward	3	2	0	18	0	22	X	Carmine
Feu Joseph Looymans	11	4	4	21	0	12	X	Light yellow
Florence H. Veitch	3	0	0	10	0	27	XX	Scarlet
Florence L. Izzard	13	8	5	....	0	5	X	Yellow
Frank W. Dunlop	4	1	0	9	0	11	X	Deep rose pink
Fred. J. Harrison	3	0	0	10	3	24	X	Carmine
Frieberg 2nd	4	0	3	33	0	9	....	Bright pink
Geisha	3	1	1	74	1	9	X	Pink
General MacArthur	10	0	3	9	0	19	X	Red
General Superior Arnold Janssen	4	0	1	8	0	17	....	Deep rose pink
George C. Waud	2	0	0	7	0	17	....	Red
George Dickson	4	0	0	2	7	24	XX	Scarlet
Gladys Holland	8	0	7	29	0	9	X	Salmon pink
Glory of Steinfurth	7	1	0	6	0	18	X	Bright pink
Gooiland	2	0	0	2	0	13	....	Satiny rose
Gorgeous	4	2	0	19	0	15	....	Coppery pink
Gruss an Teplitz	3	0	0	13	0	71	XX	Scarlet
Gwyneth Jones	4	1	2	10	0	14	....	Coppery orange
Hadley	6	0	2	18	0	16	X	Crimson red
Hawlmark Crimson	5	1	0	7	7	33	X	Crimson scarlet
Hawlmark Scarlet	3	0	2	32	6	17	XX	Crimson scarlet
H. E. Richardson	2	0	0	12	0	13	XX	Brilliant crimson
Hoosier Beauty	9	3	2	23	0	10	XX	Velvety carmine
Imperial Potentate	2	1	1	10	0	11	X	Bright rose
Independence Day	4	2	2	10	0	4	....	Orange pink
Innocence	3	1	1	36	0	9	X	White
Irish Elegance	2	0	0	9	0	38	X	Orange bud, pink bloom
Ivy May	2	0	1	12	0	14	X	Creamy salmon pink
I. Zingari	4	0	3	17	0	13	....	Coppery rose
J. B. Clark	8	1	0	9	9	13	X	Brightest rose pink

TABLE No. III.—(Continued).

HYBRID TEAS: RESULTS OF THREE-YEAR TESTS.

VARIETY	Number Tested	Number Winter Killed	Number Died Out	% Black Spot	% Mildew	Blooms per Plant per Season	Fragrance	Principal Colour Effect
Jean C. N. Forestier	4	0	0	13	0	12	XX	Light pink
J. G. Glassford	6	0	1	19	7	11	XX	Scarlet
John Henry	2	0	1	10	0	17	....	Pink
Juliet	2	0	0	30	0	15	X	Rose pink and gold
K. of K.	6	3	1	11	0	20	X	Red
Lady Alice Stanley	4	1	1	5	0	17	XX	Pink
Lady Ashtown	5	1	0	14	0	18	X	Pink
Lady Florence Stronge	2	1	0	25	0	9	X	Salmon pink
Lady Hillingdon	5	1	2	12	0	8	....	Creamy white to yellowish
Lady Inchiquin	10	3	4	11	0	16	....	Orange-cerise
Lady Martha Bruce	2	0	0	27	0	8	X	Pink
Lady Maureen Stewart	5	0	2	10	0	16	X	Scarlet
Lady Pirrie	8	2	1	16	0	28	X	Coppery salmon
Lady Roundway	7	5	1	17	0	8	....	Apricot
Lamia	2	0	0	7	3	25	XX	Pink to apricot
La Tosca	3	1	1	12	0	19	X	Pale pink
Laurent Carle	5	0	2	12	0	20	XX	Red
Leader	2	1	0	23	0	14	XX	Deep pink
Liberty	3	1	0	5	7	18	X	Crimson
Lord Allenby	3	0	3	28	0	16	....	Crimson
Lord Charlemont	4	1	2	36	0	6	....	Crimson
Lord Lambourne	4	1	1	20	0	15	X	Pale yellow
Los Angeles	8	2	4	27	0	4	XX	Salmon pink
Louise Joly	2	0	0	15	0	25	X	Pale pink
Mabel Morse	10	3	2	12	0	4	....	Yellow
Marcia Stanhope	4	0	0	19	0	10	X	White
Maria Reid	2	0	2	30	0	8	....	Fine deep pink
Martha Drew	5	2	2	10	0	12	....	Orange cream
Maud Cuming	6	1	3	12	0	12	XX	Light pink
Miss Beckwith	3	0	2	43	0	13	X	Pink
Miss C. E. van Rossem	4	0	2	16	0	20	....	Scarlet
Miss Connor	2	2	0	60	0	9	X	Creamy yellow
Miss Cynthia Forde	3	1	2	40	0	12	X	Pale pink
Miss Willmott	9	6	1	17	0	13	X	White
Mme. Butterfly	8	3	0	23	0	13	XX	Light pink
Mme. Caroline Testout	3	0	1	7	0	10	X	Rose
Mme. Edouard Herriot	10	3	0	27	0	16	X	Orange-red to salmon pink
Mme. Emile Van der Goes	3	1	0	17	0	14	X	Delicate pink
Mme. Jules Bouché	5	3	0	12	0	8	X	White
Mme. Leon Pain	6	2	0	10	0	16	XX	Silvery pink
Mme. P. Dothier	2	0	0	15	0	22	X	Creamy pink
Mme. Ravary	6	1	0	11	0	23	X	Deep cream
Molly Bligh	3	0	2	34	0	29	XX	Deep shell pink
Mrs. A. W. Fisher	3	0	1	10	0	14	X	Delicate pink
Mrs. Courtney Page	10	2	5	31	0	6	X	Bright pink flushed orange
Mrs. David McKee	3	2	1	27	0	15	X	Creamy white
Mrs. G. Beckwith	3	0	2	32	0	10	X	Creamy yellow
Mrs. Geo. Marriott	2	0	1	40	0	4	....	Cream flushed rose
Mrs. Geo. Shawyer	2	1	0	10	0	7	X	Rose pink
Mrs. Henry Bowles	4	3	1	40	0	18	X	Silvery pink
Mrs. Henry Morse	11	1	3	21	0	14	X	Pink
Mrs. Henry Winnett	4	1	3	17	0	7	....	Satiny rose
Mrs. H. R. Darlington	4	0	2	34	0	9	....	Cream
Mrs. James Shearer	2	0	2	10	0	3	....	Cream, centre apricot
Mrs. J. H. Welsh	9	3	0	28	4	9	X	Creamy white
Mrs. J. Williamson	3	1	1	30	2	9	X	Cream flushed pink
Mrs. R. B. MacLennan	2	0	1	18	0	23	....	Creamy pink
Mrs. R. B. Moloney	2	0	0	15	0	9	X	Deep pink
Mrs. R. D. McLure	3	0	2	37	0	17	X	Shell pink
Mrs. W. Christie-Miller	5	3	0	19	0	14	X	Light pink

TABLE No. III.—(Continued).

HYBRID TEAS: RESULTS OF THREE-YEAR TESTS.

VARIETY	Number Tested	Number Winter Killed	Number Died Out	% Black Spot	% Mildew	Blooms per Plant per Season	Fragrance	Principal Colour Effect
Mrs. Wemyss Quin	7	1	0	11	0	9	....	Light yellow
Mrs. W. J. Grant	3	0	0	9	3	21	X	Deep rose pink
Noblesse	4	1	1	11	0	27	X	Palest pink
Ophelia	4	1	3	21	0	21	XX	Pale pink
Padre	2	0	0	9	0	17	X	Bright orange rose
Pharisaer	2	0	2	40	0	13	X	Light pink
Phoebe	3	1	1	15	0	8	X	Deepest cream
Premier	4	2	1	8	0	8	XX	Delicate rose pink
President Cherioux	5	4	1	16	0	9	....	Salmon pink
Pride of Waltham	4	0	0	8	7	23	..	Pink
Prince de Bulgarie	2	1	0	5	0	12	X	Silvery pink
Prince of Wales	3	1	1	25	0	14	XX	Rose pink
Prince Yugula	3	0	2	20	0	17	X	Darkest crimson
Red Letter Day	6	3	0	12	0	30	....	Red
Red Premier	2	1	0	7	0	11	X	Deep rose pink

19. H. T. Dainty Bess. The largest and finest single rose introduced to date. The blooms are pale pink and frequently are 3½ or 4 inches in diameter. Vigorous plants to a height of three feet or more. A rose of high decorative value.

TABLE No. III.—(Continued).

HYBRID TEAS: RESULTS OF THREE-YEAR TESTS.

VARIETY	Number Tested	Number Winter Killed	Number Died Out	% Black Spot	% Mildew	Blooms per Plant per Season	Fragrance	Principal Colour Effect
Rev. F. Page-Roberts	4	0	1	15	0	4	X	Yellow and apricot
Rheims	2	1	0	25	0	8	....	Pink and apricot
Richmond	13	1	3	9	5	9	XX	Scarlet
Salmon Spray	2	0	0	13	0	80	X	Salmon pink
Saltaire	4	0	2	17	0	10	X	Rose
Scarlet Glory	2	0	0	16	2	11	X	Scarlet
Sensation	6	0	0	23	0	10	XX	Dark crimson
Simone de Chevigne	3	0	1	17	2	8	X	Shell pink
Souvenir de Claudius Pernet	11	4	1	16	0	12	X	Yellow
Souvenir de Geo. Pernet	8	0	4	8	0	12	....	Salmon pink
Sunstar	5	0	2	25	0	11	....	Apricot, pink and yellow

20. H.T. Mary Merryweather. A new semi-double rose of real beauty. The blooms are bright yellow and are usually borne in clusters. Good foliage.

TABLE No. III.—(Continued).

HYBRID TEAS: RESULTS OF THREE-YEAR TESTS.

VARIETY	Number Tested	Number Winter Killed	Number Died Out	% Black Spot	% Mildew	Blooms per Plant per Season	Fragrance	Principal Colour Effect
Superb	5	0	0	15	3	25	X	Shell pink
The Queen Alexandra Rose	5	3	1	28	0	6	X	Crimson and orange
Una Wallace	8	2	0	22	1	17	X	Deep pink
Walter C. Clarke	2	0	0	2	2	12	X	Red
Waltham Crimson	3	0	0	12	2	35	X	Deep crimson
Waltham Cross	3	0	0	10	0	19	X	Red
White Ensign	7	1	3	12	0	8	X	White
Wilhelm Kordes	6	2	0	32	0	9	XX	Salmon and pink
Willowmere	10	2	0	11	0	19	X	Pink

A summary of Table III. offers the following results:

FIRST—VARIETIES SATISFACTORY FOR GARDEN USE.

Admiral Ward
Augustus Hartmann
Betty Uprichard
British Queen
Charles K. Douglas
Crimson Emblem
David Gilmore
Dean Hole
Duchess of Wellington
Florence H. Veitch
Fred J. Harrison
General MacArthur
George Dickson
Gruss an Teplitz
Hawlmark Crimson
Irish Elegance
Lady Pirrie
Lamia
Louise Joly
Mme. Ravary
Molly Bligh
Mrs. R. B. MacLennan
Noblesse
Ophelia
Pride of Waltham
Red Letter Day
Salmon Spray
Superb
Waltham Crimson
Willowmere

SECOND—VARIETIES SATISFACTORY FOR HARDINESS.

Admiral Ward
Avoca
British Queen
Courtney Page
David Gilmore
Dorothy Page Roberts
Florence H. Veitch
Frank W. Dunlop
Fred J. Harrison
General MacArthur
General Superior Arnold Janssen
George Dickson
Glory of Steinfurth
Gruss an Teplitz
Hawlmark Crimson
J. B. Clark
Jean C. N. Forestier
J. G. Glassford
Lady Ashtown
Marcia Stanhope
Mme. Ravary
Mrs. Henry Morse
Mrs. Wemyss Quin
Mrs. W. J. Grant
Sensation
Superb
Una Wallace
Waltham Crimson
Waltham Cross
Willowmere

THIRD—VARIETIES SATISFACTORY FOR CUTTING.

Admiration
Barbara Robinson
Betty Uprichard
Capt. F. S. Harvey Cant
Dean Hole
Diadem
Feu Joseph Looymans
Frank W. Dunlop
General MacArthur
General Superior Arnold Janssen
George Dickson
Lady Alice Stanley
Lady Ashtown
Lady Inchiquin
La Tosca
Laurent Carle
Miss Willmott
Mme. Butterfly
Mme. Caroline Testout
Mme. Edouard Herriot
Mme. Jules Bouché
Mme. Leon Pain
Mrs. Henry Morse
Mrs. Wemyss Quin
Mrs. W. J. Grant
Ophelia
Phoebe
Premier
Rev. F. Page Roberts
Sensation
Souvenir de Claudius Pernet
Souvenir de Georges Pernet
Superb
Una Wallace
Wilhelm Kordes
Willowmere

TABLE No. IV.

HYBRID TEAS: RESULTS OF TWO-YEAR TESTS.

VARIETY	Number Tested	Number Winter Killed	Number Died Out	% Black Spot	% Mildew	Blooms per Plant per Season	Fragrance	Principal Colour Effect
Arthur Cook	5	0	2	35	0	11	XX	Crimson
Betty	5	0	1	8	0	12	....	Pink
Billy Boy	3	0	0	21	0	31	....	Pale yellow
Briarcliff	3	1	0	30	0	4	XX	Rose pink
Chas. P. Kilham	3	0	1	5	0	11	....	Orange-red
Cheerful	3	0	3	27	0	12	....	Pink
Clovelly	3	0	2	5	0	4	X	Rosy salmon
Cuba	7	0	2	8	0	9	X	Scarlet and orange
Dainty Bess	6	0	0	13	0	34	....	Pink
Dame Edith Helen	5	0	4	47	0	6	....	Pink
Desmond Johnston	3	0	0	10	0	18	X	Scarlet
Doris Trayler	4	0	2	20	0	11	....	Orange
Emily Dodd	3	0	0	10	0	18	X	White
Eva Eakins	3	0	0	8	0	10	X	Crimson flushed yellow
Fascination	3	0	0	29	0	10	X	Deep pink
Florex	2	0	0	22	0	3	X	Pink
F. M. Vokes	6	0	2	4	0	17	....	White
Fontanelle	3	0	3	87	0	2	....	Pale yellow
George H. Mackereth	4	1	1	12	0	11	XX	Crimson
Golden Emblem	4	2	1	7	0	5	X	Yellow
Golden Ophelia	4	1	3	5	0	7	X	Yellow
Gooiland Beauty	3	0	0	15	0	20	X	Salmon yellow
H. C. Valeton	2	0	1	5	0	5	XX	Yellow
Herman Neuhoff	2	0	0	7	0	10	....	Rosy pink
Hon. Charlotte Knollys	3	0	1	5	0	14	....	Rose pink
Hortulanus Budde	6	0	3	7	0	23	X	Brilliant scarlet
H. V. Machin	3	0	0	12	2	3	X	Crimson
Irish Charm	3	0	1	18	0	10	....	Pink
Irish Courage	3	0	2	5	0	12	....	Pale salmon
Irish Fireflame	6	0	1	20	0	13	XX	Cream flushed pink
Irish Hope	3	0	0	17	0	11	....	Scarlet
Irish Sweetness	3	0	0	27	0	13	X	Rosy carmine
Johannezauber	2	0	0	7	0	13	....	Rose
John C. M. Mensing	3	3	0	24	0	4	XX	Rose pink
Julia Countess of Dartrey	3	0	0	7	0	15	X	Rosy pink
Kardinal Schulte	2	0	1	5	0	14	X	Scarlet
Lady Helen Maglona	3	0	0	7	0	22	....	Crimson
Lady Margaret Stewart	3	0	1	5	0	10	....	Apricot
Lady Mary Elizabeth	2	0	0	7	0	11	X	Pink
Lady Worthington Evans	3	0	0	12	0	17	....	Crimson
Leslie Evans	3	0	0	5	0	22	X	Scarlet
Lilly Jung	2	0	1	5	0	9	X	Yellow
Lord Castlereagh	3	0	0	13	0	11	X	Darkest crimson
Lucinda	3	0	0	22	0	3	X	Dark pink
Mabel Lynas	4	0	0	5	0	19	X	Red
Margaret McGredy	3	0	0	3	0	30	....	Orange red
Marion Cran	6	0	2	3	0	20	....	Salmon pink
Mars	3	0	1	20	0	9	....	Coral pink
Mary Merryweather	3	0	0	12	0	15	....	Yellow
Matchless	3	0	1	44	0	2	....	Deep pink
Melody	3	0	2	40	0	7	X	Yellow
Mevrouw G. A. van Rossem	8	0	4	20	0	12	X	Apricot
Mme. Chamouton Murgue	2	0	0	7	0	20	....	Orange carmine
Mme. Jules Grolez	3	0	1	15	0	16	X	Red
Mons. Julien Potin	6	0	0	36	0	4	X	Yellow
Mrs. A. R. Barraclough	6	0	2	27	0	9	....	Rose pink
Mrs. Beatty	3	1	0	28	0	11	X	Yellow
Mrs. Charles Lamplough	2	0	0	15	0	5	X	White

TABLE No. IV.—(Continued).

HYBRID TEAS: RESULTS OF TWO-YEAR TESTS.

VARIETY	Number Tested	Number Winter Killed	Number Died Out	% Black Spot	% Mildew	Blooms per Plant per Season	Fragrance	Principal Colour Effect
Mrs. C. W. Edwards	3	2	1	20	0	2	X	Deep rose
Mrs. F. R. Pierson	3	0	1	22	0	6	XX	Red
Mrs. S. W. Burgess	2	0	1	10	0	9	X	Pale apricot
Mrs. Talbot O'Farrell	3	0	0	45	0	29	X	Crimson and yellow
Mrs. Tom Smith	2	0	0	5	0	30	X	Bright pink
Mrs. W. E. Nickerson	3	0	0	23	0	18	....	Salmon orange
Naomi	6	0	0	8	0	17	X	Buff
Norman Lambert	6	0	3	12	0	16	XX	Salmon yellow
Old Gold	3	0	0	3	0	25	....	Orange flushed pink

21. H. T. Julia, Countess of Dartrey. A new light pink rose of considerable value. The long pointed bloom is typical of a first class rose for the exhibition table. Vigorous plants, which are moderately prolific. Bloom is fragrant.

TABLE No. IV.—(Continued).

HYBRID TEAS: RESULTS OF TWO-YEAR TESTS.

VARIETY	Number Tested	Number Winter Killed	Number Died Out	% Black Spot	% Mildew	Blooms per Plant per Season	Fragrance	Principal Colour Effect
Pink Pearl	4	0	2	8	0	14	X	Deep rose pink
Princess Elizabeth of Greece	6	0	0	9	0	6	X	Salmon orange
Princess Marie Jose	7	1	3	10	0	7	X	Pink
Radiance	6	0	0	7	0	19	X	Pink
Rapture	3	0	0	25	0	3	X	Clear pink
Red Radiance	6	1	3	12	0	4	X	Light crimson
Richard E. West	3	0	0	20	0	5	X	Creamy yellow
Roselandia	4	0	·2	3	0	10	X	Pale yellow
Shot Silk	5	0	0	10	0	20	XX	Salmon and orange pink
Sir David Davis	8	0	1	7	0	15	....	Crimson
Souv. de Chermonde	5	0	1	2	0	9	X	Salmon pink

22. H.T. Miss Willmott. Cream blooms which fade white. This is the most satisfactory white Hybrid Tea in our gardens. Moderately prolific. Vigorous.

TABLE No. IV.—(Continued).

HYBRID TEAS: RESULTS OF TWO-YEAR TESTS.

VARIETY	Number Tested	Number Winter Killed	Number Died Out	% Black Spot	% Mildew	Blooms per Plant per Season	Fra-grance	Principal Colour Effect
Souv. de Geo. Beckwith	4	1	1	5	0	7	....	Pink
Templar	3	0	0	41	0	5	XX	Red
Totty's Red	3	1	1	35	0	3	XX	Red
Vesuvius	3	0	1	10	0	10	X	Crimson
Ville de Paris	5	0	0	16	0	9	....	Yellow
W. A. Bilney	3	0	0	15	0	9	X	Pale pink
W. C. Gaunt	3	0	1	12	0	3	X	Scarlet
W. F. Dreer	2	0	1	20	1	9	....	Yellow

If we take for granted the fact that those varieties in table IV. which give the most bloom are those which are best for garden use we can make the following list:

VARIETIES SATISFACTORY FOR GARDEN USE (TABLE IV).

Billy Boy
Dainty Bess
Gooiland Beauty
Hortulanus Budde
Lady Helen Maglona
Leslie Evans
Margaret McGredy
Marion Cran
Mrs. Talbot O'Farrell
Mrs. Tom Smith
Old Gold
Shot Silk

VARIETIES SATISFACTORY FOR CUTTING (TABLE IV).

Betty
Briarcliff
Charles P. Kilham
Dainty Bess
Desmond Johnston
Emily Dodd
F. M. Vokes
Golden Emblem
Golden Ophelia
Hon. Charlotte Knollys
Julia Countess of Dartrey
Lady Margaret Stewart
Mary Merryweather
Mevrouw G. A. van Rossem
Mons. Julien Potin
Mrs. A. R. Barraclough
Mrs. Beatty
Mrs. Tom Smith
Norman Lambert
Pink Pearl
Roselandia
Souvenir de George Beckwith
Templar
Ville de Paris

TABLE No. V.

HYBRID PERPETUALS.

Note: Asterisk (*) denotes two years' test; all others, three.

VARIETY	Number Tested	Number Winter Killed	Number Died Out	% Black Spot	% Mildew	Blooms per Plant per Year After July 31	Total Blooms per Plant per Season	Principal Colour Effect
Alfred Colomb	6	0	2	7	6	7	15	Pink
Baron de Bonstetten	3	0	0	3	8	1	13	Dark crimson
*Captain Christie	3	0	0	5	3	0	18	Flesh pink
*Captain Hayward	1	0	0	5	15	0	15	Crimson
Coronation	11	2	1	10	9	2	22	Pink
*Eugene Furst	3	0	1	0	6	0	8	Red
Everard Ketten	2	0	0	20	0	10	25	Pink
*Fisher Holmes	4	0	0	4	3	2	12	Red
Frau Karl Druschki	11	1	0	6	12	3	29	White
General Jacqueminot	8	3	0	6	7	4	33	Crimson
*Georg Arends	6	0	1	4	4	3	17	Pink
*Gloire de Chedane Guinoisseau	3	0	0	5	5	11	17	Crimson
Heinrich Schultheis	1	0	0	7	10	1	10	Deep rose pink
Helen Keller	3	0	0	4	20	1	13	Rose pink
Her Majesty	3	1	0	3	9	5	20	Rose
Hugh Dickson	9	0	2	4	9	4	18	Crimson
King George V.	2	0	0	5	10	5	12	Red
*Louis van Houtte	3	0	0	0	0	0	9	Red
*Magna Charta	3	0	1	5	10	1	14	Bright pink

TABLE No. V.—(Continued).

HYBRID PERPETUALS.

Note: Asterisk (*) denotes two years' test: all others, three.

VARIETY	Number Tested	Number Winter Killed	Number Died Out	% Black Spot	% Mildew	Blooms per Plant per Year After July 31	Total Blooms per Plant per Season	Principal Colour Effect
*Mme. A. Barbier	2	0	0	6	0	2	6	Deep cream to pale yellow
Mme. Gabriel Luizet	2	0	0	10	6	2	37	Pink
Mrs. Geo. Dickson	1	0	0	17	13	6	29	Red
Mrs. Hugh Dickson	3	0	0	9	8	3	13	Red
Mrs. John Laing	16	1	1	6	10	1	17	Pink
*Mrs. R. G. Sharman-Crawford	3	0	0	18	2	2	6	Rosy pink
Paul Neyron	4	0	1	10	6	5	29	Rose
*Prince Camille de Rohan	4	0	1	5	10	6	46	Dark crimson
Ulrich Brunner	11	0	1	5	6	4	24	Red

23. H.P. Frau Karl Druschki. Possibly the most perfect rose yet introduced. Certainly the finest white rose on the market. Has one fault: No fragrance. Vigorous plants to five feet or more. Prune lightly for maximum bloom.

TABLE No. VI.

DWARF POLYANTHAS.

Note: Asterisk (*) denotes two years' test; all others, three.

VARIETY	Number Tested	Number Winter Killed	Number Died Out	% Black Spot	% Mildew	Number of weeks in Bloom per Season	Fragrance	Principal Colour Effect
*Aschenbrodel	3	0	0	35	0	9	XX	Creamy salmon
*Chatillon	2	0	0	10	0	13	....	Bright pink
*Dorothy Haworth	4	0	0	9	0	10	....	Pink
Eblouissant	5	0	0	10	5	14	....	Dark crimson
*Ellen Poulsen	2	0	0	13	3	13	X	Rose pink
*Else Poulsen	13	0	1	26	0	14	....	Bright rose pink
*Erna Teschendorff	2	0	0	5	0	11	....	Red
Gruss an Aachen	8	0	0	4	0	9	X	Salmon fading to cream
Jessie	3	0	0	15	10	11	....	Cherry red
*Katherine Zeimet	5	0	0	6	0	12	XX	White
Kirsten Poulsen	9	0	2	16	0	11	X	Light red
*Lady Reading	3	0	0	8	2	12	X	Red
Miss Edith Cavell	2	0	0	6	0	12	....	Scarlet
Mme. Norbert Levavasseur	17	0	0	11	6	12	....	Bright red
Mrs. W. H. Cutbush	3	0	0	7	6	11	....	Rosy pink
*Orange King	3	0	0	15	2	10	....	Salmon
*Perle d'Or	3	0	1	18	0	10	X	Deep cream
Yvonne Rabier	2	0	0	10	0	10	....	White

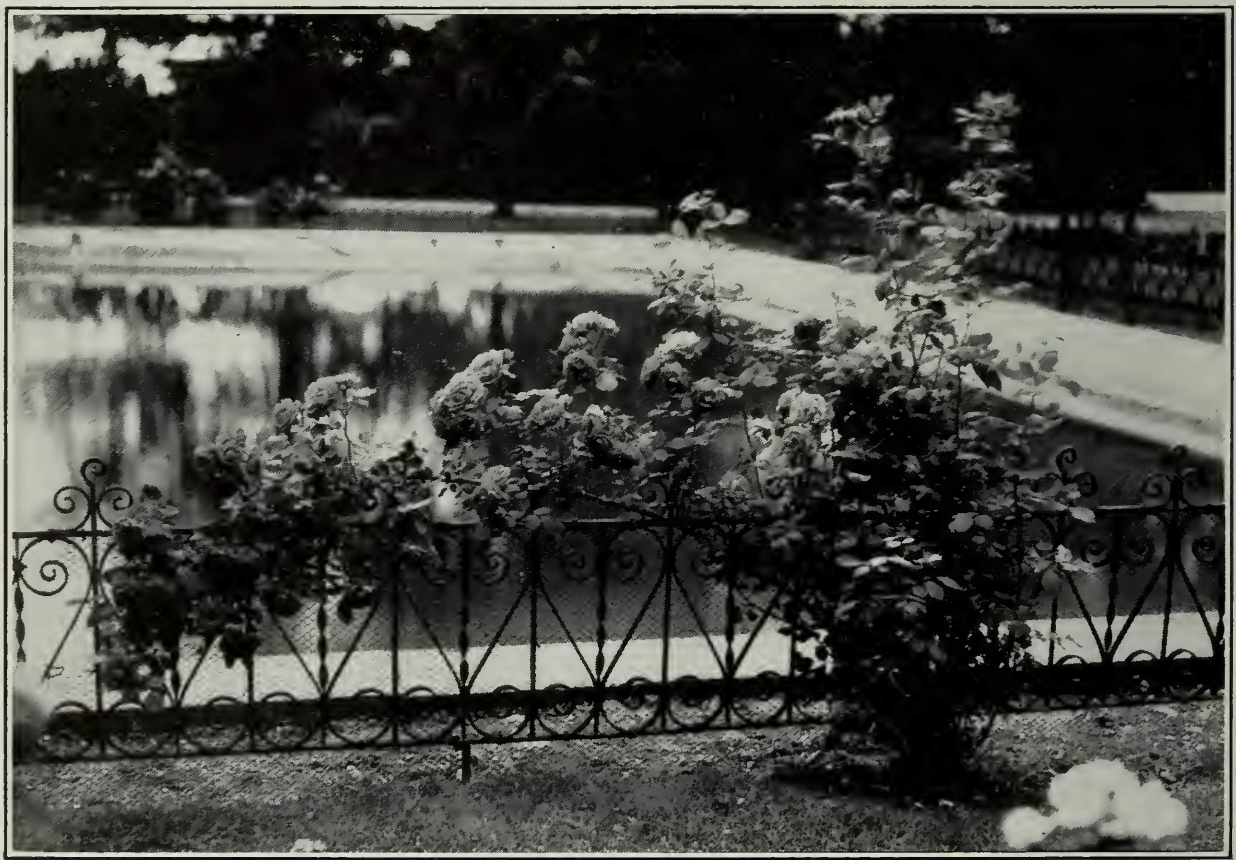
24. Goldfinch, a Climbing Rose of the Multiflora type. Extremely vigorous and very prolific. The deep cream (or pale yellow) blooms fade white in our bright sunshine.

TABLE No. VII.

CLIMBERS.

Note: Asterisk (*) denotes two years' test; all others, three.

VARIETY	Number Tested	Number Winter Killed	Number Died Out	% Black Spot	% Mildew	Number of weeks in Bloom per Season	Type	Principal Colour Effect
*Alberic Barbier	3	0	0	0	0	4	Rambler	Cream
Crimson Rambler	3	0	0	0	30	5	Climber	Bright crimson
Dorothy Perkins	3	0	0	0	0	5	Rambler	Rose pink
*Dr. Van Fleet	3	0	0	0	0	3	Pillar	Flesh pink
*Flower of Fairfield	4	0	0	12	0	9	Climber	Bright crimson
Fraicheur	4	0	0	2	0	4	Rambler	Pale pink
*Francois Juranville	3	0	0	2	0	3	Rambler	Fawn pink
*Gerbe Rose	3	0	0	0	0	3	Rambler	Pink
Goldfinch	2	0	0	0	0	4	Climber	Deep cream to white
Hiawatha	2	0	1	0	0	6	Rambler	Rich crimson (single)
Paul's Scarlet Climber	4	1	1	2	1	5	Pillar	Scarlet
*Sanders White	2	0	0	0	0	4	Rambler	White
*Silver Moon	3	0	0	7	0	3	Rambler	Creamy white
Snowflake	3	1	0	0	0	3	Rambler	White
Tausendschon	3	0	0	0	0	5	Climber	Pink
*Veilchenblau	2	0	0	0	0	2	Climber	Magenta
White Dorothy Perkins	2	0	1	0	0	3	Rambler	White
*Yvonne	2	0	0	0	0	3	Rambler	Pink



25. Paul's Scarlet Climber. A Pillar rose of the Wichuraiana type. Probably the most popular Pillar rose in existence to-day. Scarlet-red blooms of good size are borne in profusion over a five-week period.

Tables V., VI. and VII. need no summarizing because they are sufficiently short to enable any reader to reach his own conclusions briefly.

26. Dr. Van Fleet. A climbing Rose of the Wichuraiana type. Bears large individual pink blooms of high quality.

RECOMMENDED VARIETIES OF HYBRID RUGOSAS.

Agnes, amber	Mme. Georges Bruant, white
Belle Poitevine, single deep pink	Mrs. Anthony Waterer, red
Blanc Double de Coubert, white	Pink Grootendorst, pink
F. J. Grootendorst, red	Sir Thomas Lipton, white

All but the first three bloom more than once during the season.

COMMERCIAL ROSE CULTURE.

Rose-growing, as a business, is rapidly developing throughout Canada, into a trade of considerable magnitude. Although the great majority of those in the profession are to be found in Ontario, nurserymen and florists are cultivating roses in every Province in the Dominion.

In an attempt to ascertain the volume of business reached by Canadian firms in 1928, a circular letter was mailed to every nurseryman and florist in the country. Unfortunately, only some twenty-six per cent replied to this questionnaire, but the answers received were both interesting and informative.

TABLE No. VIII.

NUMBER OF ROSE BUSHES SOLD FOR OUTDOOR PLANTING IN 1928.

Type	Number Sold
Tea	3,700
Dwarf Polyantha	11,272
Pernetiana	21,400
Hybrid rugosa	22,454
Hybrid Perpetual	41,485
Climbers	45,138
Hybrid Tea	98,820
Miscellaneous (type not Specified)	175,000
From greenhouses	58,600
Pot roses	5,000
	482,869

When we consider the comparatively small percentage of replies, and the fact that chain and departmental stores and individual agents for foreign firms failed to respond to the questionnaire to any appreciable extent, we may realize that rose selling is indeed becoming "big business" in Canada.

Judging from personal conversation with many importers and growers who quoted round figures, but who forwarded no written reply, it is safe to say that approximately one million rose bushes were sold for outside planting in Canada in 1928.

It is interesting to note that the hardier types are not as popular here as some of those supposedly not vigorous enough to withstand our winters: Hybrid rugosas and Hybrid Perpetuals, together, constitute slightly more than one-seventh of the total number sold. This is conclusive evidence that flower lovers in this country know how to grow roses, and that their preference is for the types productive of much bloom, even though these classes are more difficult to grow well. It is conclusively demonstrated that roses can be grown in Canada; a fact disputed by many poorly informed citizens of this country.

NUMBER OF BUSHES GROWN COMMERCIALLY.

In response to this question we find that Canadian nurserymen are cultivating 501,200 rose bushes, and that most of them anticipate enlarging the area devoted to this crop in the near future.

COMMERCIAL VALUE OF THE HYBRID RUGOSA.

Apparently little demand exists for this type of rose; yet, as noted elsewhere, it is the hardiest class of popular rose we have. Ninety per cent of those answering the questionnaire stated that there was insufficient demand for this type to warrant "pushing" or advertising it particularly; that, in spite of its many advantages and uses, they could not consider it, by any means a "best seller". The average number of varieties handled by our nurserymen is six, yet more than twenty good varieties are on the market.

TABLE No. IX.

OWN ROOT vs. BUDDED ROSES.

	Own Root	Budded	Exceptions in Favour of Own Root
	4	11	----
Hardy types	----	----	4
In British Columbia	----	----	1
Climbers	----	----	7

Table Number IX. shows what nurserymen think of own root roses—for most bush roses (for all, in fact, but Hybrid Perpetuals and Hybrid rugosas) budding is preferred. This coincides with our own experience, except that most Hybrid Perpetuals will be more satisfactory if grafted. Climbers, of course, do not need to be budded—most of them will react well from cuttings—but, if budded, the understock should be similar; that is, Climbers of the Multiflora type should be budded on R. multiflora, while those of the Rambler type should be grafted to R. Wichuraiana.

Only one nurseryman, and he lives in a mild section of British Columbia, recommended own root roses for all types; while several others from the same Province disagreed with his opinion.

PROPAGATION OF CLIMBING ROSES.

As stated above, Climbers do not need to be budded, but Table Number X. carries interesting information dealing directly with the propagation of Climbers.

TABLE No. X.

PROPAGATION OF CLIMBING ROSES.

Type of Understock	Multiflora Type	Wichuraiana Type	Climbing Hybrid Teas and Hybrid Perpetuals
R. multiflora japonica	4	2	2
R. canina	7	7	7
R. rugosa	3	3	5
Manetti	1	1	1
R. Wichuraiana	0	2	0
Layering	3	3	0
Cuttings	12	12	12

Undoubtedly most commercial men prefer propagation of all types of climbing roses by cuttings and layering; but the truly interesting point in the above table is the decided preference shown for Rosa canina, the Dog Rose. This species is generally considered to be fairly satisfactory for bush roses—particularly for Hybrid Teas—but these figures point to its real popularity as an understock for Climbers.

UNDERSTOCKS FOR OUTDOOR BUSH ROSES.

There is no question that nurserymen in Canada are doing everything in their power to determine just what understocks should be used for bush roses in Canada. The following list of understocks tried by them (with the number experimenting with each type in brackets) is indeed illuminating: R. canina (17); R. multiflora japonica (13); R. rugosa (11); Manetti (9); R. laxa (4); Grifferi (2); R. Wichuraiana (2); and each of the remainder was tried by one nurseryman: R. blanda, R. cinnamomea, Kokulinski, R. nutkana, R. rubiginosa, R. rubrifolia, and Senff.

TABLE No. XI.

BEST UNDERSTOCKS FOR OUTDOOR ROSES IN CANADA.

Type of Understock	Hybrid Tea	Tea	Pernetiana	Hybrid Perpetual	Climbing Multiflora	Wichuraiana	Cl. H.T.'s and H.P.'s	D. Poly
R. multiflora japonica	5	1	1	7	4	2	2	1
R. canina	9	7	10	9	7	7	7	9
R. rugosa	5	3	4	7	3	3	5	5
Manetti	3	1	0	5	1	1	1	0
R. laxa	2	0	0	2	0	0	0	0
R. Wichuraiana	0	0	0	0	0	2	0	0

Here we see again the overwhelming popularity of R. canina as an understock for rose bushes—this type receiving nearly twice as many recommendations as any other; and almost half as many as the remainder put together. This information is particularly valuable when we consider that these reports are from commercial growers who give us the benefit of their own practical experience with budding roses in their nurseries.

THE COMMERCIAL FLORIST.

Twenty-nine varieties of roses, all Teas, Hybrid Teas or Pernetianas, are grown under glass by our florists, and are listed here in order of the number of growers cultivating them: Mme. Butterfly (9); Souvenir de Claudius Pernet (8); Templar (8); Briarcliff (7); Mrs. F. R. Pierson (6); Premier Supreme (6); Premier (5); Rapture (5); Red Premier (5); White Killarney (5); Columbia (4); Talisman (4); Wilhelm Kordes (4); Mons. Julien Potin (3); E. G. Hill (2); Joanna Hill (2); Mme. Dreux (2); Roselandia (2); Amelia Gude (1); America (1); Florex (1); J. C. Mensing (1); Lady Canada (1); Lady Willingdon (1); Matchless (1); Mrs. Aaron Ward (1); Rose Hill (1); Sunburst (1); and Sweetheart (1).*

The principal information in this list is the fact that deep pink roses are the most popular with red and yellow varieties practically on a par with each other, and with white a long way behind. Only one of the twenty-nine varieties bears white blooms, and is grown by less than fifty per cent. of those reporting. Some of the varieties towards the end of the list are of comparatively recent introduction and several of these will be more popular in a few years' time.

PROPAGATION OF GREENHOUSE ROSES.

The choice of understock is much more limited for roses grown under glass, and the firms replying to the questionnaire are practically unanimous on this subject. It is interesting to note that all firms report that no rose types other than Tea, Hybrid Teas and Pernetianas are grown in their ranges; and that at least seventy-five per cent belong in the Hybrid Tea Class.

TABLE No. XII.

PROPAGATION.

		Hybrid Tea	Tea	Pernetiana
In favour of own Root Roses	50%			
In favour of Grafted Roses	50%			
Manetti		100%	90%	
R. odorata				100%
R. multiflora			10%	

EXTENT OF BUSINESS.

Fifty per cent of these florists have more than half of their entire range devoted to rose culture, several of them producing no other crop, and the total value of the blooms sold is indeed illuminating.

TABLE No. XIII.

THE COMMERCIAL FLORISTS' ROSE BUSINESS IN 1928.

Number of rose bushes grown (exclusive of pot roses)	505,800
Number of rose bushes sold for outdoor planting	58,600
Number of pot roses sold	5,000
Total value of blooms sold	$430,800.00

The total value of blooms sold appears high, but in reality—even though the firms in question reported in round figures—it must be ridiculously low.

*The Sweetheart rose is actually the Dwarf Polyantha sold as Cecile Brunner.

For instance, one firm reports the production of 1,200,000 roses from 43,000 bushes; an average of approximately 28 per bush. This result is very conservative, many growers securing a larger number of blooms per bush; but, taking this known figure for the total number of bushes, we find that 506,800 bushes would produce 14,190,400 flowers; which at the total value, must have sold at the absurdly low average sum of 3.04 cents. Evidently the commercial men have been modest in estimating their returns.

Although only one-quarter as many florists as nurserymen answered the questionnaire, the former have more bushes under cultivation: though, of course, in fewer varieties.

The above figures contradict the frequently heard assertion that too many commercial florists sell roses for outdoor planting. In reply to the question: How do you dispose of the "worn out" bushes which are intended for discard?, seventy-five per cent "throw them away." Of the remainder, all report that good bushes only are selected, after they have served their purpose in the greenhouse benches, for sale. It is a fact, too, that more than half of the greenhouse bushes disposed of in this way were sold by one firm.

DISEASE ON GREENHOUSE ROSES.

Sixty per cent of the florists find Black Spot more prevalent on Pernetiana roses than on the other types, and the following methods are adopted to combat this trouble:

37.5% use sulphur.
37.5% use an ammoniacal solution of copper carbonate.
12.5% use grape dust.
12.5% use only careful culture.

It is only fair to note that all practise good cultural methods, and do all in their power to combat disease attacks by proper heating, ventilation and watering; and all hand-pick diseased foliage.

ROSE INSECTS.

L. Caesar, Provincial Entomologist.

There are three very common insect enemies of roses in Ontario. These are—aphids, leaf hoppers and slugs. In addition there are two or three others not so common or with a more limited range; namely, rose chafers, red spiders and rose midges.

APHIDS. There are three species of these but they look so much alike and have so nearly the same habits that we may consider them as one. They are all small, never more than about one-eighth of an inch long; are usually green in colour though sometimes pink; are sluggish in movement; and most of them have no wings. Like nearly all species of aphids they produce offspring at an enormous rate and, if weather conditions are favourable and enemies scarce, can soon become so abundant as almost to cover every bud and all the tender new growth.

The injury is done by hundreds of them inserting their sharp, hair-like mouth-parts through the surface of the buds, leaves, and tender shoots and sucking out the juices, thus starving the plant and causing sickly foliage and dwarfed or ruined blossoms.

CONTROL. The most satisfactory method of control is to spray the plants heavily from every side with some form of tobacco extract. The spraying should be done as soon as there is a sufficient number of aphids present to justify it and always before serious injury has taken place. There are several forms of tobacco extract which may be procured. The most common, however, is nicotine sulphate 40 per cent. Directions for use are always given on the containers but it is usually wise to make the spray a little stronger than these directions indicate, and to add soap as recommended.

Instead of a nicotine spray a 2 per cent nicotine dust may be used. This dust can be purchased from the manufacturers of orchard dusts. It is applied by means of a hand duster or dust gun. Dusting should be done only when the weather is calm and preferably when it is warm.

Soapsuds at a strength of 1 pound of whale oil soap or of common laundry soap to 6 gallons of rain water will also kill aphids, but it is necessary that the soap be washed off with water after a couple of hours, as otherwise it may cause severe injury to the foliage.

Another and sometimes satisfactory method of control is to use a garden hose and with a strong, moderately fine spray knock the aphids off the plants. This is, of course, the cheapest of all the methods, but requires a lot of patience and thoroughness.

LEAF HOPPERS. Like aphids, leaf hoppers are small insects, not more than about one-sixth of an inch long. The adults are creamy white in colour and may be seen on the leaves from about the middle of June until the frosts come in winter. They are nearly all found on the under surface and if disturbed will dart quickly away. The young or nymphs are much smaller than the adults. They are white or greenish-white in colour and like the adults are regularly found on the under side of the leaves. They begin their injury soon after the leaves have opened and most of the damage will have taken place by the end of June.

Leaf hopper injury is easily recognized, as it causes the leaves at first to become mottled with tiny, white spots, chiefly along the midrib. Later the whole leaf will become mottled and after awhile will turn a sickly yellowish or pale brownish colour. It is not uncommon to see every rose leaf thus affected. The mottling is brought about by the sucking of the juices by the nymphs and adults from the under side of the leaves, the results of this work showing on the upper side. The insect winters in the egg stage in little slits in the bark of the branches and main stem.

CONTROL. It is impossible to prevent the mottling of rose leaves unless attention is given to the insects early or in other words about as soon as the first leaves are almost full size, which will usually be about the time apple trees are in full bloom. At this stage all or almost all the hoppers will have hatched out and will still be immature and can easily be reached and killed by the spray, but if the spraying is postponed until they get their wings it will not kill the insects. In spraying one must always remember that the leaf hoppers are on the under side of the leaves and must be hit with the liquid to be killed. Hence spray heavily with the same substance or substances as recommended above for aphids. There is nothing better than the nicotine sulphate 40 per cent. Nicotine dust, however, is also good. Begin treatment soon after the mottling has begun to appear on the leaves and before any appreciable damage has taken place. Usually one application will be sufficient but there are times when it is better to give a second after about a week's interval.

SLUGS. These are green or yellowish-green, sluggish caterpillars which feed upon the leaves. There are at least two species. The most common one feeds on the upper side of the leaf and eats off all the green tissues, after which the leaf turns first white and then brown and dies. The other species feeds on the under side, eating off at first the green tissues and later making holes in the leaves and finally devouring everything but the main ribs or veins. Injury is done chiefly in late May and June but may occur also in the summer months. Slugs are not commonly abundant, as are the aphids and the leaf hoppers, but most growers of roses, from time to time have suffered considerable loss from them.

The adults of the slugs are small, black, four-winged flies known as saw flies. One species is only one-quarter of an inch long, the other is about one-third of an inch. Both may readily be seen, especially in May, on the foliage, laying their eggs. Their life histories have not been worked out fully in Ontario but, from observations we have made, both species have at least two broods a year.

CONTROL. This is quite easy. The same nicotine spray as for aphids and leaf hoppers will kill them, but it is usually cheaper to use arsenate of lead at the strength of about 1 ounce to 2 gallons of water. The only objection to the arsenate of lead is the staining of the leaves. It may be applied as a dust and in this way will leave less stain. Paris green at the strength of 1 level teaspoon or a little less to 1 gallon of water will also destroy rose slugs but is somewhat dangerous at times to the foliage.

RED SPIDERS. These are tiny mites just visible to the naked eye. They feed on the under surface of the leaves usually under a thin web. Here they suck the juices out of the plant and cause the leaves to turn a sickly yellowish-brown colour, somewhat like the colour due to leaf hopper injury. The mites themselves are usually pale yellow and not red, as one would expect from the name. They are regularly worse in dry weather. In the winter they hide in the ground just beneath the plants.

CONTROL. On the whole, the safest control method is the one which is commonly practised by experienced growers; namely, to spray heavily with cold water from the under side of the leaves, repeating the spraying every couple of days until the mites have been washed off and disappear. A very weak lime-sulphur mixture about 1 part to 60 parts of water is also effective but is not quite so safe and tends to stain the leaves.

ROSE CHAFER OR ROSE BUGS. These are greyish-brown or fawn coloured beetles about one-half inch in length. They have long legs and crawl slowly over the plants, sometimes congregating in swarms on a single blossom and utterly ruining it. They feed also to some extent on the foliage and on the buds. Their attacks are not limited to rose bushes, as grapes and fruit trees and many other plants are also injured. Fortunately they are troublesome only in sandy localities and even there only if there is a good deal of waste land or land left long in grass; for it is only in this kind of land that they breed. The injury takes place chiefly in the latter part of June and early July, after which the beetles completely disappear.

CONTROL. It is impossible at present to give a satisfactory means of control for rose chafers. In some cases it may be practicable to cover the plants with mosquito wire or mosquito netting to keep the beetles off. Spraying has not been very satisfactory, because no spray will kill them quickly enough to prevent injury as new beetles keep arriving. To get good results the whole community should co-operate and see that all waste land is plowed and either has some crop put on it or else is sown to sweet clover. Another good method is to plant pine trees on the wasteland and allow them to grow up into a forest. While the trees are still small it will be wise to plow and cultivate the soil between them each year or else keep it seeded down with sweet clover. The best time to break up sandy land is in spring about the 24th of May, for at this time the larvae in the soil have just transformed to pupae and stirring the soil kills these and thus prevents their transforming into beetles.

ROSE MIDGE. The rose midge adult is a two-winged, light-brown or yellowish-brown insect about one-twentieth of an inch long. The midges themselves do no harm but their little white larvae, which when full grown are not more than about one-eighteenth or one-twentieth of an inch in length, do all the damage. They feed chiefly on the terminal leaves and blossom buds, killing the buds or else so disfiguring the bloom as to make it worthless and causing the leaves to become crumpled and stunted. Usually these are greenhouse pests but sometimes they do a good deal of damage in the summer to plants outside. Wherever the insect is abundant it is one of the worst of all our rose pests but fortunately most rose growers are free from it up to the present.

CONTROL. Control is not very difficult but to understand the reason for the method used it is necessary to remember that when the maggots are full grown they drop to the ground and enter it to pupate. Control then consists in thoroughly drenching the soil beneath the plants with water and then spreading a layer of tobacco dust nearly one-half inch thick all over it. This kills any larvae that may try to enter the ground after coming out of the plants and also kills any adults that try to come up through the dust, in case they succeed in hatching from the pupae beneath. The main trouble in control is to secure enough fine tobacco dust. The best place to secure it is from tobacco factories of various kinds.

ROSE DISEASES.

J. E. Howitt, Professor of Botany, O.A.C.

The rose, the queen of flowers, is not exempt from diseases. All plant life appears to be heir to troubles of one kind or another. Most fortunately, nearly all the diseases which affect the rose can be prevented from doing serious injury if care and attention are given to the plants at the proper time.

The more troublesome diseases of the rose in Ontario are Black Spot, Powdery Mildew, Brown Canker, and Crown Gall. There are of course other diseases that affect the rose but as they are not often widespread and severe in Ontario, they will not be dealt with in this article.

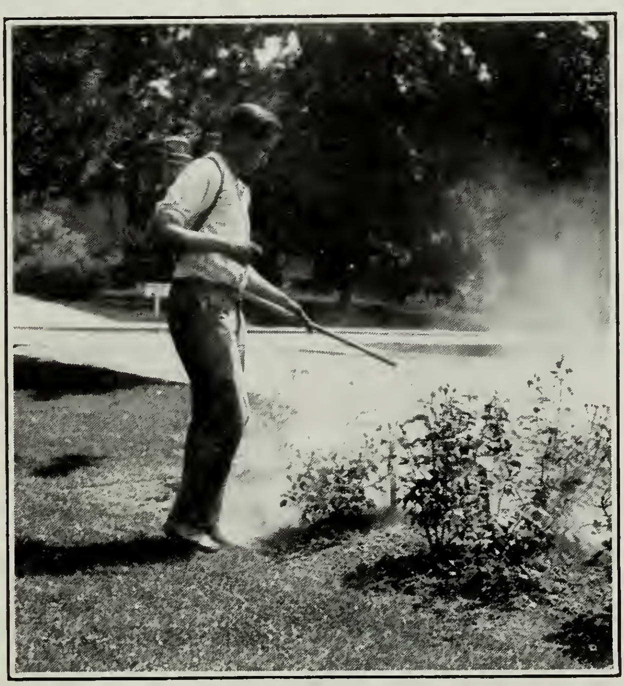
BLACK SPOT. This is probably the most common and most serious disease of roses in Ontario. In wet seasons it often disfigures the plants when they are coming into full bloom or shortly afterwards, and thus mars their beauty when they should be at their best. The name Black Spot is very descriptive of the most conspicuous symptom of this disease. Large, somewhat circular radiating black spots appear upon the leaves. These may be very numerous and coalesce. When the disease is bad the affected leaves turn yellow and drop early in the season and often almost complete defoliation of the plant results. Such early defoliation not only disfigures the bushes but it also renders them very liable to winter injury as the loss of the leaves prevents the tissues of the plant being properly matured and ripened so as to withstand the severe weather of winter.

PREVENTION. Black Spot of roses can be prevented by good cultural practices combined with spraying or dusting as recommended in the spray schedule for roses which is given below. Among the good cultural practices are the burning of all fallen leaves in the autumn, and the removal and destruction of all dead canes and stubs.

POWDERY MILDEW OF ROSES. This is a conspicuous and disfiguring disease which causes much trouble to rose growers especially on certain varieties of ramblers. Leaves, shoots, stems and buds become covered with a dense white powdery mildew. If this mildew is very severe the buds may fail to open and the shoots and leaves may be stunted and deformed.

PREVENTION. One of the important points in the prevention of mildew is in selecting a proper place to grow roses. Rose bushes and vines should be planted in situations where there is free circulation of air and plenty of sunshine so that the moisture does not remain too long on the plants after every shower or heavy dew. It is also important to water roses subject to mildew early in the morning rather than in the evening. If the above precautions are taken, roses can be kept free from mildew by spraying or dusting as recommended in the spray schedule for roses given below.

SPRAY SCHEDULE FOR ROSES. These recommendations are based upon the results of several years' experiments carried on at the College. Spray roses first early in the spring before the buds open with commercial lime sulphur of the strength of one part by measure to ten of water. Give a second spraying just after the leaves are unfolded. At this time use commercial lime sulphur of the strength of one part by measure to forty of water. A week or ten days after the second spray give a third application with commercial lime sulphur of the strength of one part by measure to fifty of water. If the weather is very wet spray at intervals of a week or ten days until the roses come into bloom. If the autumn is very wet it may be necessary to give one or two additional sprayings after the blooming period is well advanced. For all the later applications lime sulphur of the strength of one part by measure to fifty of water should be used. The objection to spraying with lime sulphur is that it somewhat disfigures the foliage and stone or woodwork near which roses may be growing. On this account many rose growers prefer to use sulphur dust. Our experience would lead us to believe that sulphur dust if properly applied is as effective as the liquid lime sulphur provided one spraying with strong liquid lime sulphur (one part by measure to ten of water) is given early in the spring before the roses come into leaf. If lime sulphur dust is used it should be applied at intervals of about a week during wet weather.



27. Dusting Rose Bushes.

In order to secure the best results from dusting the so-called dusting sulphur which is more finely ground than the flowers of sulphur should be used. The dust may be applied with a hand dusting machine of which there are many on the market, or if such a machine is not available the dust can be put on quite well by placing it in a bag of loose cheesecloth and then beating this with a stick over the bushes. The dust should be applied when the plants are moist with dew, rain, or after the garden hose has been used.

A large amount of sulphur is not needed but after an application one should be able to see the fine dust on the leaves. It is better to make two light applications at intervals than one heavy one.

BROWN CANKER. This disease is frequently met with in Ontario and sometimes causes very severe injury to outdoor roses.

The cankers may appear on any portion of the stem. They are usually brown in the centre with a distinct reddish-purple border. They gradually increase in size until they encircle the stem and girdle it. This disease also sometimes affects the leaves and blossoms. The former are sometimes badly disfigured by it.

PREVENTION. Rose bushes showing any signs of cankers on the stems should never be set out in the garden. Stems or parts of stems showing cankers should be carefully removed and burned. The affected plants should be sprayed with Bordeaux mixture during the growing season. The number of applications required varies from three to seven. In applying the Bordeaux care must be taken to cover the canes rather than the foliage. These should be thoroughly covered from both sides. In order to make the spray stick it is advisable to add one to two pounds of fish oil soap to each forty gallons of Bordeaux.

The following are the directions for preparing Bordeaux mixture in gallon lots: Dissolve one heaping teaspoonful of small copper sulphate crystals in one quart of warm water in an earthen or wooden vessel. As soon as dissolved add two quarts of cool water. In another vessel add five heaping teaspoonfuls of fresh hydrated lime to one quart of cool water. Stir thoroughly and pass through a cloth strainer into the diluted copper sulphate water. Stir the mixture while the lime is being added. To each gallon of the Bordeaux add about one ounce of fish oil soap as a sticker. This solution should be used at once. After it has stood a few hours it is not safe to use it on the foliage. Prepared Bordeaux may be purchased from most dealers in garden supplies. Directions for use are on the containers. Some growers object to the discoloration of the foliage which results from the use of Bordeaux. In order to avoid this discoloration a spray solution of ammoniacal copper carbonate may be substituted. This mixture with directions for using it can be purchased at seed stores or it can be made in small quantities according to the following formula:

*Copper carbonate ¼ ounce, strong ammonia water (26° Baume) 4 tablespoonfuls, water 2 gallons. This mixture should be prepared in the open on account of the strong fumes. The ammonia should be diluted with water to several times its volume. The copper carbonate is mixed with sufficient water to make a paste. To this the diluted ammonia is added slowly with constant stirring until the copper carbonate is entirely dissolved. Water is then added to increase the volume to two gallons. On account of the difficulty of working with strong ammonia this spray is recommended only when other sprays are unsuitable for any reason. This ammoniacal copper carbonate solution does not stain the foliage.

In addition to spraying the canes, affected blossoms should be cut and burned. If plants are very badly affected by this disease it is often advisable to dig them out and burn them rather than to attempt to bring them back into a healthy condition again.

CROWN GALL. This disease has been observed many times by the writer in Ontario. It has apparently done more damage to roses grown under glass than those grown in the open. The same disease also affects fruit trees and raspberries. It is a bacterial trouble.

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*(Farmers' Bulletin No. 1547—U.S. Dept. of Agriculture (Rose Diseases—Their Cause and Control).

The symptoms are very marked. Affected plants grow slowly and have an unhealthy appearance. When they are dug up and examined they are found to have large irregular gall-like growths on the stalk or main roots.

There is no remedy for plants with large galls on the main stem. Such plants should be dug up and burned. In buying roses all plants should be carefully inspected and any specimens showing any indication of galls on roots or stems should be rejected.

CANADIAN ROSE ORIGINATIONS.

In so far as we can determine, the following varieties make a complete list-to-date of Rose varieties originated in this country. A real step forward has been initiated; and it is hoped that the success attained by our first hybridists will be sufficiently encouraging to stimulate further action in this engrossing endeavour.

Agnes, H. rug. (R. rugosa X Persian Yellow). Originated at Central Experimental Farm, Ottawa, Ontario.

Betty Bland, Shrub-rose. (R. blanda X a Hybrid Perpetual). Originated by Mr. F. L. Skinner, Dropmore, Manitoba.

Bonnie Bess, H.T. (Sunburst X Crusader: sdlg. X Wilhelm Kordes). Originated by Dale Estate, Brampton, Ontario.

Canadian Jubilee, H.T. (Priscilla X Commonwealth). Originated by John H. Dunlop and Son, Richmond Hill, Ontario.

Frank W. Dunlop, H.T. (Mrs. Charles Russell X Mrs. George Shawyer). Originated by John H. Dunlop and Son, Richmond Hill, Ontario.

Grace, H. rug. (R. rugosa X Harisonii). Originated at Central Experimental Farm, Ottawa, Ontario.

Lady Canada, H.T. (Madame Butterfly X Premier). Originated by Dale Estate, Brampton, Ontario.

Lady Willingdon, H.T. (Ophelia X Premier). Originated by Dale Estate, Brampton, Ontario.

Larry Burnett, Shrub-rose. (R. acicularis X Burnett rose). Originated by F. L. Skinner, Dropmore, Manitoba.

May Arnott, H. rug. (R. rugosa X Prince Camille de Rohan). Originated at Central Experimental Farm, Ottawa, Ontario.

Mrs. Henry Winnett, H.T. (Mrs. Charles Russell X Mrs. George Shawyer). Originated by John H. Dunlop and Son, Richmond Hill, Ontario.

Muriel Pasquill, H.T. (Sport, Padre). Originated by Pasquill's Rose Nursery, Vancouver, B.C.

Nootkana, H.T. (Richmond X R. Nootka). Originated by Mr. Geo. Fraser, Ucluelet, B.C.

Red Beauty, H.T. (Sport Matchless). Originated by John H. Dunlop and Son, Richmond Hill, Ontario.

R. Harisonii, varieties Antenor, Ardelia, Lucasia, Orinda, Regina, Rosania, Silvander and Valeria. (All open fertilized seedlings of Harisonii). Originated at Central Experimental Farm, Ottawa, Ontario.

R. Helenae, var. Patricia. (Open fertilized seedling of R. Helenae.) Originated at Central Experimental Farm, Ottawa, Ontario.

R. rubrosa, var. Carmenetta. (R. rubrifolia X R. rugosa). Originated at Central Experimental Farm, Ottawa, Ontario.

THE ROSE SOCIETY OF ONTARIO.

We have, in Ontario, a rose organization to which every one really interested in the culture of this flower should belong; the Rose Society of Ontario is an active flourishing institution which is doing much good in fostering a love for and knowledge of the rose. This organization, the third largest Rose Society in existence, is operated by a group of people who do the work simply and solely to help others to grow roses.

Membership costs one dollar per year, and includes one copy of the Society's Rose Annual; six copies of seasonal bulletins dealing with practical rose culture; a ticket to the Rose Show staged annually in Toronto under the auspices of this Society; and acquaintance with fellow-rosarians who will delight with you in friendships formed through this common interest.

Further information concerning the Rose Society of Ontario may be secured by writing to the Department of Horticulture, Ontario Agricultural College, Guelph, Ontario.

ACKNOWLEDGMENTS

The authors wish to express their deep appreciation of the co-operation of Mr. Roland Watson of the Provincial Motion Picture Bureau in securing illustrations for this bulletin; and to Mr. Henry Bertram, of Dundas, for the assistance he has given Mr. Watson.

Thanks are extended, also, to those commercial rose growers all over the Dominion who saw fit to reply to the questionnaire forwarded to them; a very unique contribution to rose literature being made possible through their co-operation.

Then, too, the material dealing with rose varieties (a modified rose symposium) could never have been presented without the able and willing assistance of Mr. J. A. Aitken and Mr. W. M. Gammon who, as students, assisted in taking the records tabulated in Tables III., IV., V., VI. and VII.

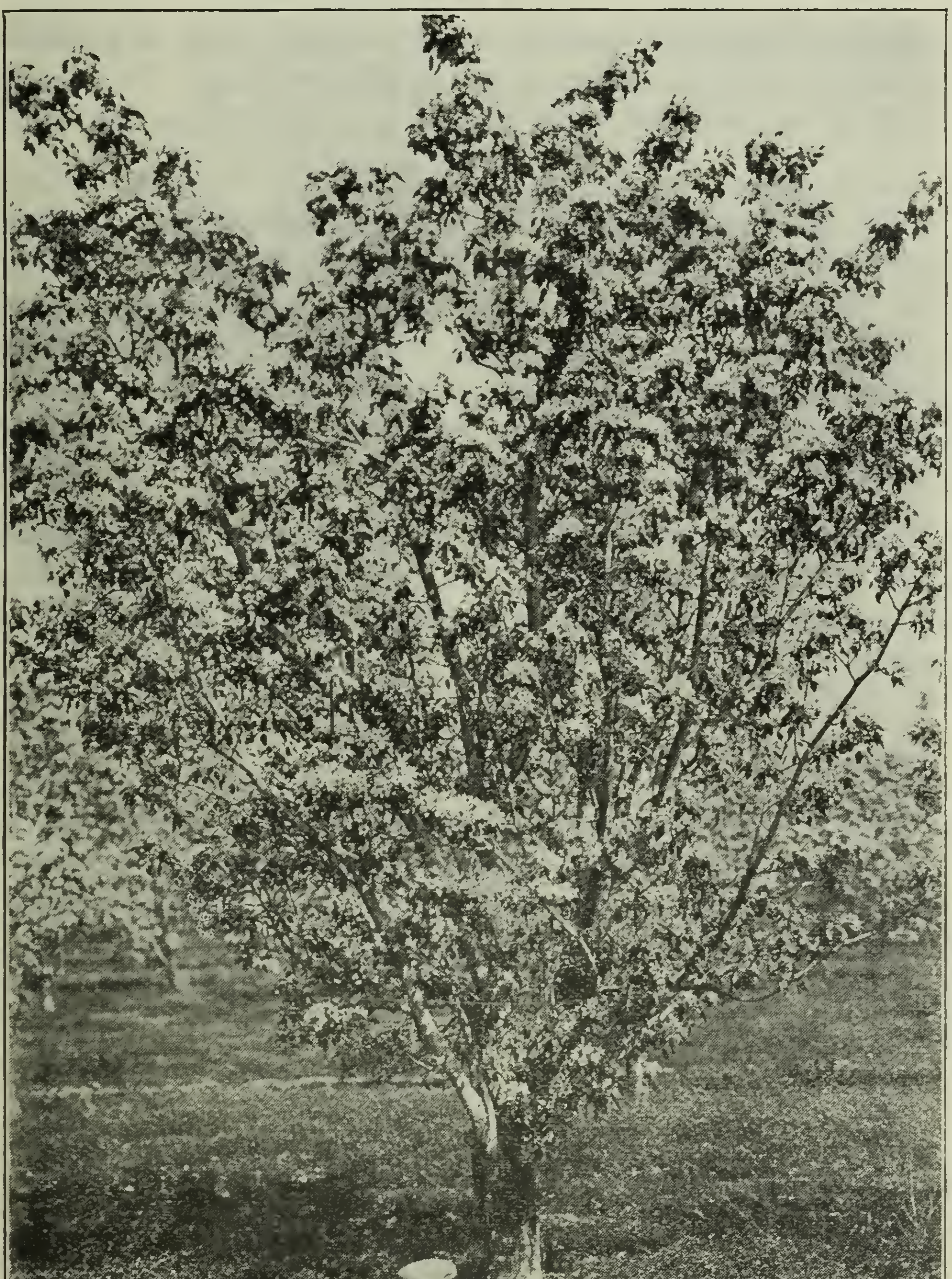
The writers also wish to acknowledge the co-operation of Professor L. Caesar of the Department of Entomology, and of Professor J. E. Howitt of the Department of Botany of the Ontario Agricultural College. Their respective contributions to the bulletin appear under the headings of "Rose Insects" and "Rose Diseases."

BULLETIN No. 354 MAY, 1930

Ontario Department of Agriculture

THE PEAR IN ONTARIO

D. A. KIMBALL and G. H. DICKSON



Dwarf pear tree in bloom, age, 10 yrs.

HISTORY

The pear is one of the oldest and most interesting of fruits. It was cultivated by the Romans hundreds of years before the Christian Era and probably known and used centuries before any record is available. This fruit reached its highest development with Belgian and, to a lesser extent French horticulturists commencing in the 17th century. To these workers we owe most of our present home garden and commercial varieties.

Pear seeds were brought to Canada by the earliest settlers, were planted in the Maritimes and Quebec, and spread with the development of the country. There is little definite information regarding the history of the pear in this country, but we are safe in assuming that it followed generally the course of the apple. The Ontario Experiment Stations from 1897 on, tested and reported on a great many varieties from many sources, the stations chiefly concerned with the pear being located at Whitby, Trenton, Maitland and Grimsby.

The varieties we grow have been derived almost altogether from the wild pear of Southern Europe and Asia (*Pyrus communis*). A few varieties, notably Kieffer, are hybrids between the former and a Japanese type, *Pyrus serotina*.

THE INDUSTRY

Over 90% of the Canadian pear crop is produced by Ontario and British Columbia. Nova Scotia produces about a tenth, or only enough to supply the local demand. The pear situation in Canada will be clearly shown in the following tables giving bearing and non-bearing trees, fruit production and importations. The figures will likely be found somewhat surprising in several particulars.

TABLE 1.

Fruit Production in Bushes.

	Dominion—Census Reports. 1900	1910	1920	Crop Reports. 1924	1925	1926	1927	1928	1924-1928 5-year average
Canada	531,837	504,171	450,000	196,809	156,422	266,440	332,200	300,000	250,400
Ontario	487,759	423,568	323,600	95,200	114,240	114,240	211,300	126,780	132,400
British Columbia	25,364	51,000	109,587	80,609	24,182	143,200	107,400	158,450	102,800

TABLE 2.

Trees Bearing and Non-Bearing.

(Census Figures).

	Bearing. 1901	1911	1921	Non-Bearing. 1901	1911	1921	Trees Purchased, 1921-1927 Inclusive.
Canada	617,293	581,704	450,000	344,808	385,538	175,000	300,000
Ontario	564,798	505,368	331,271	280,175	237,769	116,772	183,000
British Columbia	24,984	32,908	93,172	19,795	116,487	37,295	102,000

TABLE 3.

ONTARIO PRODUCTION AND TREES BY COUNTIES.

County.	Fruit—bu. 1910	1920	Bearing Trees. 1911	1921	Non-Bearing Trees. 1911	1921
Brant	7,243	6,042	7,141	5,237	2,306	1,946
Durham	9,115	2,869	9,715	4,460	4,362	1,981
Elgin	10,526	7,473	10,583	6,457	2,659	1,212
Essex	14,544	12,605	16,286	7,659	6,068	1,073
Grey	10,709	2,286	17,438	3,251	5,898	625
Haldimand	11,884	4,667	9,589	4,197	2,504	782
Halton	25,789	21,973	43,207	34,511	31,588	13,979
Huron	7,845	5,181	14,186	5,339	3,130	1,227
Kent	12,343	12,258	17,903	6,667	4,254	2,405
Lambton	11,062	12,260	17,913	8,293	7,856	2,770
Lincoln	86,645	98,715	97,465	105,944	60,228	29,436
Middlesex	12,880	12,748	15,761	8,485	6,481	2,781
Norfolk	13,707	10,009	13,706	8,627	7,164	4,283
Northumberland	13,056	2,303	10,821	2,814	3,972	517
Oxford	17,111	8,682	12,897	8,770	5,543	1,934
Peel	8,879	7,949	10,671	6,306	7,236	6,814
Welland	28,983	20,390	25,177	15,681	8,331	9,507
Wentworth	49,421	50,327	63,412	59,650	28,445	22,590
York	14,612	6,530	18,379	7,336	6,910	4,071

The Census figures for Ontario's crop are probably somewhat above commercial production. Other figures are from the Dominion of Canada Fruit Statistics for the years given.

Ontario production has decreased markedly although the number of trees has not decreased to as great an extent. This difference is due largely to the Pear Psylla which, shortly after 1920, threatened to wipe out the industry. Fortunately adequate control is now possible. Blight also has reduced acreages to some extent and lessened the interest in pear growing. Plantings of both bearing and non-bearing trees are decidedly less from 1911 on, and there have been barely enough new trees set out to keep up the number in bearing, if they will do even that. Taken by counties the number of trees, both bearing and non-bearing, showed a decrease between 1910 and 1920 of 20% to 60% in all except Lincoln, which remained stationary, while since 1920 there has been a further reduction. The counties of Lincoln, Welland, Wentworth and Halton produce two-thirds of the Ontario crop.

British Columbia doubled in production every ten years from 1900 to 1920, and since then has increased about 20%. Present indications are that the acreage will remain about as it is, just under that in Ontario. If it had not been for the increase in British Columbia the Dominion production and acreage would have shown a heavy decline.

TABLE 4.

PEAR IMPORTS—FRESH FRUIT (Dept. of Trade and Commerce).

Quantity—Bushels.

Year.	Total.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
1923	339,028	144	67	930	70	56	28	18,411	141,932	120,196	80,822	14,410	7,250
1924	395,684	2,222	8,749	1,496	140	73	73	26,591	112,171	81,665	76,706	110,997	3,308
1925	412,580	31	140	240	42	466	89	12,765	121,768	150,344	159,595	10,671	2,161
1926	464,560	668	1,008	536	814	82	310	57,100	155,590	164,627	77,606	43,989	3,804
1927	498,448	1,404	2,856	1,355	720	710	79	5,167	113,495	180,145	63,312	35,554	5,051
1928	409,675	2,105	619	2,916	280	80	163	44,794	193,708	192,200	123,580	43,670	4,443
							Value—$.						
1923	566,729	684	290	1,117	287	469	235	57,247	289,778	240,696	139,690	27,077	13,393
1924	782,464	4,840	7,023	1,729	951	565	517	85,432	301,027	220,871	99,170	89,870	7,742
1925	807,959	233	681	900	416	2,364	527	47,020	297,312	328,310	214,575	24,525	6,056
1926	926,398	2,057	2,389	847	1,390	375	1,492	137,992	269,556	262,316	116,091	47,657	7,432
1927	855,274	2,835	5,414	2,724	1,672	1,053	498	19,044	303,781	408,018	124,136	42,750	12,373
1928	928,565	4,557	2,189	8,494	1,381	367	717	115,676	344,651	330,036	152,465	49,790	10,315

Practically all of the imports shown were from the United States and the major portion came in the months of domestic production, August to November. On the basis of figures given later, it is likely that at least half of these were from New York and for canning purposes. Export figures as furnished by the Dominion Fruit Branch, show a five year average of only 23,000 odd bushels, slightly more than half being from British Columbia. With a population of 9,400,000 Canada used *3.2 lbs.* of pears per person per year, of which our growers supply *1.2 lbs.* The above figures are based on a five year average of production and imports less exports.

A survey of the Canning Industry in Canada for 1922, made by the Department of Trade and Commerce, gives the quantity of fresh pears used in this way as 189,117 bushels, chiefly packed in Ontario. It is impossible to find out the number of cases exported.

Further information on this phase of the question is given in a communication from A. Fulton, until recently Chief of the Markets Division, Fruit Branch, Ottawa. He says, in part,—

"Included in the imports there is an average of 150 to 200 cars brought in annually for canning purposes. This is divided up with about 150 cars for Ontario and the balance for British Columbia. So far as the varieties imported into Ontario are concerned, in 1928 about 130 cars were Kieffers and 20 Bartletts.

"According to figures published by the Agricultural Experimental Station, Ithaca, New York, showing the distribution of Western New York pears in Canada in 1924, it appears that 250 cars were brought into Ontario as follows:

Destination	Cars	Destination	Cars
Grimsby	56	Port Dalhousie	16
St. Catharines	29	Delhi	15
St. David's	28	Hamilton	11
Montreal, Que.	24	Niagara-on-the-Lake	10
Jordan	18	Waterford	10
Vineland	17	Winona	2
Fonthill	16		
		Total	252

Judging from the places at which the above cars were received, it is reasonable to expect that they were used for canning purposes. Prices paid for canning pears range from 2 to 2½ cents per pound.

"It is our information that the canners prefer the imported pears to the Ontario product not because they are of superior quality but on account of the ease with which they can purchase their supplies properly graded as to size and maturity. In addition to the imported product being better graded, price might also be an important factor entering into consideration. Also one of the great troubles in Ontario in so far as the canners are concerned, is the difficulty in purchasing pears owing to the necessity of dealing with individual growers rather than with organizations."

It is evident that the larger part of our pear requirements are imported at prices ranging from 90c to $1.15 per bushel for canning stock and considerably higher in the case of boxed fruits for dessert trade. The quantity of this latter must be considerable.

Pears can be and have been successfully grown outside what are now the main production centres, namely the counties of Lincoln, Wentworth, Welland and Halton. The tree is considerably more tender than the apple however, and present varieties should not be counted on commercially much outside the regions where the Baldwin apple is successful. Variety hardiness will be discussed under the head of varieties. The main questions to be considered before planting new orchards are: can blight be controlled, and do the prices mentioned above provide a profit to the grower?

It is unlikely that many will take sufficient precautions to save very susceptible varieties from blight. There are however, a few good kinds which are not highly susceptible and in which the disease can be economically controlled, especially as the trees get older.

Orchards which are not well fertilized and otherwise cared for due to the fear of stimulating blight susceptible wood have not a high enough production to give a profit at the prices mentioned. There is no information regarding the production per acre of varieties, and consequently very little on which to base an estimate. Census figures would indicate only about a bushel of fruit per tree for Province or Dominion, with a slightly increased amount in the more intensive districts.

CHOICE OF VARIETIES

The first thing to consider when making a choice of varieties is that for practical purposes all pear varieties are self-unfruitful, that is, they must have other varieties planted with them to insure fertilization of blooms. Certain varieties, as the Duchess, are more or less self-fertile or self-fruitful, and there are variable reports on other varieties indicating that under some conditions and in some seasons they may be self-fruitful. However, as self-fertile varieties set even better with pollen other than their own the best practice is that all pear varieties should be provided with suitable varieties to insure cross-fertilization.

For the most part pear varieties are interfertile, that is, any variety will set fruit freely with pollen from any other variety. Bartlett and Seckel are apparently one exception, and will not intercross. Since the booming season is relatively short in Ontario most varieties will overlap in bloom season. This permits the choice of desirable varieties without considering the effectiveness of varieties as pollinators for each other.

To insure proper pollination a minimum of one tree of the pollinator variety for every nine others might be suggested although more trees offer better opportunities for fertilization. When providing for cross-fertilization there must always be considered a minimum for the most adverse conditions. In a cold windy spring the bees are not nearly as active as when the weather is calm, warm and bright. Bad weather must be expected and provided against. Pear trees are planted closely together and for this reason the minimum of one to nine is suggested. With greater distance between trees, as for sweet cherries and apples, relatively more pollinator trees would be required for the same results.

Honey bees are the most efficient pollinating insects we have and if a grower does not have bees of his own, and is not getting a good set of fruit, he should make arrangements with some beekeeper to have bees in his orchard during the blooming period. For this purpose one hive of bees per acre seems to give ample in the way of pollen carriers. It must be remembered that this does not mean that for ten acres, ten hives in one spot is a proper arrangement. Bees are most active close to the hive and in stormy weather may not get very far afield. To provide for this the hives should be distributed well throughout the orchard.

Fig. 1.—Bartlett Pears—The top row shows the Russet Bartlett, a bud sport of ordinary Bartlett.

The next consideration in the choice of varieties is the type of fruit growing engaged in. (1) Is it the intention to specialize in pears? If so, the choice of varieties will probably be such that the season will be covered from early to late. (2) Is the preference for one or two varieties only to fit in with other crops now growing? The Bartlett pear fits in well with apple growing in that it is ready between the pickings of Duchess and Melba, and Wealthy and therefore tends to provide a continuous fruit picking season. (3) What market is being catered to? For fruit stand purposes a wide range of choice varieties can be planted. For canning factory purposes Bartlett and Kieffer have the preference. With these two it might be advisable to include a third variety as there is some doubt as to the value of Kieffer pollen in some seasons. A third variety would eliminate this doubt.

When the decision has been made as to where pear growing fits in with ordinary farm arrangements, the consideration of the varieties is of next importance, selections being made according to the plan adopted.

The following is the list of recommended varieties selected by a committee of growers for the Niagara District and arranged in order of maturity:

RECOMMENDED.	OTHER VARIETIES OF MERIT.
Giffard	Boussock
Clapp	Flemish Beauty
Bartlett	Clairgeau
Howell	Bosc
Anjou	Seckel
Duchess	Sheldon
Winter Nelis	
Kieffer	

Varieties worthy of note and limited trial are:

Cayuga
Conference
Gorham
Laxton's Superb
Russet Bartlett

The relative extent to which these varieties have been planted in recent years is indicated in the following table which lists those varieties of which more than 500 trees were planted. The British Columbia figures will indicate the trend of planting in that province.

TREES SOLD.

British Columbia.

Variety	1919	1920	1921	1923	1924	1925	1926	1927	Total 1919-27
Anjou	......	4,229	2,404	2,550	1,253	1,582	1,403	1,276	14,697
Bartlett	430	9,746	4,922	6,344	3,745	5,786	5,612	5,335	41,920
Bosc	......	520	750	1,369	521	......	961	624	4,745
Boussock	......	650	......	913	......	......	......	......	1,563
Clairgeau	......	1,155	628	1,162	571	......	......	516	4,032
Clapp Favorite	......	......	......	561	......	......	......	......	561
Flemish Beauty	......	5,683	4,471	5,851	3,166	3,596	4,037	2,160	28,964
Dr. Jules Guyot	......	......	600	1,170	......	466	......	......	2,236
Kieffer	......	......	......	......	......	......	......	......	......
Winter Nelis	......	......	......	583	......	......	......	......	583
Assorted	21,615	4,659	993	1,216	576	625	416	508	30,608
Total	22,462	26,723	15,622	21,994	10,365	13,580	13,956	11,048	......

Ontario.

Variety	1919	1920	1921	1923	1924	1925	1926	1927	Total 1919-27
Anjou	945	746	636	940	1,222	1,186	1,241	1,667	8,583
Bartlett	7,325	18,220	10,257	11,229	11,428	14,817	18,546	15,209	107,031
Clairgeau	531	......	......	......	......	......	......	......	531
Clapp Favorite	2,828	4,628	2,577	3,401	3,250	2,976	2,527	2,617	24,804
Duchess	......	1,561	711	882	1,244	2,363	1,432	1,615	9,808
Flemish Beauty	715	2,327	1,096	1,323	944	1,132	1,274	......	8,811
Kieffer	1,840	2,716	1,548	1,658	1,160	3,374	3,205	2,426	17,927
Sheldon	......	572	454	693	933	888	1,003	929	5,572
Assorted	11,912	5,568	950	1,428	10,188	2,595	1,394	1,608	35,644
Total	27,363	36,824	19,099	22,282	31,111	30,202	31,574	27,836	......

Giffard. The Giffard is a fine quality pear maturing just before Clapp's Favorite. The fruit is of medium size and attractive appearance. The tree has good vigor but is inclined to overbear in the "on year" and to obtain fruit of desirable size it must be thinned. The fruit ripens over a considerable period necessitating several pickings. This allows the smaller fruits to size up, but even so, some thinning is necessary if fruit of good commercial size is to be obtained.

Clapp. Where Clapps Favorite can be grown successfully it is a very desirable pear, ripening about a week or ten days in advance of Bartlett. Unfortunately the tree is very susceptible to blight and the fruit itself does not keep well nor will it ship any distance owing to a softness at the core. The trees are very hardy, bear well and thrive in very heavy clays but where blight is a serious factor the variety cannot be unreservedly recommended. In fact many claim it should not be grown because the variety is a constant menace, from the standpoint of blight, to other pear and apple varieties.

Bartlett. This is the most common and most popular pear grown in the Province. The tree is a heavy and regular bearer producing large handsome fruits of good quality which ship well and are so well known that they sell readily on all markets. The tree blights easily but with care can be nursed along and when mature is less susceptible to blight than when young. The tree is not as hardy as some, but is sufficiently hardy for the pear growing sections of Ontario.

Howell. The Howell is a pear of very uniform apparance and free from scab. The fruit is not high quality but the trees bear early, annually, and abundantly, making it a desirable orchard variety. It seems also relatively free from blight.

Anjou. If this variety were not such an uncertain cropper and the fruit did not drop so readily, it would be one of the most promising varieties. The fruit keeps well. It is in season over a long period, is of good quality and appearance. The tree is a strong vigorous grower and is much less susceptible to blight than many other varieties. Briefly, the most serious objection to the variety is its uncertain bearing habit and dropping of the fruit before full maturity, especially if heavy winds prevail.

Duchess. At the present time the Duchess market is dull and while this variety was included in the list of varieties a few years ago it is doubtful if it would be so placed to-day, although even in 1927 the plantings of this variety were still heavy. The Duchess has done best on dwarf stock and many orchards are so planted. The variety has proven an uncertain cropper and the fruit itself is large and coarse. Its chief use was for export, but the Old Country has stopped buying this variety. Nothing therefore remains but to replace it with better varieties. If the variety Conference succeeds as hoped in this country it will be a splendid variety to plant instead of Duchess for the same season.

Winter Nelis. The Winter Nelis is the standard winter pear and as such deserves a place. The fruit is small but of good quality. This is a variety which is hard to grow in the nursery and in the orchard usually makes a poor tree. On the Station grounds at Vineland it has done very poorly, but it is stated the variety does much better if topworked on

Duchess or Bartlett. The season for Winter Nelis is from Christmas to March and longer if kept in cold storage.

Kieffer. The Kieffer probably has done more to injure the fresh fruit pear industry than any other pear, but it has at the same time been one of the most profitable varieties from the grower's standpoint. If the grower will realize that this is a pear primarily for canning, and perhaps for export, and only grow it as such it still seems to be a valuable pear to plant. This is indicated partly by the pear imports in 1928 which consisted of 120 car loads of Kieffers.

Because of its firm flesh the pear when canned retains its color, shape and flavor and will stand shipping after canning much better than other varieties. For these reasons it is very popular with the canners and if the grower realizes that it is not a fresh fruit variety, unless for export, and plant accordingly it should still be a profitable pear to grow.

The tree is relatively immune to blight. For good crops it must and can be much more heavily pruned than any other commercial variety. This heavy pruning also helps to increase the size of the fruit and as the crop is sold by the pound to the canner this increased size is an important consideration.

Some years Kieffer pollen has appeared to be abortive. It will be safer not to depend on this variety to act as a pollinator but to provide an extra variety with it for this purpose.

OTHER VARIETIES OF MERIT

Boussock. The large handsome tree of this variety is one of its chief assets. The brisk acid quality of the fruit is not pleasing to many and the fruit soon goes soft at the centre. It drops readily unless grown in a sheltered spot. The regularity of cropping together with the handsome fruit and good tree seems to warrant it a limited place particularly for nearby markets. Season early September.

Flemish Beauty. If scab could be controlled economically on this variety it would be on the favored list without hesitation because it is of excellent quality, many claiming it to be the finest quality pear grown. To obtain this quality it is necessary to pick and ripen the pears under cover. The tree is one of the most hardy and is very prolific, but in certain seasons even with most thorough spraying it seems impossible to control scab. A connoisseur of pears would probably wish this variety retained because of its quality. Season late September.

Clairgeau. The appearance and shipping qualities of Clairgeau are its chief recommendations because the quality at best can be classed as fair only. It has a coarse granular flesh. Even with this lack of quality it is still considered a desirable pear for distant shipments to follow Bartlett on account of its appearance and ability to ship. The tree qualities are good and it can be grown either as a dwarf or standard.

Bosc. The Bosc has so many virtues that, in spite of its many defects, one is loath to discard it. The appearance and quality of the fruit is such that it can scarcely be faulted. Unfortunately, however, the trees are slow coming into bearing and are very susceptible to blight. When the tree is established and bearing it is not so subject to this trouble. The chief difficulty is to keep it free from blight, particularly trunk blight, until the trees are established.

Seckel. This variety has never been well enough known nor grown in large enough quantities for people in Ontario to know it other than as a pickling pear. The excellent quality and appearance, even though small in size, should give it a much better position than it holds. In the United States it ranks third in importance among pear varieties. The tree characteristics are ideal, a nice round-topped tree of excellent vigor, productive and is more resistant to blight than any other high quality pear. The fruit is of splendid appearance and excellent quality. Size is against it

Fig. 2.—A view of a wide planted pear orchard. This is probably the most productive orchard in the Niagara District. These trees are approximately 12′ x 24′ apart. The owner advises 20′ x 20′ or 16′ x 22′ for future plantings. Note the sod strip method of cultivation.

and unless the variety is known on the market, as it is not in this country, it seems doomed to remain a pickling pear.

Sheldon. The Sheldon is too erratic in bearing to be relied upon. The fruit is attractive and of good quality. The fruit keeps and ships well, but the trees are slow to come into bearing and the fruit often drops badly. The variety cannot be depended on except for a special trade or home use. Season October.

NEWER VARIETIES

In addition to the above there are a few varieties which have not yet had a trial in this Province, but which are worthy of note because of their possibilities.

Cayuga. Cayuga is a promising seedling of Seckel originated at the New York Agricultural Experimental Station, Geneva, N.Y. The following is the originator's description of the variety: "The tree characters of this new sort on the Station grounds seem to be about all that could be desired. The young trees are vigorous, healthy, and free from blight. This does not mean that the variety is blight proof; it will take years and plantings under many conditions to make sure of the relations of Cayuga to blight. The pears average as large as those of Bartlett, but in shape are similar to Seckel and in color to Clairgeau. The flesh is firm and fine in texture quite to the centre, with the rich, delectable flavor of Seckel. It is not too much to say that the quality is better than in any other standard sort excepting Seckel." Season about with Seckel.

Conference. The Conference, an English variety, was introduced there in 1894 and is now grown in enormous quantities and is said to be one of the most regular cropping varieties. The fruit is attractive and of good quality. In England it is regarded as an excellent pollinator for Bartlett. Michigan reports very favorably on this variety and considers it promising for extensive test.

In Ontario it has not fruited as yet, but from reports elsewhere it seems an excellent variety to grow instead of Duchess, which matures at the same season. It is possible the variety will not here develop the russet finish that it does in England, yet the Michigan fruit is attractive under conditions similar to ours. It is not badly troubled by blight.

Gorham. Gorham is another New York variety described as follows: "Gorham now offered by the New York Fruit Testing Association ripens its fruits a month later than Bartlett, and these keep six weeks or two months longer. The fruits resemble those of Bartlett in size, color and shape. The flavor is sweet and vinous with a very marked and pleasing aroma. The flesh is white, tender, buttery and juicy—a combination, which with the rich flavor and spicy aroma, make this one of the very best flavored pears of its season. Whether Gorham will resist blight can not be said—but as yet it has not blighted on the Station grounds. The tree are vigorous and productive."

Laxton's Superb. A cross of Beurre Superfin X Williams (Bartlett) which received the award of merit R.H.S., August, 1915, and is described in Laxton's catalogue as follows: "The best flavored early pear. Equal to Beurre Superfin and very similar in shape but rather larger. It wants eating two or three days after gathering."

Russet Bartlett. This pear originated as a bud-sport on the farm of N. P. Moyer and Son, Jordan Harbor. Examination of the parent Bartlett tree and of the "sport" branch show conclusively that it is a true bud sport. The russet fruits were first brought to the attention of the Horticultural Experiment Station in 1918. The following year grafts were secured from the russet-fruited branch and were inserted on a Bartlett tree in the Station orchard.

These grafts have been bearing fruit since 1922. These fruits, and the fruit from the parent bud-sport, are typical Bartlett fruits in all particulars save in the complete and handsome russeting of the skin, and also perhaps in season and keeping quality. Similar sports of the Bartlett as to russet color have been noted by other observers in Ontario, and in the states of New York and Michigan. This particular sport, while essentially Bartlett, seems to differ slightly from that variety in one or two particulars besides color. It hangs to the tree better than Bartlett, is a few days later in maturity, retains its quality longer if left hanging and, after picking, keeps for a longer period in ordinary storage.

Entirely apart from the russet coloring, therefore, this Bartlett budsport was thought to have sufficient merit to warrant distribution for trial purposes. Accordingly, a number of trees were propagated and were sent out by the Experiment Station in 1927. Possibly the variety should not be further propagated or disseminated until these trees have come into bearing and confirm or disprove the present opinion of its merits.

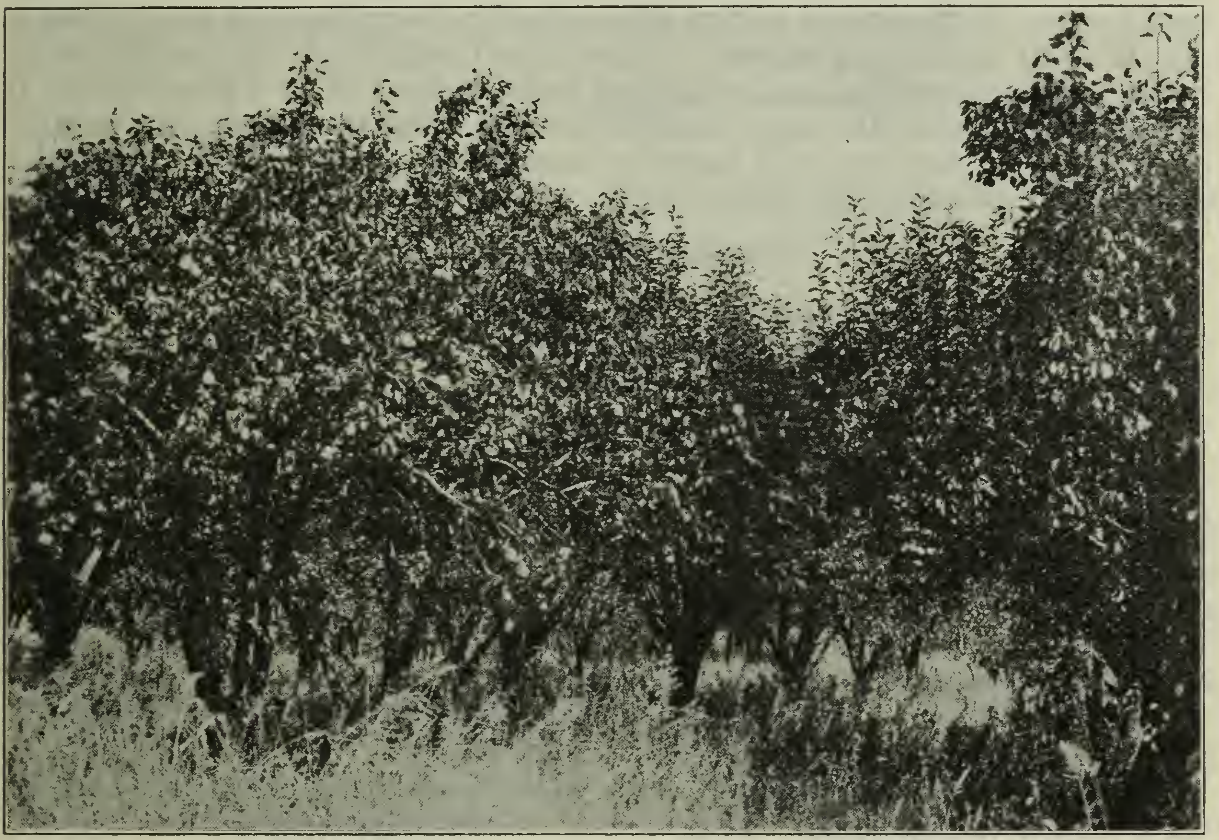


Fig. 3.—A closely planted pear orchard. In such an orchard it is impossible to secure commercial control of psylla. Removal of some of the trees would correct this condition.

LOCATION

Soil.

Before deciding to plant pears on a certain piece of land it is well to decide whether the soil is suited to pears or whether it would be more economically planted to some other crop. Pears generally grow best on a fertile heavy soil and while they will grow quite well on a fairly wide range of soils, a fertile clay of good depth is to be desired. The pear is deep-rooted, a much deeper feeder than the apple and for this reason depth of soil is desirable. They require considerable moisture but will not stand wet feet any better than other fruit trees, therefore wet spots must be avoided. The soil requirements of the pear are therefore, a fertile heavy soil of good depth, well drained and having a reasonably uniform moisture content.

Site.

The main thing to be avoided is the planting of trees in low areas where there is poor air drainage. The cold air settles down in these low spots and if there is no freedom of air circulation frost injury to the blossoms is very likely to result. Also the same conditions of poor air drainage during the summer form an ideal location for the pear psylla.

PLANTING

Preparation of the Soil.

Before any attempt is made at planting, the soil should be put into proper shape to receive the trees, that is, thoroughly worked up and in good heart. If the soil is not in good physical condition, in most cases it pays to delay planting a season. Grow some hoed crop to thoroughly work up the soil to insure the newly planted trees getting off to a good start. If a poor start is made the trees become stunted, with the result that it takes longer to get them into full bearing than had planting been delayed a season while the soil was being prepared.

Systems of Planting.

There are several systems of planting but for general purposes and for simplicity the one most in use is the Square, or the Rectangular, which is a modification of the Square system, as the name implies.

Distance of Planting.

The distance the trees are planted from one another will depend somewhat (1) on the variety, (2) on how much growth the particular soil is likely to give, (3) whether Standards or Dwarfs are used for fillers. A good conservative distance would be 16′ x 20′. This distance can be varied to suit local requirements, but it is best to err slightly on the side of too great a distance. If planted too closely the tendency of the crowded trees is to grow upright. To keep these trees within bounds heavy cutting back, with its accompanying dangers, is necessary.

One of the greatest dangers with close planting is that it provides the close, "dead air" condition so favorable to the pear psylla, and greatly increases the difficulty of its control. Wide planting therefore is to be encouraged and especially having a wide distance between rows as is allowed for in the 16′ x 20′ distance.

Time of Planting.

Either fall or spring is suitable for pear planting providing matured nursery stock can be obtained in the fall. Therefore it is a matter for the individual grower to decide for himself which time is the more convenient. Most nursery trees are fall dug and wintered in the nursery. When fall planted the trees are subjected to more drying of the tops than if heeled in by the nurserymen, but to offset this, they are able to get a much earlier start in the spring than spring planted trees.

Laying Out of the Field.

The importance of properly laying out the field for planting cannot be over emphasized. In olden days many considered that the only real advantage in having the rows planted straight from every direction was that of appearance, which was often a deciding factor when a sale was pending. To-day, with the tractor in common use, the rows must be straight, because with more rapidly moving machinery, it is impossible to watch and allow for all deviations in the row. Unless the rows are straight some injury to trees will result and a few barked trees cost more than the slightly longer time necessary to properly lay out the field.

First select a base line along one side of the field. This will probably be along a boundary line. Next set a stake on this base line where the corner tree is to stand, allowing plenty of room at the ends for turning. Next set a range stake at the other side of the field at the same distance from the boundary line. These two stakes establish the base line. Set in stakes the required distance apart beginning at the corner stake and working along the base line. At about the centre run another line at right

Fig. 1—The planting board made from inch board 5 feet long, 3 inches wide. Cut notches for stakes.

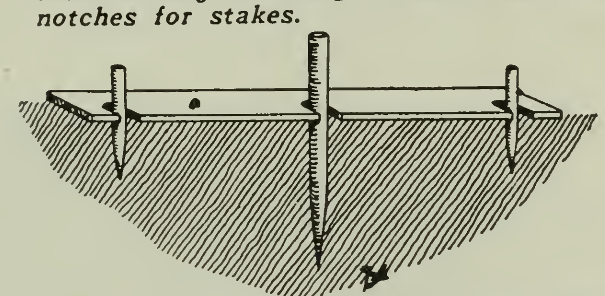


Fig 2—Planting board and stakes placed in position before digging holes.

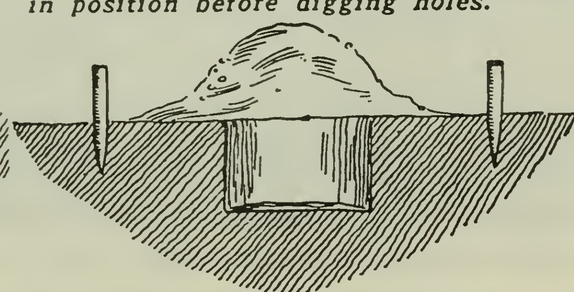


Fig. 3—Remove planting board and center stake, don't disturb the small stakes. Dig the hole.

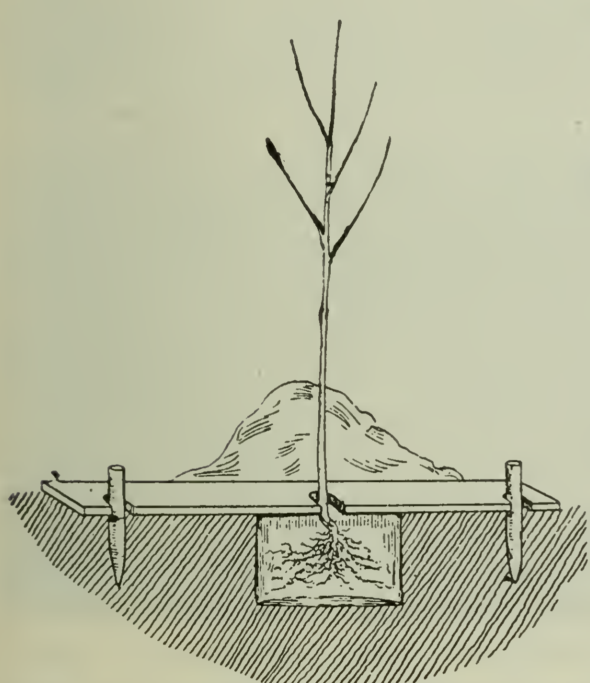


Figure 4

Fig. 4.—The planting board in use. (Courtesy Picture Bureau, Province of Ontario).

angles to the first. Use the carpenters' method of laying off a right angle, using multiples of 3, 4, 5 such as 30 and 40 ft. for the sides and 50 ft. for the angle. Repeat this operation at the two sides and the end opposite the base line. Then by means of a wire with marks at the required distances stake the other rows across. The measured lines will be guides for sighting to insure the straightness of the rows.

With a stake for every tree and having the whole field laid out with each stake in line every way the planting board is brought into use. This is simply a board about five feet long and six inches wide with a hole at each end and a notch cut in the edge at the centre. This board is placed on the ground so that the tree stake comes in the central notch. Then wooden pins are placed in the holes at the end of the board. The board is lifted off one pin and swung back on the other. The hole is dug for the tree in the position of the original stake. When the hole is ready the board is put back in place, the tree is slipped into the central notch and held in position while earth is put into the hole and firmed. The tree will then stand in the position formerly occupied by the stake.

If much planting is being done several planting boards will be useful. By having these boards alike men can go ahead, dig the holes and leave the end pegs. The planters follow using other, but identical planting boards on the same pegs. To insure further accuracy, if the boards are all placed one way, there should be no danger of any trees being off centre.

SYSTEMS OF ORCHARD MANAGEMENT

Intercropping.

With most of our tree fruits intercropping is strongly recommended, particularly if one is situated near enough to markets to permit the economical handling of truck corps. In many cases they are more desirable than the use of filler trees.

With pears, that ever present "bugbear" blight, must be considered. The general practice of intercropping can not be advised because the frequent cultivation and intensive methods necessary to obtain profitable returns from these intercrops are the methods which are most conducive to pear blight. There are possibly certain crops which might be planted, but it is safe to say that intercropping is not to be recommended in any district where blight is a factor.

Fillers.

The use of fillers in an orchard is a much debated problem because in the majority of cases the filler trees have little more than come into profitable bearing when they are crowding the other trees and must be removed. The expense of removing these trees and levelling up the orchard has probably done considerable to offset any returns from these trees.

On the other hand we must take into consideration the fact that these filler trees have been bringing in money during the early years of the orchard and have tided the grower over a lean period. Even if in the long run the filler system has netted a loss it may have been justified. This is particularly true for the man who is just getting established.

When one talks of fillers there immediately crops up the question, what is one to use? As a guide it is safe to say never plant any trees other than of the kind the standards are to be. That is, use apples with apples, peaches with peaches, etc. The reason for this is that most orchard operations, such as spraying, are so entirely different for each fruit that they cannot be combined economically. The spray which would benefit apples would be disastrous on peaches. Insects which are not serious on one fruit might harbor on it, and seriously infest some other fruit.

Some growers recommend the interplanting of pears and plums with the idea of removing the least profitable fruit when the trees begin to crowd. There are several objections to this practice, chiefly separate spray schedules, heavy plum curculio injury to pear fruits, and excessive distance of planting where either one or the other fruit is eventually removed.

On the whole therefore it is better to stay with pears if fillers are desired. With pears there is the advantage that many of the varieties are obtainable in dwarf form. Therefore it is not necessary to plant a possibly undesirable variety simply because the tree is an early bearing small growing tree.

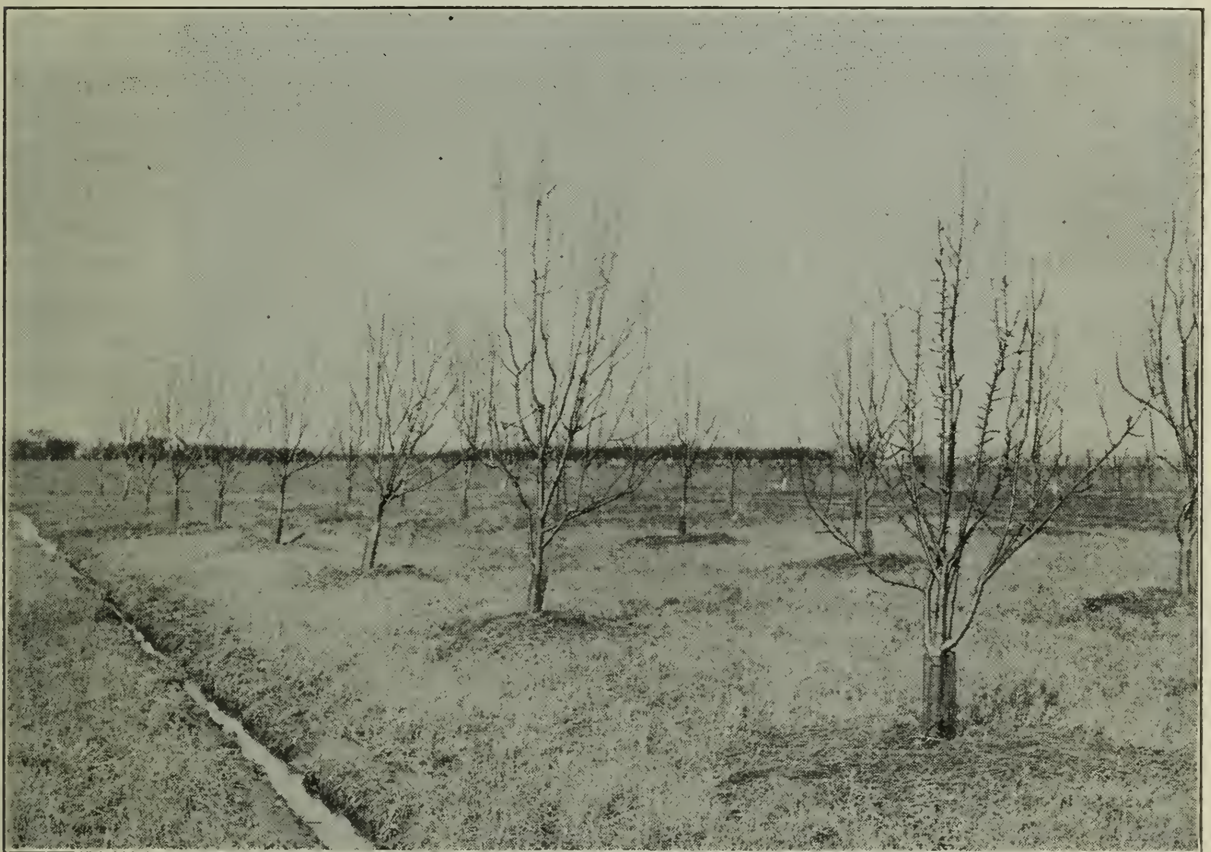


Fig. 5.—Young pear orchard in sod. Note the mulch immediately under the trees and also the wire guards as a protection against girdling.

With pears the smallness of the tree, allowing for relatively close planting, almost precludes the use of filler trees except in the dwarf form. They might perhaps be used as shown in the diagram using the large space in the centre of the rows for this purpose. P—Permanent. F.—Filler.

```
P     P     P     P
   F     F     F
P     P     P     P
   F     F     F
P     P     P     P
```

Some growers overcome this difficulty by the use of dwarf trees entirely. These are planted deep which causes the pear to send out roots above the dwarfing stock. In the early years of the orchard it is a dwarf proposition with all its merits. Later the trees are on their own roots and become standard in habit. When crowding commences the trees can then be thinned out to the required distance.

Cultivation.

The extent to which tillage should be practiced is a very live question and one to which considerable thought has been given in recent years not only in this country but in the south and west. This is indicated by the number of reports which appear from time to time dealing with modified cultural treatments and the necessity of adding humus to the soil.

A brief review of some of the conditions which have lead up to the present day recommendations might be useful. It will enable one to fully appreciate these changes and stand in a better position to study local conditions and modify them accordingly.

In the early days all orchards were grown in sod and were chiefly sidelines to general farming. As fruit-growing became a more specialized industry and without the present day knowledge of the use of nitrogenous fertilizers the sod orchards were not remunerative. This change in the fruit industry lead to the adoption of clean cultivation because this cultivation resulted in a very marked increase in growth. Not only were considerable quantities of nitrates liberated, but the heavy sod in decomposing supplied the soils for some time with an abundance of humus. This, together with such weeds or green manuring crops that grew prevented the soil from becoming seriously depleted of humus.

At the present time it would seem that many of our better growers are overdoing this matter of cultivation in the attempt to keep the orchards free from weeds. The result is that in certain localities to-day there are indications that the orchard soils seem to lack the texture they did years ago, and that many soils bake more readily than formerly. This is probably due to the continuous burning-out of humus by thorough cultivation and an insufficient green manuring crop growth. In older orchards, with late cultivations given, there is very little opportunity for such crops to make a worth-while growth.

Such conditions exist possibly only in a very limited way. Is it not possible that unless some thought is given this matter and a decided improvement made in the methods used that the time will not be far distant before greater difficulties are encountered? The old adage, "Lime makes the father rich and the sons poor," may be equally true of, "Too thorough orchard cultivation will make the fathers rich but the sons poor." Soils will be depleted to such an extent that it will be only with difficulty and considerable expense that they can be returned to a satisfactory degree of fertility.

Crop rotation is practiced in all other farming operations to guard against soil depletion. Granting that the roots of fruit trees are able to spread to great depths and widths, it seems reasonable to suppose that, unless some system is practiced to return ample humus to the soil, depletion is bound to occur. With this in mind a brief description of the various cultural practices will be given.

Sod Mulch.

Sod mulch for apples has received considerable attention throughout the country. From the results to date it is evident that, on soils which are not too shallow the sod mulch system of producing apples is both economical and practical. It must be realized however, that because grasses are gross nitrate feeders, and as there is no cultivation to liberate nitrates it will be necessary to supply the soil with sufficient nitrogenous fertilizers to offset these conditions.

With sod mulch no material is removed from the orchard and if necessary to give sufficient mulch it should be supplemented with strawy material. This mulch in the early years of the orchard is cut and placed about the trees to help conserve moisture. Later on when the trees reach a wide spread it is simply cut and let lie. As the mulch increases in thickness it

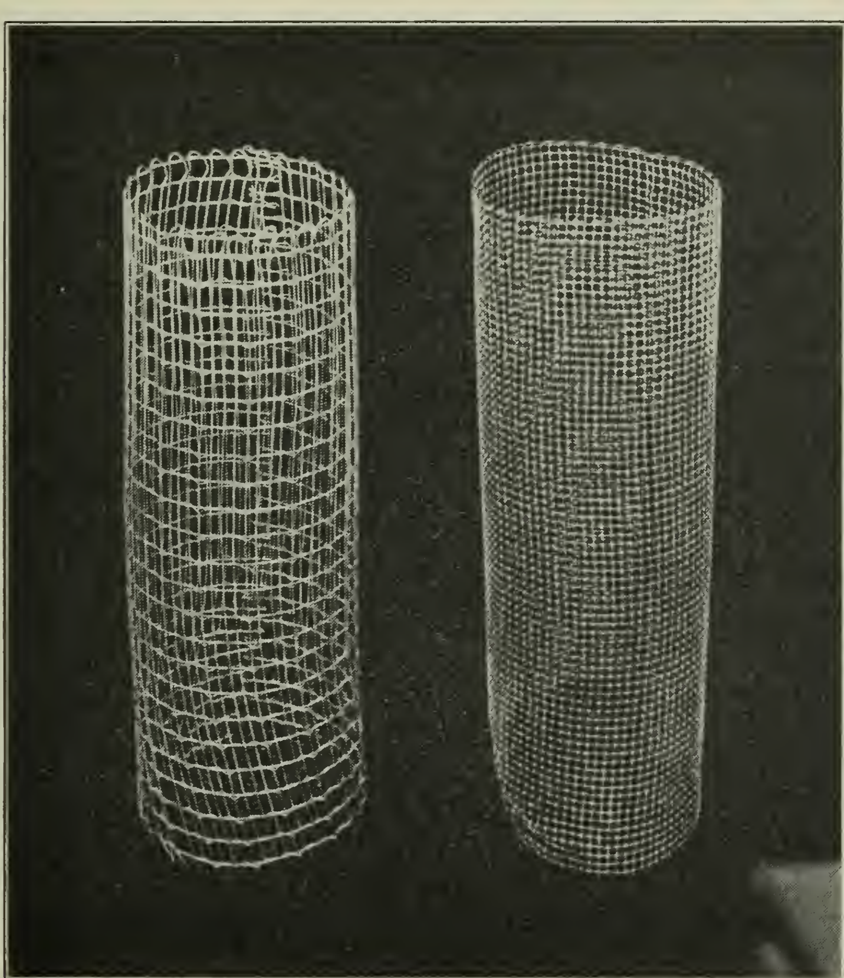


Fig. 6.—Two types of wire guards which may be used to protect young fruit trees from girdling by mice and rabbits.

helps to conserve rainfall by holding moisture instead of letting it run away, as in clean cultivation. Through this saving the moisture is usually ample for both trees and grass and no real competition results.

Grasses, as already indicated, are heavy nitrogen feeders and the nitrogen supply will have to be looked to, usually by annual applications. Phosphorus should also be supplied, particularly if alfalfa or a clover is used.

There is not so much known of the effect of sod mulch for pears as for apples but from five seasons' growth of Bartlett trees on the Horticultural Experimental Station grounds there is very little to choose between the two systems. While the clean cultivation trees are slightly ahead in diameter growth, the sod trees have borne more fruit to date.

The average increase in trunk diameter growth per tree (5 seasons) is as follows:

Clean culivation and cover crops	1.56 inches.
Clover sod mulch	1.48 "
Alfalfa sod mulch	1.34 "
Grass sod mulch plus 10 tons manure ann	1.24 "
Grass sod mulch	.96 "

Five seasons is, however, too short a time to judge future results but briefly some of the advantages from Sod Mulch are:

1. It costs less to bring the trees into bearing than under Clean Cultivation.

2. In a wet spring the grasses warm up the soil quicker and the trees get away to a quicker start.

3. With the mulch system it is always firm underfoot which facilitates pruning and spraying.

4. Blight is usually more easily controlled under sod.

5. The trees begin bearing somewhat earlier under sod and the finish to the fruit is more attractive.

6. While no tests have been made with pears, sod conditions do improve the keeping quality of apples. It is probably equally true of pears.

7. Less washing of soil occurs.

8. Most windfalls are not injured.

Some disadvantages which should be noted are:

1. Such conditions may prove favorable for certain insects and permit them to become troublesome (The Buffalo Tree Hopper, Curculio, etc.).

2. Offers a harbor for mice but where rabbits or mice are plentiful all trees should have a ¼" mesh 18" wire band about them. This placing of guards should be attended to in any case. The only extra then is to insure each fall that the guards are well in place about the trees.

3. May fail on shallow soils, but if a trial proves this system unsatisfactory a modification of sod can be used, or clean cultivation resorted to.

Sod Strip

The Sod Strip method of cultivation, which is the leaving of a strip of sod down both sides of the row and cultivating down the centre of the row, while used to a considerable extent with pears has all the objections of the Sod Mulch in harboring insects, mice, etc., and has few if any advantages over this latter method.

Where one is satisfactory the other would do equally well and it is mostly a matter of choice which is used.

Alternate Strip.

The Alternate Strip is a compromise system between Sod and Clean Cultivation and holds many of the advantages of both. With the Alternate Strip method, or the Johnston Method, as it is known in Nova Scotia, one land remains in sod one year while the other is receiving clean cultivation and cover crops. The next year this cover crop is allowed to grow while the other land is worked up. By this system only half the orchard needs to be cultivated any given year thus saving on cultivation and cost of cover crop seed. By permitting the cover crop to grow on through the next season it makes a good, substantial growth returning to the soil a heavy green crop which is difficult to obtain by the ordinary method in old orchards on heavy soils.

The Alternate Strip method also, due to regular working, keeps the harboring insects and mice more in check than does the complete sod system. Unfortunately the leguminous cover crops are the ones which lend themselves most readily to this system of cultivation. Until the

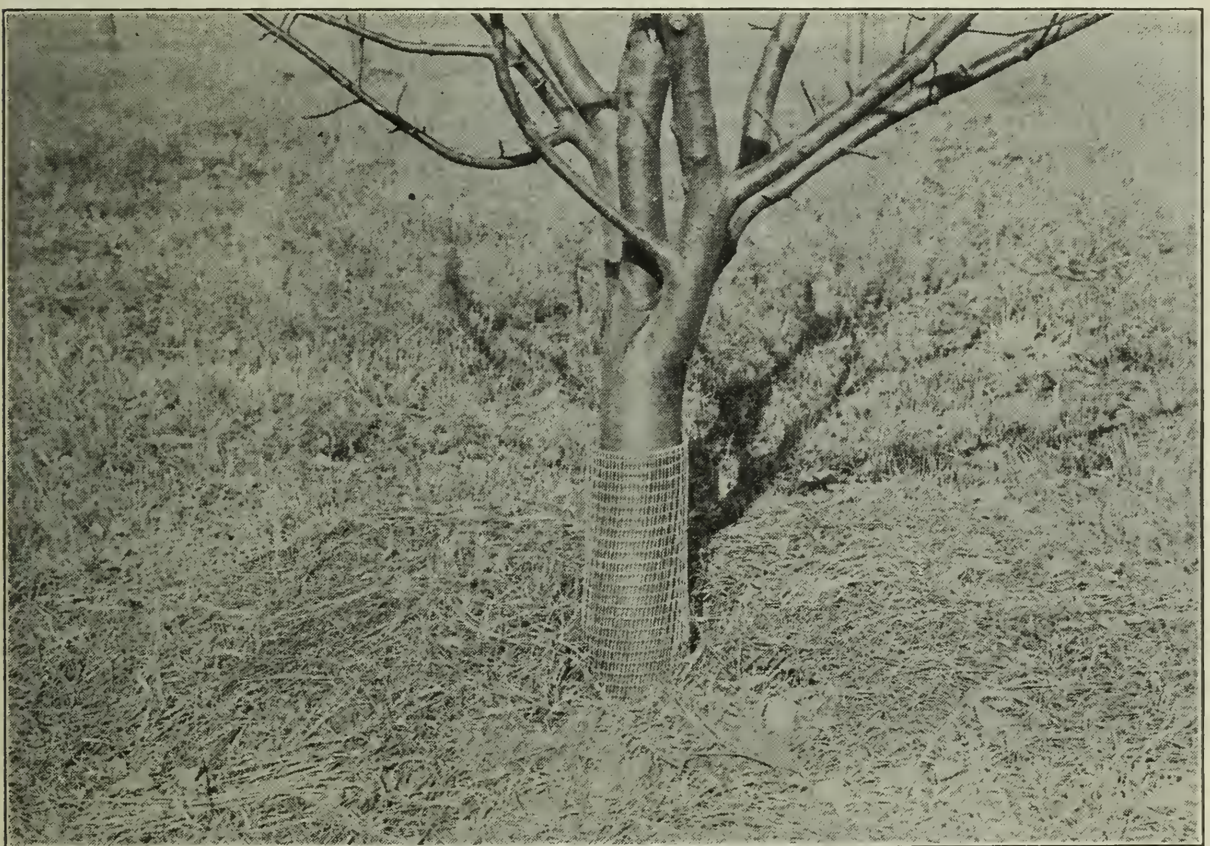


Fig. 7.—Young tree with wire guard in position. Note that the guard extends well into the soil around the tree.

orchards have reached regular bearing, such forms of cover crops have to be used judiciously and with caution because of their effect in promoting strong growth with consequent susceptibility to blight.

Tillage and Cover Crops.

At the present time the vast majority of our orchards are under clean cultivation and, as was intimated earlier, the matter of cultivation is perhaps being overdone. This would be especially true for pears.

Until more work is done on sod mulch systems with pears or if one thinks his soil is not adapted to this treatment, clean cultivation and cover crops is probably the safest and most conservative system to follow. Where cultivation is practiced for pears the recommendations would be—Work up the soil thoroughly as early as possible in the spring and then seed down to some cover crop. This early cultivation will stimulate growth early in the spring and permit the trees to make good growth. The early seeding will permit the cover crop to make sufficient growth to draw on the water and food reserve in the soil. This competition causes the trees to ripen their growth early and thereby escape the ravages of blight in July and August.

Early seeding will also allow the cover crops to grow to such an extent that when plowed under they will return something worth while in the way of humus. This improves the texture of the soil and helps it to retain moisture and fertility.

Fig. 8.—The alternate strip or Johnson method of cultivation suitable for both pears and apples. The new cover crop on the left is just getting away to a good start.

Cover Crops.

Cover Crops or green manuring crops as they might more properly be called, fill many purposes, some of the primary ones being:

(1) They add humus to the soil and thereby add to the water capacity of the soil and general fertility.

(2) They prevent leaching of the soils by making use of the available plant foods late in the season when the trees are ripening off. This is returned to the soil when the plant decomposes following cultivation.

(3) If left until spring before being plowed under they help to hold snow and prevent the soil blowing away during the winter. This consideration is quite a factor in some sections.

(4) They prevent the washing of soils to a marked extent.

(5) They may also assist materially in the prevention of bruises to fallen fruit and assist in keeping them clean.

(6) Certain cover crops add considerably to the nitrogen content of the soil.

Cover crops are two types, the leguminous (nitrogen gatherers) and the non-leguminous ones. The leguminous crops such as clovers, beans, vetches, etc., add nitrogen to the soil. This type is able, through the bacteria which live in the nodules on their roots, to take up and store nitrogen from the air. When the cover crop is plowed under or as the old roots decay, to be replaced by new, this nitrogen becomes available for the use of the fruit trees. As many of the leguminous crops have a deep root system they also assist materially in opening up the sub-soil.

The non-leguminous crops add considerable humus to the soil and prevent loss of much available food, but when plowed under they do not add any fertilizing element to the soil other than that which they took out.

When one follows the method of early cultivation and early sowing of a cover crop the crop to use is of greater consequence than when seeding is left until mid-July. Many of the crops used are annuals and when planted early they mature seed and ripen off before they have fulfilled one of their real objects, that of assisting to mature the trees. The clovers fit in splendidly with this type of cultivation, but unfortunately with pears they may over-stimulate tree growth. Therefore they must be used with discretion on account of pear blight.

Following are the leading cover crops which are recommended for general use, together with the rate of seeding:

Leguminous	Quantity per acre
Sweet Clover	12-15 lbs.
Red Clover	10-12 "
Hairy Vetch	1 bushel
Cow Peas	1½ "
Soy Beans	1 "
Non-Leguminous	
Buckwheat	3 pecks
Fall Wheat	2-2½ bushels
Japanese Millet	2 pecks
Rape	6 lbs.
Rye	1½ bushel
Weeds	....

Because of the necessity of carefully choosing the cover crop, if one uses the early seeding system, brief descriptive notes concerning each are given.

LEGUMINOUS CROPS

Sweet Clover. Sweet clover to-day, except where blight has to be considered, probably would rank first in importance among the cover crops. It thrives well on a wide range of soils and assists greatly in opening up the heavier soils. Sweet clover also adds greatly to the soil fertility and humus content as indicated by work conducted in Wisconsin which shows that 6.4 tons dry matter (sweet clover) furnishes as much humus forming material and as much nitrogen as would be furnished by 25 tons of average farm manure.

Red Clover. Red clover fits in with the early seeding where a legume can be used because it makes a good growth during the long season. It also is used with the Johnston system. Sweet clover is cheaper and returns more to the soil, but occasionally a grower does not wish the rank growth one obtains with sweet clover and for this reason prefers red clover. Red clover on many soil unfortunately winter kills easily.

Hairy Vetch. Were the price of hairy vetch seed not high it would be grown more as a cover crop than it is, but the price makes it almost prohibitive. Otherwise it is a splendid cover crop and even with the high price might be grown to advantage in combination with rye.

Cow Peas and Soy Beans. In some parts of the province these crops do well, especially the soy beans, but at the Station grounds at Vineland, they have not proven reliable. Where they will grow satisfactorily they make splendid growth and furnish a good cover to the soil. They kill down with the first frost. Soy beans are likely to prove the most reliable, using some of the O.A.C. strains.

NON-LEGUMINOUS CROPS

Buckwheat. Buckwheat ranks high as a cover crop because it will grow on almost any type of soil. It can be planted at almost any time, although if planted too early must be cut later to prevent seeding, which is a disadvantage. The plant furnishes lots of bulk and therefore humus to the soil. The seed is cheap. The plants kill down with the first frost. In exposed situation it may be advisable to plow the buckwheat down in the fall as it is somewhat easily broken and scattered by heavy winds. If planted thickly it makes a dense growth and becomes a good smother crop for various noxious weeds. On the other hand when sown lightly on heavy soils it makes an admirable nurse for various clovers. When the clovers are established the buckwheat is cut.

Fall Wheat. Fall wheat sown in the spring appears to have a place among cover crops where a non-leguminous crop for early spring seeding is required. There is danger even then that in certain seasons it may go to seed and be objectionable from that standpoint.

Japanese Millet. This is a rapid growing crop which can be sown late in the season and yet give a good growth by fall. It is killed early by frost but stands up well, holds snow well during the winter, and can be left until spring before plowing. It also will prevent the soil blowing during the winter.

Rape. Rape is probably the cheapest cover crop in use to-day. The seed is cheap and relatively small quantities of seed are required per acre. It makes a splendid cover and generally freezes down enough to allow the soil to be disced in the spring and thus saves the necessity of spring plowing. At fruit picking time some difficulties are experienced due to the rape holding moisture until late in the day. By the use of a roller or disc at that time this can be largely overcome.

Rye. Rye is a cool season crop and when planted at the regular early July season, if the weather is hot does not make growth until the fall. It is usually left for some time in the spring to make further growth. If care is taken this is a good practice, but it grows rapidly in the spring and must be handled at the right time, otherwise it gets out of hand. This is important if a large acreage is sown to this crop. On heavy soil, if plowed down when the soil is wet and the crop heavy, it has a tendency to dry out the soil quickly and cause it to bake in lumps. No observations have been made as to its value as a crop for early spring seeding but it should serve almost as well as fall wheat.

Weeds. Many growers depend on a volunteer crop of weeds to furnish them with a cover and providing a good stand of non-noxious weeds is obtainable they are satisfactory from a humus standpoint but will not qualify as nitrogen gatherers.

PRUNING

No actual pruning experiments have been conducted on the pear in this country, but as this fruit is quite similar in nature to the apple it

Fig. 9.—Unpruned pear tree—8 year old Bartlett.

seems safe to assume that the same *general* recommendations for the apple will apply to the pear. The following pruning information taken from Bulleton No. 323, "The Apple in Ontario," is therefore applicable here.

The Effect of Pruning on Growth.

Generally, the principal point to be considered in the formative pruning of a young tree is to select those branches which will make a strong well-balanced tree with a good distribution of fruiting wood around the circumference and throughout the outer two-thirds of the head.

In actual practice it may be somewhat difficult to get the trees to conform to any well-defined scheme of training, and consequently the orchardist will have to take the tree as it is and work toward the ideal.

After the head has been formed, corrective pruning only is necessary, until bearing age is reached. The heavy annual cutting back and thinning out of young trees which has been practised so extensively in past years serves no useful purpose, and in fact actually dwarfs the tree and delays fruiting. It is better to give the young non-bearing tree too little pruning rather than too much, delaying the heavier cutting until bearing age, when the danger of blight injury due to rapid growth will also be lessened.

The experimental work at Vineland and elsewhere has shown that the unpruned or lightly pruned non-bearing apple tree actually makes a considerably greater total wood growth than the more severely pruned tree, and also comes into bearing earlier. Pruning therefore does not make for an increase in growth, but rather inhibits growth. True, after dormant pruning there is an immediate growth from just back of the cut, of long thick sappy wood, the amount of such growth depending upon the severity of the pruning. Growth is thus apparently induced by pruning. But these sappy growths are not sufficient to make up for the amount of wood cut off plus the normal amount of growth that would have taken place on this pruned-off wood. In this case, therefore, pruning simply alters the type and direction of the new growth. In the lightly pruned young tree there is an even distribution of new growth in every part of the tree, the aggregate growth being sufficient to make it a larger tree than if heavily pruned. In the heavily pruned tree the wood cut off is not wholly made up for by the new growth induced.

The underlying reason for the unpruned or lightly pruned young tree being larger than the tree receiving more severe treatment is in reality very simple and logical. The soil may contain an abundance of proper plant food and the system may be well able to absorb it but this "raw" food must first go to the leaves and be there manufactured into "available" food before the tree can make use of it. The roots themselves must receive some of this manufactured food before they can grow and develop further. Pruning, by removing part of the possible leaf area of the tree, reduces by just that much the ability of the tree to manufacture plant food and the tree therefore does not make the amount of growth that it would if unpruned.

We see therefore that, theoretically, the more severe the pruning the tree receives the more will its growth be retarded. That this theory is absolutely correct is amply borne out by the great amount of experimental evidence resulting from work being carried on at various Experiment Stations.

Not only is the above true, but it is also true that the more moderately pruned tree, a tree in which the pruning is too little rather than too much, has a stronger framework better able to carry the maximum load of fruit. The heavily pruned tree ordinarily has many comparatively weak crotches and joints. The sappy growth incident to heavy pruning is not a strong growth. It is not strongly attached to its parent limb. The normal and natural growth in a tree consists in the pushing out of new growth from the terminal buds and such growth is the strongest that is made. This suggests that when a tree requires pruning, cutting back to buds should not be practiced, but rather the whole limb should be removed or the branch shortened back to a side branch, this side branch carrying on the growth of the limb. This kind of pruning will tend to keep the tree more open. When promiscuous cutting back of the young wood to buds is practiced, two or three of the buds just back of the cut will start into growth with the result that further pruning will be necessary to remove the surplus young branches, otherwise the tree will become bushy.

Heavy Pruning Delays Fruiting.

Thus far we have dealt only with the effect of pruning on the growth of the tree. It has also been mentioned that pruning, particularly heavy pruning, delays fruiting. Let us consider the underlying reason for this.

Briefly, it may be stated that there are two main classes of food which enter into the plant or tree. These classes of food are,—

Fig. 10.—Same tree as in Fig. 9. In pruning this tree it was necessary to sacrifice one or two very low branches which interfered with orchard operations. As the tree comes into full bearing it will assume a more open spreading form.

1. The moisture and mineral food or soil nutrients, principally nitrates, but including also potassium and phosphoric acid which are essential to the manufacture of the finished food.

2. The carbohydrates, the sugars and starches which represent the finished food manufactured in the leaves. This manufactured food is stored principally in the branches, twigs, and fruit spurs.

What have these foods to do with pruning? It has been established that a certain proper balance between the above two factors, nitrates and carbohydrates, or raw food and manufactured food, gives proper growth and fruiting in the tree. Therefore the fundamental principle underlying pruning is to first establish this proper balance and then, when the tree comes into bearing, to maintain it. It must be remembered, however, that pruning is only one means of maintaining this balance. Soil fertility is, if anything, more important. Trees on soil too rich in raw food will continue drawing from the soil large quantities of this raw food. This abundance of raw food will delay the establishing of the proper balance between the nitrates and carbohydrates and will therefore delay fruiting. Pruning should therefore be regarded not as an independent cultural operation, but rather as being correlated with other factors, particularly soil fertility and cultivation. However we shall discuss here the effect of pruning only, on the bearing of the tree.

We have all observed that the fruitful tree is a tree of moderate annual growth. Similarly the unfruitful tree if young, is a comparatively rapid grower; or if old, is making little or no new growth. Chemical investigation shows us that the vigorous unfruitful tree is high in "nitrates" as compared with "carbohydrates"; the unfruitful tree of poor vigor is just the reverse, while the fruitful tree of moderate growth has a comparatively "balanced" condition.

Pruning of vigorous unfruitful trees removes part of an already inadequate supply of manufactured food (since, as previously stated, this manufactured food is stored in the small branches, twigs, fruit spurs, etc.,) and therefore makes the proportion of carbohydrates to nitrates worse instead of better. Fruiting of the young tree is thereby delayed.

The impression should not be gained from the foregoing that young trees require no pruning. It is recommended, however, that there be more moderation in the pruning of young fruit trees until they reach bearing age than has heretofore been generally considered advisable. As previously mentioned, no pruning, or light pruning will give a larger and stronger tree and a tree which will come into bearing earlier than where more severe pruning is practiced. The unpruned or insufficiently pruned tree however, especially in some varieties, may grow too straggly and thick, requiring too severe treatment after it comes into bearing. We might possibly get a better conception of the question if we would consider the pre-bearing period as a "training" period for the tree where such pruning as is given is "corrective," consisting in the removal of undesirable branches and having as its object a well-balanced tree. After bearing age, pruning practice should have as its object the maintaining of the tree in fruiting condition by insuring a sufficient amount of new growth annually. Annual pruning and sufficient feeding will give this desired result.

Pruning the Bearing Tree.

The pruning of the bearing tree calls for somewhat different treatment than the non-bearing tree. Sufficient pruning should be given to keep the tree properly open, and to encourage moderate new growth each year. The following suggestions will serve as a guide.

1. Cut out broken, dead, or diseased branches.

2. Where two branches closely parallel or overhang each other, remove the least desirable, taking into account horizontal and vertical spacing.

3. Prune on the horizontal plane, that is to say, leave those laterals on the main branches that grow horizontally or nearly so and remove those that hang down or grow upward. This cannot always be done, but where possible it should be followed.

4. All varieties should be thinned out enough to permit of thorough spraying, and the entrance of sunlight and air.

5. Where it is desired to reduce the height of tall trees, cut the leader branches back moderately, to a horizontal lateral if possible.

6. Varieties which tend to produce numerous twiggy, lateral growths, should have some of these removed to prevent overcrowding.

Fig. 11.—20-year-old pear tree. Unpruned.

7. Make close, clean cuts. Stubs are unsightly and often decay, thus forming a source of injury to the parent branch or trunk.

8. Prune moderately. Very heavy pruning is likely to upset the balance between wood growth and fruitfulness, and generally should be avoided.

9. Prune regularly. Trees which are given some attention each spring are more easily kept in good condition than trees that are pruned irregularly.

10. Distribute the pruning throughout the tree. This is particularly important with old trees. New growth will be stimulated only in those parts of the tree where pruning has been given.

11. Do not remove a branch unless there is a very good reason for doing so. It should not be forgotten that the leaves of a tree are the food-

manufacturing organs, and if the leaf area is reduced unnecessarily the tree will be injured in growth, or fruitfulness, or both.

12. Kieffer seems to be one variety which should be heavily headed back for best results.

Time to Prune.

It has been said that the time to prune is when your knife is sharp. There is probably a measure of truth in this statement, but it is not a safe rule to go by, because some people never have a sharp knife.

Pruning is better done in the spring, preferably before growth starts, but in case it is impossible at that time it may be done immediately after the trees leaf out. It is desirable to have the wounds, particularly if large, heal as rapidly as possible to prevent decay. When pruning is done in the autumn or early winter, the cambium layer is likely to die and the wood dry out and split. It is obvious, then, that pruning is best done when the healing process is about to commence. This applies particularly to northern sections. In southern Ontario, no serious damage has resulted from winter pruning. In cases therefore where a large number of trees have to be pruned, it would seem advisable to do the work at any time during the dormant season when weather conditions permit.

THINNING

Pears do not usually require thinning to the same extent as many other fruits. This should be considered however, as a regular orchard practice when necessary and will undoubtedly prove profitable for late varieties or those that are inclined to run smaller than market demands. Overbearing on young trees results in stunting of growth, which is often permanent. Small pears, except the Seckel, are less in demand than undersize specimens of many other fruits, while uniform fruit and good size is demanded by canning factories and much desired by the fresh fruit trade. The necessity of uniformity to the canning trade is evident when machine handling and the appearance of the finished product are considered and the importance of size is clearly shown in the following figures taken from the Dominion Department of Agriculture Bulletin 90, 1927:—

Comparative Yield of One Ton of Bartlett Pears of Equal Maturity.

	2″ size	2¼″ size	2½″ size
No. of pears per ton	10,800	7,900	6,500
Dried yield in pounds	228	261	308
Drying ratio	8.7–1	7.6–1	6.5–1

As the differences were entirely due to waste in peeling and coring these same conclusions would be justified and applicable to canned fruit.

No market will take what it does not want if its requirements can be met from another source, and most growers know when their trees have set more fruits than can be matured to the required size for the variety. Only thinning will correct this condition. The work should be started as soon as the amount of fruit set is certain and can be carried on for a considerable period without loss of effectiveness. The cost need not be high if thinners learn to work with both hands and without breaking off the spurs.

HARVESTING

The careful handling of fruit is of far greater importance than the equipment used. It is frequently evident that a crop of fruit has been well grown, then careless picking or handling is allowed to ruin the work and expense which has gone before. Pears are much more tender than apples and therefore must be handled more carefully, even when green.

Bags are quite suitable for picking small trees but less bruising results if buckets or baskets are employed on larger trees.

Fig. 12.—Same tree as in Fig. 11. Pruned.

Time to Pick.

Most pears attain higher quality when ripened off the tree. If picked too green however, they will shrivel instead of ripen and never reach good dessert quality. With the pear, as perhaps with no other fruit, ideal quality is attained only by picking at a stage of maturity suited to each variety and while this is a connoisseur's problem rather than one for commercial growers, the fact remains that to reach its highest excellence the pear requires a specialist's handling.

The Western States and British Columbia are using a device called a pressure tester which measures the hardness of the fruit by the number of pounds pressure required to force a 5/16″ plunger a certain distance into the flesh. The pressure required for each variety when in best picking condition has been ascertained by trial. However, our diverse conditions of soil, orchard management and climate would materially affect the texture of the fruit and consequently its hardness at a given stage of ripeness, while western conditions are relatively uniform. When we have a large volume production of a few varieties from one district the pressure test method could probably be established with advantage.

The surest guide to time of picking under Ontario conditions is when the grass green ground color changes *slightly* to a whitish or yellowish green. Fruit that is fully white or yellow, although it may still be hard, is too mature for storage or distant shipment.

The ease with which the stem parts from the spur is also a valuable indication in picking, and harvesting before this time is too costly in the destruction of spurs and injury to fruit to be advisable. Varieties that loosen early may have to be picked sooner than they might otherwise be to avoid loss from dropping.

In many cases fruit for local sale and especially fall varieties would move more profitably if showing a tinge of white or yellow rather than full green. It is common practice, especially with Bartlett, to pick all fruit over 2½" in diameter and leave the smaller fruits to size up for later harvesting.

Storage.

There is no great interest in storing pears in Ontario at present although it will likely increase in the future. Pears go down more quickly than apples, are a more perishable product and cannot be held long in common storage. Unless wrapped many varieties will shrivel, while scald and blackening of the flesh will take heavy toll under common and sometimes cold storage conditions. For fully satisfactory results it is necessary to work out temperatures and conditions for each variety, although it may be stated that generally storage, soon after picking, at a temperature close to freezing is necessary. Some varieties, Bartlett in particular, scald badly if stored when yellow even though they are still hard. Oregon authorities however, state that the Bosc must be ripe when picked and immediately stored at 31° F., otherwise the quality is inferior.

GRAFTING

As far as the take of cions is concerned pears can be easily top grafted by using the cleft graft and methods described in Ontario Bulletin, No. 324. The developing of a producing orchard from such trees is not always entirely successful as will be explained hereafter.

Kieffer is the variety most commonly available in Ontario for top working and opinions vary widely as to its value as a stock for this purpose. The evidence is against using relatively old trees or those which have been bearing heavily, as cions set in such trees eventually break or die off, when cropping, although they may do well for a time. Somewhat better success may be expected from young trees.

It is never advisable to use blight susceptible varieties as stocks for top-grafting as the heavy cutting necessary causes succulent growth which provides ideal conditions for the disease to flourish. Because of the danger just mentioned smaller limbs should be grafted in the pear than the apple and a longer time taken to finish the tree, i.e., few limbs cut off at one time.

All things considered it is very doubtful if it pays to graft old pear trees, although some growers have done so successfully and can show orchards which have been in bearing for a number of years. Combinations between varieties of the common pear are more likely to succeed than grafts between these and the Japanese hybrids such as Kieffer.

STOCKS

The chief stock used for the pear has been French grown seedlings of the common pear (*Pyrus communis*). They have been, on the whole, satisfactory, except in their high degree of susceptibility to pear blight. The present trend, while waiting for a blight resistant variety of commercial value, is to obtain these characters in root, trunk and main branches with a root as adaptable to soils and variety as the French roots.

Trials with various stocks have been made including poor quality, but resistant varieties such as Kieffer and Old Home; the Japanese pear, *Pyrus serotina;* or one of the Chinese pears, *Pyrus ussuriensis.* The Japanese pear has been widely used in the United States but is, among other defects, not adaptable to varying soils. Kieffer is not altogether blight resistant and frequently varieties worked on it have proved to be short lived. Only certain types or varieties of the Chinese pear will produce uniformly blight resistant seedlings. M. J. Heppner of California in a recent stock survey found that the tendency is again toward French roots with an increasing interest in the Old Home variety on Chinese roots. These latter trees are later top-worked to the desired variety, the resulting double worked tree having blight resistant trunk, main branches and root. All things considered it is better for the grower to wait for definite information rather than to experiment with stocks, which trials may prove very costly in the end.

Ontario growers have used the Quince or dwarf root largely as a stock for the Duchess. With a decreasing demand for this variety, especially on the English market, plantings have almost stopped and many orchards are being torn out. Other factors causing the unpopularity of the dwarf root are its relatively short life, variation in trees due to the non-uniformity of the quince root and frequent low production on older trees. Some of the advantages are the large number of trees, (200 to 300) to the acre, making the loss of a tree a much smaller matter than with standards and also giving possibilities of a heavy yield per acre. The trees come into bearing before standards and allow the grower to more quickly take advantage of market situations and greatly lessen the non-productive period. The smaller trees are also much easier to pick, spray and prune although they require more careful pruning than the standard. Varieties that might be of interest to Ontario growers and recommended as succeeding on Quince stock, by various authorities are:—Anjou, Clairgeau, Clapp Favorite, Duchess, Flemish Beauty, Giffard, Hardy, Howell, Lawrence, Louis Bonne, Tyson.

DWARFS VS. STANDARDS

By Colonel H. L. Roberts, Grimsby.

The question of dwarf versus standard tree in pears seems to be decided more or less in favor of the standard in Canadian practice. It would look as if we had accepted this decision from the few experiments tried by American investigators.

I believe the matter requires a fuller and more careful test especially in the case of some varieties. Particularly is this the case when one realizes the wonderful results that have recently been obtained by the experiment stations in Europe, especially the work of R. G. Hatton, East Malling, England.

The difference in climate between ourselves and Europe might not make it possible to get quite the same results here, but when one finds that the careful selection of individual stocks for budding results in increase of bearing up to 70% it would certainly look as if this method required further test here.

The greater freedom from blight of the dwarf tree is in itself enough to justify farther consideration of this question, although there are quite a number of other advantages.

These advantages of dwarfing might be briefly summed up as follows:—1. Early bearing. 2. Less liability to blight. 3. Better quality fruit. 4. More regular bearing. 5. Lower cost of (a) pruning, (b) spraying, (c) thinning, (d) harvesting; with the undoubted ability to do a much more thorough job in any of these latter.

The great disadvantage is undoubtedly: less crop per acre (at least in heavy crop years).

The European grower has undoubtedly aimed at a higher class product and a more regular output than we have and has probably, owing to the dwarf being so universally used, succeeded in avoiding to a great extent, the glut markets for his products from which we suffer so much. This advantatge could not of course accrue to a Canadian grower owing to standard trees being so generally used here.

The older American fruit authorities (such as P. Barry, Rochester) in their fruit catalogues fifteen or twenty years ago recommended certain varieties as being superior on dwarf stock which I would imagine would be the result of actual test.

A point which I have noticed also is that some varieties particularly, such as Anjou, Louise Bonne de Jersey, if planted fairly deeply on dwarf stock, will in the course of a few years root out above the union and become later practically standard trees.

It would appear that this peculiarity is of great advantage, first, in getting the early bearing characteristic of the dwarf; secondly, the protection from the blight in the early years of growth; and thirdly, there would be no question in a tree developed on these lines as to incompatibility between stock and scion, which point, it is now beginning to be realized, is so important for good bearing.

Of course the variety enters very largely into the question. Low quality pears such as Kieffer would be an absurdity dwarfed. Bartlett (for canning purposes at least) could not likely be grown in volume enough on dwarfs to make it a paying proposition at canning factory prices.

To be satisfactory, the dwarf undoubtedly requires deeper soil and more fertilization than does the standard tree and the site would therefore require more careful selection for dwarfs than for standards.

We have at present surrendered our market for high quality winter pears entirely to the Western States, which is quite unnecessary if we would produce quality pears rather than bulk, and the right varieties.

PEAR BLIGHT

Fire blight (Bacillus Amylovorus) was at a low point in the Niagara District during 1929, probably due to a lack of natural blight disseminators. One or two suggestions are offered as to certain factors which may contribute to the recent relative freedom from blight. So little is known about these contributing factors it is safer to assume that the disease may be passing through a period when natural means of spreading it are scarce. Nevertheless we must be on the lookout for fresh outbreaks and be prepared to control them.

Pear blight is a bacterial disease which lives in the delicate tissues of the inner bark and increases with such rapidity that the conducting tissues are soon blocked and the infected area dies. The bacteria work down the twigs and branches and eventually if not checked enter the larger branches where hold over cankers are formed from which new infection spreads.

The more succulent the twig growth the more open are the conducting cells and the more rapidly will the disease travel and the greater the losses. As the growing season advances and maturity begins the growth becomes less active, the conducting cells smaller, and the disease is slowed down. If the disease development is arrested in small limbs it usually dies out, the twig becoming dry, but it will continue to grow slowly in large limbs even when growth is slow and as soon as conditions are favorable disease growth again increases rapidly. These latter areas also are the places from which new infections arise.

Cultural practices therefore are those which offer the best protection to the grower. As far as possible all orchard practices should be made with the object of blight control in mind. Cultivation should be the minimum to keep the trees in thrifty productive condition without causing succulent growth. Pruning should be of the light corrective type and in addition to this pruning, special sanitary precautions are also necessary as follows:

During the dormant season all branches showing traces of blight should be cut out and the trees should be looked over for any "hold over" cankers. These when found should be removed by carefully cutting them out. This is done by the use of a spoke shave or farrier's knife. The injured area is trimmed away until all traces of the injury are removed. The diseased tissue is removed back until the cambium is free from the characteristic little black spots and has the natural appearance of healthy tissue.

Summer treatment for blight has usually proven ineffective and often is the source of new infection, but as a supplementary measure the pear orchard should be gone over during the early summer and all suckers or water spouts removed. If this operation is done at the right time no cutting will be necessary as they will break out readily. As this type of wood must be removed anyway this is the most economical time to do it, but however the main reason of doing it now is that blight is prevented from getting on this growth and developing down into the main limbs, trunk or possibly the roots.

This removal of water spouts in the early summer should become more of a recognized practice. Its value has been clearly demonstrated in the control of cherry aphids and many sweet cherry growers are removing all sucker growth as a matter of course. Pear growers would be well advised to follow the same practice with their pear trees and if these suckers are kept removed, limited pruning and cultivation given, the thorough winter clean up of blight should keep the disease well in check.

When summer cutting out of blight is considered necessary the tools should be thoroughly disinfected and the wounds also treated. Probably the best disinfectant for this purpose is the one used by the Michigan State College workers who have carried on an extensive blight control programme for some years. It is as follows: 8 half gram tablets of cyanide of mercury, 8 half gram tablets of bichloride of mercury in one pint of warm water. Add three pints of commercial glycerine and two packages of cardinal red dye. This latter is a guide to where the disinfectant has been used. Keep in a glass container and apply to the cuts and tools with a small brush.

INSECTS AND DISEASES AFFECTING THE PEAR

The pear is subject to many insects and diseases, the greater number of which also attack other tree fruits, the apple chiefly. The most destructive insect, in the pear districts, is the Pear Psylla. These pests are all fully dealt with in the Ontario Bulletins, "Insects attacking Fruit Trees" and "Fruit Tree Diseases." Those interested are referred to the above bulletins and the Ontario Department of Agriculture Spray Calendar.

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Ontario Department of Agriculture

HORTICULTURAL EXPERIMENTAL STATION

VINELAND STATION, ONTARIO

The Raspberry and Blackberry in Ontario

W. J. STRONG

INTRODUCTION

The raspberries under cultivation in Ontario fall naturally into three main classes or groups, namely, the red, the black and the purple, while the blackberries and dewberries form another group. The red raspberry is, however, by far the most important of these and so most attention is given to it in this bulletin. Next to the strawberry it is the most important small fruit grown in Ontario and also in Canada.

The primary purpose of this bulletin is to present to the novice information that may be of some assistance in growing the 'bramble' fruits, although it is hoped that the experienced grower will find some points that are of interest and help.

The information here assembled has been obtained from various sources but more particularly from the experience of the writer, from various publications, and from commercial growers. To the growers who gave freely of their experience by conversations and by filling in and returning the questionnaire sent to them, especial thanks are due.

ORIGIN AND HISTORY

Various types of raspberries and blackberries are found growing wild in most of the temperate regions of the world but more particularly in Europe, North and South America and Asia. They are commonly spoken of as 'brambles' and all belong to the genus *Rubus* which is the most important, from the fruitgrowers viewpoint, of the many genera of the great Rosaceae family. In this family also are to be found the roses and many of our common fruits such as the apple, pear, plum, peach, strawberry, etc.

The Red Raspberry. The red raspberry is known in Europe as *Rubus idaeus* and probably has been cultivated since the 16th century. Pliny speaks of wild raspberries being obtained from Mount Ida in Greece after which it is supposed to have been named by the botanist Linneaus. The American red raspberry is classified by some botanists as *Rubus Idaeus,* variety *strigosus,* while others call it simply *Rubus strigosus* believing it to be a separate species from the European type.

Owing to the plentiful supply of red raspberries found growing wild in North America during its early settlement there was no inducement to bring this plant into cultivation. However when towns and cities began to develop, a demand arose for this fruit which could not be readily supplied from the wild sources and so people began to turn their attention to growing raspberries in their gardens. To meet the consequent demand for plants William Prince, in 1771, offered plants for sale. He had a list of three varieties which later was increased to four; these included White, English Red, American Red and Large Canada. The White belonged to the Old World species while English Red, later changed to Common Red, together with the American Red and Large Canada were of the American type, Large Canada being found in great abundance in the vicinity of Montreal. In 1830 William Robert Prince, son of William

Picking red raspberries in Ontario. Note type of carrier in foreground. (*Courtesy Province of Ontario Pictures*).

Prince, described Red Antwerp, Yellow Antwerp, Barnet, Brentford Red, Tall Red Cane, Short Jointed Cane, Cretan Red and Prolific Red, which probably were of European origin, and Virginia Red and Pennsylvania, of American origin. Altogether, Prince listed eighteen red raspberries and in 1845 Downing listed twelve, most of which were of European origin. These European varieties however, did not hold up long against the hot summer suns and cold winds of Eastern North America. Among the first of American origin to become prominent were the Stoever and Brandywine, the former found wild in Vermont while the latter was of unknown origin.

Around 1860 to 1870 may be considered as the time when commercial raspberry growing began and strange to say the outstanding variety of today, namely, the Cuthbert, originated about that time.

The Black Raspberry. The black raspberry or black cap (*Rubus occidentalis*) is a native of North America. It is found on the borders of woods from Ontario to the Carolinas but it is not known when it was first brought into cultivation. Probably the first named variety was the

Ohio Everbearing found and introduced in 1832 by Nicholas Longworth, Cincinnati, Ohio.

About the middle of the 19th century the commercial culture of the black raspberry may be said to have started, but by this time only three or four varieties had been introduced. Its development as a commercial berry was no doubt retarded by the greater preference for the red varieties and also on account of the greater difficulty of propagation. With the application of its tip-rooting habit to propagation by H. H. Doolittle of New York its commercial culture began to develop and has since become well established, not so much perhaps in Ontario as in the States of New York, Ohio and Michigan, where it is used largely for canning.

The Purple Raspberry. This raspberry is looked upon by most botanists as a natural hybrid between the red and black species. Its botanical name is *Rubus neglectus* so named by Peck, at one time botanist of the State of New York, but on account of its supposed hybrid origin and its great variability it is doubtful whether it should be classed as a definite species. Its plant characters are somewhat intermediate between the black and red varieties while it propagates like the black from 'tips'. Its fruit is rather variable in color being of various shades of purple but never black or red. In texture the fruit is softer and more juicy than the black though firmer and drier than the red; it often crumbles rather readily. It is not clear just when it came into cultivation but Prince in 1832 described two varieties in his 'Pomological Manual'.

Blackberry plantation in spring.
(*On farm of Delos Price, Jordan Station*).

The Blackberry. The blackberry (often loosely referred to as dewberry, lawtonberry, kittatinny, etc.) although belonging to the same genus as the raspberry, is quite distinct from it, one of the simpler distinctions being the way in which the fruit comes off the fruit stalk. In the raspberry the 'core' stays on the plant when the fruit is picked while in the blackberry it comes off with the fruit. There are numerous species of blackberries growing wild several of which have entered into the development of the cultivated varieties. Just which ones it is difficult to say as botanists apparently do not agree on this point. Many of our so-called varieties have simply been brought into cultivation from the wild and very little has been done to improve them. The first variety to be named was the Dorchester, a seedling, introduced in 1841 by Eliphalet Thayer of Dorchester, Mass. Following this was the Lawton, known also as New Rochelle and Seacor's Mammoth; it was found by Lewis A. Seacor near New Rochelle, N.Y. and introduced by William Lawton of the same place about 1842.

Interesting as the history* of these fruits may be, this brief outline must suffice and discussion of varieties now under cultivation will be taken up under the title 'Varieties'.

VARIETIES

RED RASPBERRIES

It is estimated that between three and four hundred varieties of red raspberries have been grown at some time or other on the North American Continent. Card in "Bush Fruits" describes nearly three hundred varieties and Hedrick in "Small Fruits of New York" describes over three hundred; doubtless others have been grown that are not included in these lists. Of these, very few indeed are now grown in Ontario by the commercial grower. Judging by replies received in response to our questionnaire there is only one of the old varieties grown at all extensively, namely, the Cuthbert. Other varieties grown to a more limited extent are Marlboro, Herbert, King, Brighton, St. Regis or Ranere, Latham, Ohta, Newman, Viking and Adams 87. All of these are of more recent origin than the Cuthbert and several of them are hardly out of the experimental stage. Various others of recent origin have been tried at different times but they do not seem to have met with favor as commercial varieties in Ontario.

The Cuthbert is described below in more or less detail while briefer notes are given concerning other varieties of interest to Ontario growers.

Cuthbert. This variety has been grown more extensively than any other, not only in Ontario but in most of the raspberry growing districts of Canada and the United States. It originated in 1865 as a chance seedling in the garden of Mr. Thomas Cuthbert at Riverdale, now part of New York City, and has been known under several names such as Conover, Queen of the Market and Quimby's Favorite. Its parentage is not definitely known althought it is thought that it may be a seedling of Hudson River Antwerp as it was found growing near a plantation of that variety. If this is the case it would seem that this outstanding American variety may be traced back to an European origin, for Hedrick in "Small Fruits of New York," states that "the Hudson River Antwerp is supposed to have been brought to America about 1817 by a Mr. Briggs of Poughkeepsie, New York, who obtained it from the garden of the Duke of Bedford in England."

The Cuthbert thrives over a greater range of conditions than any other variety hence its wide spread cultivation. It is a strong vigorous grower, makes almost too many suckers and bears good crops of large dark crimson fruit. The dark color is objected to by some as the berries are apt to look stale on the fresh fruit market in a comparatively short time. For canning, however, Cuthbert is the favorite variety chiefly it would seem on account of its undoubted high quality and the rich colour

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*For further historical information and discussion of early varieties the reader is referred to "Small Fruits of New York" by Hedrick et al and to "Bush Fruits" by Card. The writer has made free use of these publications and gratefully tenders his acknowledgments.

of its fruit and juice. As a shipping berry it is usually very fair to good although it is not as firm as several of the other varieties mentioned above. Probably its chief weaknesses are its susceptibility to virus diseases (mosaic etc.) and its lack of complete hardiness; it is apt to winter kill rather badly in some seasons especially in exposed locations.

Marlboro. This variety was originated by a Mr. A. J. Caywood of Marlboro, New York, about 50 years ago and was introduced in 1884. It is supposed to be from a cross of one of Mr. Caywood's seedlings with Highland Hardy which originated as a chance seedling about 1870 on a farm at Highland, N.Y.

At one time this variety was grown quite extensively but of late years it seems to have lost favor. It is still the principal early variety in parts of New York State and in Colorado. In Ontario however, it is grown hardly at all; not one grower returning our questionnaire spoke of growing it at the present time. Just why it should fall off so in the growers

Viking red raspberry plantation in early spring. Planted on the hedgerow system. (*On the farm of Ezra Honsberger, Jordan Station*).

estimation is perhaps explained when we remember that it has several serious faults, chief of which are its susceptibility to virus diseases and its lack of vigour; it is also apt to suffer from drought and is somewhat particular as to soil, not being as adaptive in this respect as many other varieties.

Herbert. It would seem that the Herbert is the pioneer amongst improved varieties originating in Canada. It is a chance seedling found in 1887 in the garden of Mr. R. B. Whyte of Ottawa. The Experiment Station at Geneva, New York, rates it as one of the best varieties on account of its vigour, hardiness and productiveness and because it does not appear to contract mosaic as readily as some other varieties. The Central Experimental Farm at Ottawa reports some very high yields for this variety at Ottawa. Card in his 'Bush Fruits' says it is very hardy, especially adapted to cold climates. It undoubtedly is a good variety in the colder parts of Ontario, more especially where the snow stays on the ground all winter. It does not however, appear to stand up any too well in the Niagara fruit district where the winters are comparatively mild but very changeable and where it is unusual for the ground to be deeply covered with snow for any length of time.

As a rule the plants are tall and vigorous but they are a little shy in throwing up suckers. The fruit is large, somewhat rounder than Cuthbert and a little lighter in colour. It is only fair in quality and is apt to be soft and crumbly. In season it is about the same as Cuthbert.

King. It is uncertain when this variety originated but it was grown from seed by Mr. T. Thompson of Richmond, Virginia, and was introduced in 1892 by the Cleveland Nursery Co. of Rio Vista, Va. The plants are fairly tall, upright and vigorous and they form suckers moderately freely. It does not seem to take mosaic quite as freely as some varieties. The fruit is medium in size, not as conical as Cuthbert and is apt to be soft and crumbly. Quality is fair. It is grown fairly extensively as an early variety.

Brighton. This variety was originated by Dr. William Saunders of Ottawa in 1887 and was introduced in 1907 by the Central Experimental Farm. Its parentage is unknown. The plant is moderately tall, vigorous and hardy and usually throws up plenty of suckers. It is rather susceptible to mosaic but no more so than Cuthbert. The fruit is of medium size and dark red in colour. It is inclined to be a little soft. As an early variety it would seem to have considerable value.

St. Regis or Ranere. This variety was first grown under the name Ranere but in 1912 it was introduced as St. Regis by the J. T. Lovett Co. of Little Silver, New Jersey. It is classed as a fall-bearer but will produce a fair crop in the summer. It is moderately vigorous and does not appear to contract mosaic very readily or at least does not show its effects. Apart from its apparent resistance to mosaic there does not seem to be much to commend it and its fruit is apt to be small, soft and of poor quality.

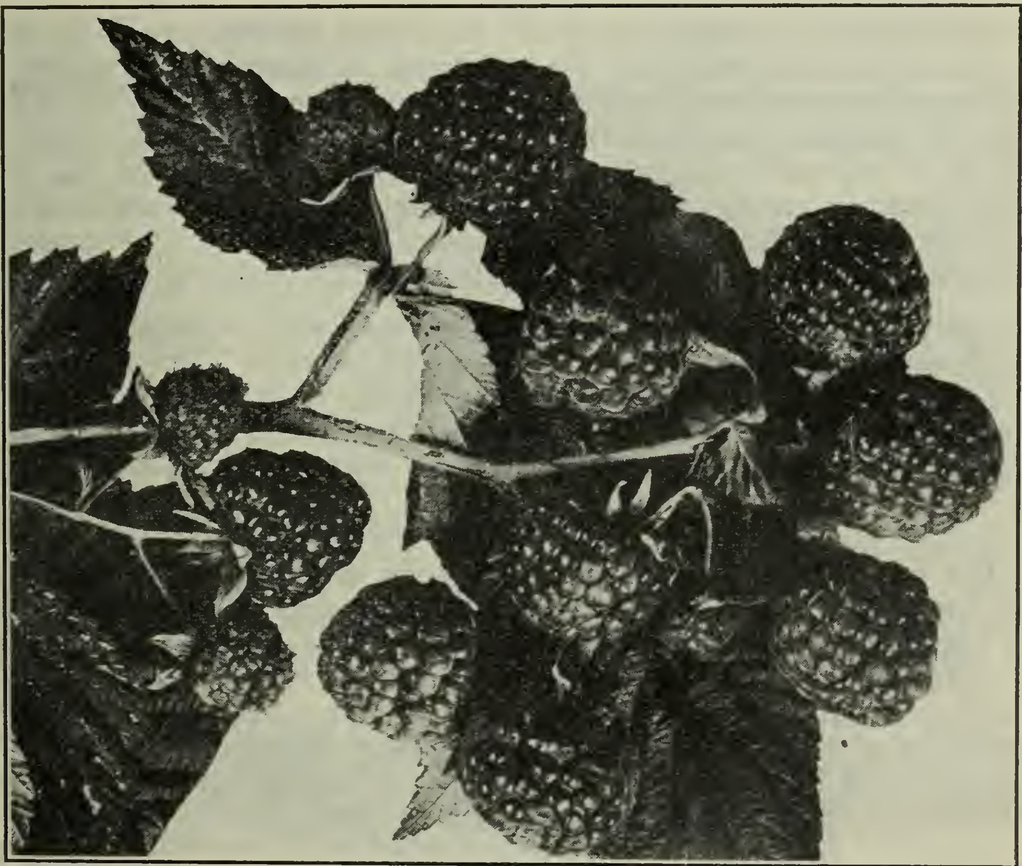
Latham. This is a comparatively recent introduction. It was originated by the Minnesota Fruit Breeding Station and was first sent out in 1912 as Minnesota No. 4. Redpath appears to be identical with it. The plants are tall, upright and vigorous; they are very hardy and seem to withstand drought but they contract mosaic rather readily. It is a productive variety and the fruits are large but inclined to crumble. Quality is only medium. In Ontario it may have value as a late variety to follow Cuthbert. It is a valuable variety in Minnesota and is being grown in Illinois, and in Connecticut and other Eastern States.

Ohta. One grower mentioned this variety in his reply to our questionnaire. It was originated by Professor N. E. Hansen of the South Dakota Experiment Station in 1906 and was sent out by that Station in 1912. Its parents were a wild red raspberry from North Dakota, and Minnetonka, a Minnesota variety. The plants are of medium height, upright, hardy and productive. The fruit is medium in size, light red in colour but inclined to be soft and of only fair quality. Where hardiness is the chief desideratum this variety is of value.

Newman. This and the two following varieties are the newest Canadian introductions. The Newman is named after its originator, Mr. C. P. Newman of Ville la Salle, Quebec. Its parentage is not definitely known but it was selected from a lot of seedlings of Herbert, King, Louden, Cuthbert and Eaton which were grown from open pollinated seed.

It is one of the most outstanding varieties recently tested at the Experiment Station at Geneva, N.Y. where it has done remarkably well. In 'Small Fruits of New York' Hedrick says, "In a collection of about one hundred varieties of red raspberries on the grounds of this Station (Geneva) Newman has been for several years one of the best if not the best." At that Station it has given excellent yields of large fruit which are firm and ship well. At this Station (Vineland) it has not shown up so well. The fruits were large and very firm but also were dry and lacked flavour. The yield has been very fair to good. In hardiness and vigour the plants are good and they do not appear to take mosaic very readily. It is a mid-season variety and is well worthy of a trial.

Viking. (Seedling 14038 of the Horticultural Experiment Station). Viking originated from a cross between Cuthbert and Marlboro made in 1914. In plant characters, growth habit, etc., it appears to be outstanding. It is a vigorous grower, producing a moderate number of tall thick canes which are of such strength that they remain upright when loaded with fruit. This means much in cleanliness of fruit and ease of picking; it



Viking red raspberry.

also facilitates cultivation and other operations during the picking season. The canes are almost entirely free of spines which makes picking easier and pleasanter. In yield it is equal to or better than Cuthbert. In season it starts in just ahead of Cuthbert.

In fruit characters Viking is as large or larger than Cuthbert, is firmer than that variety and therefore holds up better under shipment. This firmness together with the bright lively colour of the fruit probably accounts for the preference being given to Viking on the fresh fruit market. On the other hand the deep colour of the Cuthbert probably gives it the preference for canning and jam making. In quality Viking is intermediate between its two parents, Cuthbert and Marlboro.

Viking has been widely disseminated since its introduction in 1923. Its performance under varying conditions of soil and climate has been almost uniformly good so that it can now be recommended generally for commercial planting. Viking seems to have won the favour of growers because of its yielding ability and its excellent plant habits, and the markets like it because of the appearance of the fruit. Also the variety is proving hardy and promising in other ways in the colder sections of Ontario, in the Province of Quebec and elsewhere. Professor T. G. Bunting of Macdonald College, Quebec, reports Viking as particularly promising for that province being probably superior to the older commercial varieties. Some idea of the probable shipping value of Viking is contained in the following item which has reference to a crate of the variety shipped from Salmon Arm, B.C. to Calgary (a 15 hour run by passenger train) in July 1928. "It is more round in shape than the Cuthbert and is easily the firmest berry we have seen. The sample crate arrived in perfect condition, without refrigeration, which proves that it is a shipper and well merits its name." (From Markets Bulletin, B.C. Dept. of Agriculture, July 14, 1928.)

Adams 87. It is perhaps a little early yet to say much about this variety. It originated with Mr. Geo. Adams of Smithville, Ontario, who has been breeding raspberries for the last forty years. Just when No. 87 appeared we cannot say but in 1909 Mr. Adams sowed seed which produced a lot of seedlings from amongst which he selected No. 87 and has had it fruiting on his place for a number of years. Just recently he sold it to Mr. J. P. Bridgeman of Winona, Ontario, and we understand that plants are now being offered for sale by E. D. Smith & Sons, Winona.

This variety should make a place for itself as it appears to be quite hardy and does not seem to take mosaic at all readily. The plant is quite vigorous and inclined to branch but is a little slow in propagation. It gives good yields of large firm berries. The colour is perhaps a little light but not too much so for the fresh fruit market. In quality it is fair to good.

BLACK AND PURPLE RASPBERRIES

As the black and purple raspberries do not appear to be of much economic importance in Ontario very little space will be devoted to descriptions of varieties of these types. Judging by the number of plants sold by nurseries during the past seven or eight years the Cumberland and Plum Farmer are the two black varieties most commonly grown in Ontario; other varieties of this type are Conrath, Gregg, Hilborn, Older and Smith Giant among the older kinds while of more recent origin are Adam's Black Perfection, Black Pearl and Honey Sweet.

Cumberland. Probably a seedling of Gregg. Originated with David Millar of Camp Hill, Pa. Introduced in 1896. Plants vigorous and hardy, but susceptible to virus diseases. Productive, fruit large, firm and of good quality. Mid season to late.

Plum Farmer. Originated in Ohio. Found and distributed by L. J. Farmer of Pulaski, N.Y. Plants vigorous, hardy, healthy and productive. Fruits large, of high quality and firm. Mid season.

Conrath. This was a chance seedling found near a plantation of Gregg in 1886. Introduced by Conrath Bros. in 1894. Plants vigorous, healthly and drought resistant. Fruit large and firm. Early, with long season.

Gregg. A seedling from Indiana introduced about 1866. Plants tall and vigorous but rather susceptible to disease and not any too hardy. Fruit large, firm and of good quality. Late.

Hilborn. A chance seedling found on the farm of W. W. Hilborn, Arkona, Ontario and introduced in 1886. Plants vigorous, hardy and productive. Fruits large, glossy black, firm and good quality. Early to mid season.

Older. A chance seedling found in the garden of Mr. Older of Independence, Iowa. Plants hardy, vigorous and productive. Fruit large, black, firm and of good quality. Mid season.

Smith Giant. Probably a seedling of Gregg. Produced and introduced by A. M. Smith of St. Catharines, Ontario, 1888. Plants vigorous, fairly hardy. Productive. Fruit large, firm, good quality. Late.

Adam's Black Perfection. This variety originated with Mr. Geo. Adams of Smithville, Ontario. It has fruit of medium to large size and of good quality. In season it is early and the fruit ripens over a comparatively short period.

Black Pearl. A seedling found in a plantation of Kansas in 1905 by Herman Krumrei, St. Joseph, Missouri. Introduced in 1907. Plants vigorous, upright, productive and hardy. Fruits large, glossy black, not crumbly. Good quality. One of the best of the newer sorts. About a week earlier than Gregg.

Honey Sweet. A chance seedling found on his farm by Mr. A B. Katkamier, Macedon, N.Y. in 1912. Plants vigorous, upright, hardy and productive. Fruit medium to large, glossy black, does not crumble, juicy, sweet, very good quality. Mid season.

Of the purple or hybrid type only three varieties will be described, namely, Shaffer, Columbian and Royal Purple.

Shaffer. Originated with George Shaffer, Scottsville, N.Y. as a chance seedling in 1878. For many years was the principal variety grown of this type but it is now almost superseded by Columbian. Plants tall and vigorous, lacking somewhat in hardiness. Rather susceptible to anthracnose but takes mosaic slowly. Fruit a dull purple, rather soft and crumbly. Quality good. Season late.

Columbian. A seedling of Cuthbert, the pollen parent probably being Gregg. Originated by J. T. Thompson, Oneida, N.Y. in 1888. Introduced in 1891. Plants vigorous and healthy, but perhaps lacking somewhat in hardiness. Fruits large, firm and of good quality. Valuable for canning. Season late.

Royal Purple. A chance seedling, originated with L. H. Girton, Bristol, Indiana, in 1898. Plants tall, vigorous, hardy and productive. Contracts mosaic slowly. Fruit medium in size, dull purple, firm, somewhat dry, poor quality. Season later than Columbian.

BLACKBERRY VARIETIES

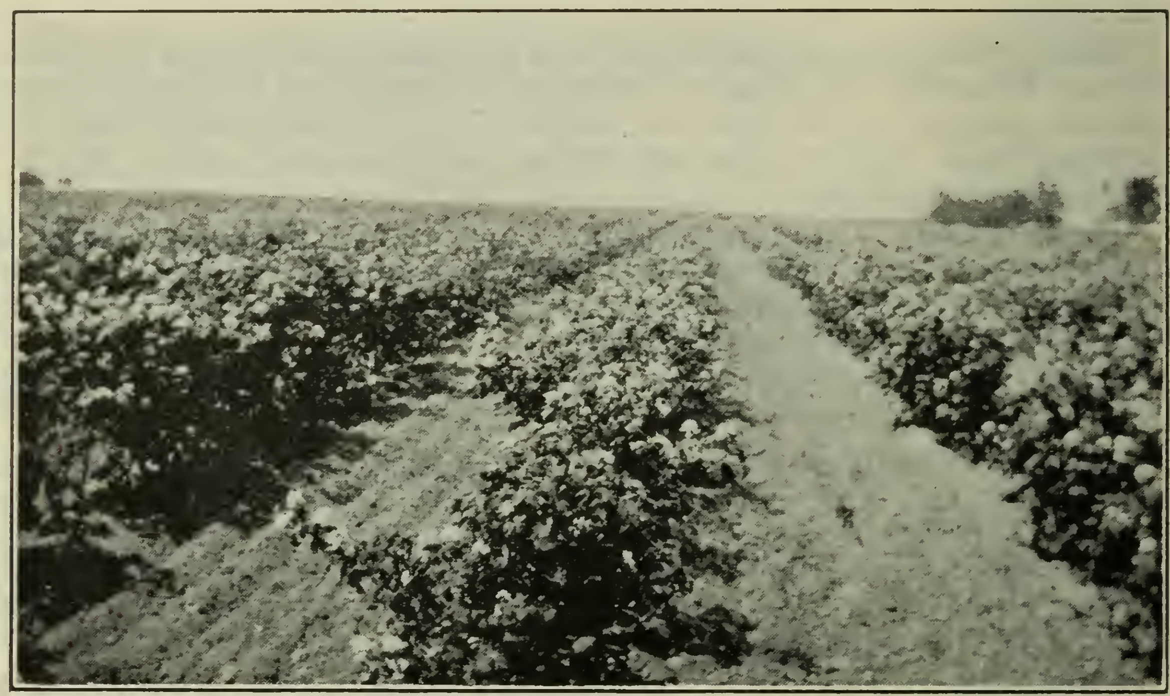
Owing to lack of hardiness, to the ravages of the Blackberry Leaf Miner, and to difficulty in controling Orange Rust, the blackberry is grown commercially in Ontario to only a very limited extent. A few of the commoner varieties are Eldorado, Mersereau, Kittatinny, Snyder and Wilson.

Eldorado. Originated as a chance seedling near Eldorado, Ohio, about 1880. Plants tall, vigorous, hardy, productive and healthly; seldom attacked by Orange Rust. Fruit large, black, firm and sweet. Quality good. Midseason.

Mersereau. Originated with Mr. Mersereau of Cayuga, N.Y. about 1890. Supposed to be a seedling of Snyder. Plants vigorous and hardy, but somewhat susceptible to Orange Rust. Rather hard to propagate and so other varieties are apt to be substituted. Fruit large, glossy black, firm and juicy. Good quality. Midseason.

Kittatinny. Taken from the wild near the Kittatinny Mountains in New Jersey. Introduced about 1865 by E. Williams, Montclair, N.J. For many years was the standard commercial variety of North America. Plants tall and vigorous but lack somewhat in hardiness. Susceptible to Orange Rust. Fruit large, glossy, black, firm, sweet and of good quality. Midseason.

Snyder. Originated as a chance seedling with Henry Snyder near La Porte, Ind., about 1851. Plants very vigorous, healthly and productive. Apt to be injured by drought. Fruit medium size, firm and black but quickly becoming redish after picking. Quality only fair. Mid to late season



Blackberries in bloom.
(*Plantation of F. H. Jory, Beamsville*).

Wilson. Found by John Wilson of Burlington, N.J., about 1854. Plants moderately vigorous, not particularly hardy. Fruit large, glossy black, firm, juicy and sweet. Good quality. Early.

The Dewberry is of little or no commercial importance in Ontario and so it is merely mentioned in this bulletin. Its culture is very similar to that of the blackberry, although it will thrive on a lighter type of soil. The Lucretia is the variety commonly grown in the Eastern States.

THE RASPBERRY AND BLACKBERRY INDUSTRY IN ONTARIO

Judging by the figures of production from the Census Report of Canada of 1921 and from those of the Dominion Bureau of Statistics for the years 1920 to 1928 the raspberry industry has fluctuated considerably, not only in Ontario, but in Canada as a whole. Table 1 gives the production in quarts for each of these years for the whole of Canada and for the individual provinces. No figures are available for Prince Edward Island. For Quebec the only figures given are for the year 1920, when 216,405 quarts were produced. The prairie provinces produced 17,420 quarts in the same year.

TABLE I.—PRODUCTION OF RASPBERRIES IN CANADA. QUANTITIES GIVEN IN QUARTS. FROM COMMERCIAL PLANTINGS AND HOME GARDENS.

Year	Canada	Nova Scotia	New Brunswick	Ontario	British Columbia
1920	8,360,518*	34,192	30,827	6,194,642	1,863,842
1921	7,522,950	22,200	24,600	4,200,000	3,276,150
1922	6,271,725	33,081	28,324	3,360,000	2,850,320
1923	4,496,840	36,060	16,995	840,000	3,603,765
1924	2,000,450	32,000	17,500	1,050,000	900,950
1925	1,962,000	30,000	32,000	1,000,000	900,000
1926	4,744,500	22,500	40,000	1,200,000	3,482,000
1927	5,232,700	21,700	35,000	2,304,000	2,872,000
1928	4,306,860	20,000	28,000	1,843,200	2,415,660

Of the 8,360,518 quarts produced in Canada in 1920, 6,815,796 quarts were from commercial plantations and the balance of 1,544,722 quarts were produced in home gardens. Of the Ontario crop of 6,194,642 quarts for the same year, 5,297,130 quarts were from commercial plantations and the balance 897,512 quarts were from home gardens. The value of the commercial crop from Ontario in that year was placed at $1,170,980. which works out at just over 22 cents per quart. From the figures in Table I it will be noted that the total production in Canada gradually declined during the years 1920 to 1925 while in 1926 and 1927 there was a considerable rise with a drop again in 1928. Also it will be observed that the greatest falling off was in Ontario. In 1920 the crop in Ontario was far ahead of that in any other province but since then the output in British Columbia has come nearer to that in Ontario and in some years, namely, 1923, 1926, 1927 and 1928 has exceeded it.

The Dominion Census Report of 1921 gives some rather interesting figures on the production of red raspberries in Ontario according to counties:

TABLE II.—RED RASPBERRY PRODUCTION IN ONTARIO FOR 1920 FROM COMMERCIAL PLANTATIONS IN SIX OF THE LEADING COUNTIES

County	Quantity in quarts	Value
Lincoln	925,402	$204,606
Wentworth	452,787	103,418
York	366,668	84,155
Norfolk	351,481	84,283
Halton	345,221	78,199
Peel	313,544	81,134
	2,755,103	$635,795

This total of 2,755,103 quarts is just over 52 per cent of the commercial crop of Ontario for 1920. Twelve other counties produced from around 230,000 quarts down to about 100,000 quarts each. These were Welland, Brant, Prince Edward, Middlesex, Elgin, Simcoe, Northumberland, Lambton, Kent, Ontario, Oxford and Essex. These twelve counties produced 1,849,779 quarts which is almost 35 per cent of the commercial crop. The remaining 13 per cent was produced by the remaining counties and districts of Ontario.

No figures on the production of the other 'bramble' fruits are available although some idea of their relative importance may be obtained from

*According to the Dominion Census Report for 1921, figures for other years from Dominion Bureau of Statistics.

Tables III and IV which give the numbers of plants sold by nurseries in Ontario.

TABLE III—NUMBERS OF PLANTS OF THE RED, BLACK AND PURPLE RASPBERRIES, SOLD BY NURSERIES IN ONTARIO.

	1920	1923	1924	1925	1926	1927	1928
Cuthbert (red)	165,539*	186,348	132,929	84,251	202,448	106,284	126,373
Herbert (red)	35,363	36,789	47,028	31,090	40,141	28,895	38,225
King (red)	35,319	3,080	30,500	34,844	55,706	41,575	58,069
St. Regis (red)	28,974	15,656	11,279	9,778	18,981	13,280	17,369
Marlboro (red)	8,165	11,743	11,922	7,973	13,891	9,251	4,446
Cumberland (blk.)	13,330	19,800	29,650	27,115	36,515	31,316	34,513
Diamond (blk.)	975	1,300	1,000	2,260	....	2,150	1,600
Gregg (blk.)	6,481	....	600	75	124	410	40
Plum Farmer (blk.)	27,275	4,890	11,968	3,030	3,488	5,513	7,784
Columbian (Purple)	40,540	45,997	56,744	51,919	67,794	71,553	82,293
Unclassified	32,860	32,338	13,307	9,651	45,958	18,146	28,517

TABLE IV.—NUMBERS OF PLANTS OF SEVERAL OF THE LEADING BLACKBERRY VARIETIES SOLD IN ONTARIO.

	1923	1924	1925	1926	1927	1928
Eldorado	6,587	12,820	6,685	13,178	9,330	14,111
Kittatiny	2,010	2,700	800	3,249	570	....
Mersereau	2,835	2,100	3,003	1,050	2,567	875
Rathbun	3,383	1,350	2,200	3,500	1,700	3,700
Snyder	1,121	575	6,205	2,030	2,778	3,851
Taylor	3,300	1,500	600	....	....	....
Unclassified	15,352	5,914	15,635	11,742	8,885	10,847

These figures do not take into account the large numbers of plants, more particularly of the red raspberry, which are sold from grower to grower. It will be observed that there are considerable fluctuations amongst varieties from year to year but the Cuthbert red raspberry is always considerably in the lead of all others. One rather surprising thing is that over 80,000 plants of the Columbian purple raspberry were sold in 1928 which is far ahead of all other varieties excepting Cuthbert.

A few figures from the Dominion Bureau of Statistics as set forth in Table V show that comparatively small quantities of raspberries, blackberries and gooseberries are being imported from the United States. Unfortunately these three fruits are lumped together so that we cannot tell what quantities of each kind came in.

TABLE V.—IMPORTS OF RASPBERRIES, BLACKBERRIES AND GOOSEBERRIES INTO CANADA FROM THE UNITED STATES DURING THE MONTHS OF JUNE, JULY, AUGUST AND SEPTEMBER FOR THE YEARS 1924, 1925, 1926 AND 1927. (THE IMPORTS DURING THE REST OF THE YEAR ARE QUITE INSIGNIFICANT).

Year	Quantity pounds	Value $
1924	103,480	11,663
1925	37,722	6,136
1926	307,636	38,056
1927	247,841	35,347

LOCATION AND SITE

The remarks regarding the location and site for the strawberry (Bulletin 335, page 7) apply with equal force to those for the 'bramble' fruits. The general location is, of course, decided by the location of a

*Quantities in Tables III and IV were obtained from the Dominion Bureau of Statistics.

man's farm and if he is thinking of making these fruits one of his main crops there are certain points that should be kept in mind in this connection. The chief of these are climatic conditions, labour supply, marketing facilities, and market preferences.

Climatic Conditions. As the red raspberry is found wild over a very wide territory (see Origin and History in this bulletin) it might be assumed that it is tolerant of a wide range of climatic conditions. Varieties, however, differ considerably in their climatic preferences; some are adapted to the cool moist climate of the British Isles, others are better suited to the climate of eastern North America, while very few if any thrive in the heat of the Southern and Middle Western States. In passing it may be worth noting that two of the most favourable localities for the growth of red raspberries are in certain districts of Scotland and in the Pacific North West, more particularly on the Lower Mainland of British Columbia and in the Puyallup Valley of Washington State. In these sections the climate is usually cool and moist with no great extremes of temperature.

The black raspberry, being a native of the eastern part of North America, thrives in most of the north eastern states and suffers less from extreme heat than the red raspberry. Also it seems to be less subject to winter killing.

The purple raspberry, also a native of eastern North America, does not seem to be as hardy as the black although it thrives in the milder sections of Ontario.

The blackberry of various types is fairly widely distributed both in Europe and North America but practically all varieties under cultivation in Ontario are of American origin; they are not altogether hardy however and also are apt to suffer from drought.

These remarks as to climatic conditions will give some idea as to why certain types will thrive in Ontario and others not.

Labour Supply. The usual operations of growing raspberries such as cultivating, pruning, etc., do not call for any great amount of extra labour, probably not as much as for tree fruits, but the picking of raspberries does require considerable extra help and provision must be made for securing it when needed. If it is impossible to get this extra help it is not advisable to go into raspberry growing on an extensive scale. It is not necessary though to be near a village or town, as many growers make provision for housing families of Indians, Poles or Italians for the busy season. These people as a rule make good pickers, especially the women and children.

Marketing facilities. The importance of good marketing facilities for such a tender fruit as the raspberry cannot be over estimated. While some of the newer varieties are very firm and stand up quite well relatively, yet even the best of them deteriorate rapidly after picking and so must be marketed promptly and with a minimum of handling. A grower who has to haul his raspberries a long distance will be seriously handicapped in growing this fruit at a profit.

Market preferences. Another matter of importance in connection with marketing is the preference for one type of berry over another. As a case in point may be mentioned the demand by the fresh fruit trade for a bright attractive berry that does not readily become dull or stale in appearance, and on the other hand the demand of the canning factories for a berry that will have a good rich appearance and hold together well when canned. Other things of course, enter into the make up of a commercial berry such as size, firmness, quality, etc., but all markets demand these characteristics.

The actual site for a raspberry plantation is of as much importance as the general location and should be selected with great care. Under site must be considered such important matters as natural drainage, moisture supply, physical condition of the soil and winter protection.

Natural drainage. Raspberries must be grown on land that is naturally well drained. Ditches and tile drains may do much to improve drainage but if land is naturally poorly drained it is not desirable for raspberry growing. Low wet pockets especially should be avoided as water is apt to accumulate in them and it is decidedly harmful to have water standing around raspberry plants for any length of time. 'Raspberries will not tolerate wet feet' is a trite expression. Rolling high land is usually well drained but if too high and steep it is apt to be too dry and perhaps unfertile on the high spots and the slopes are likely to 'wash' badly under cultivation.

Moisture supply. Although raspberries need good drainage they need also a good supply of moisture, especially during the time of fruiting and, as many growers know to their sorrow, this is just the time when moisture is apt to be deficient through drought and intense heat. Even though the weather cannot be controlled the moisture supply can be regulated to some extent by growing raspberries in moisture retentive soil and by suitable cultural methods.

Winter protection. A matter that may have considerable bearing on the success of the raspberry grower is that of providing protection against winter injury. It is not at all uncommon for the canes to die back a little at the tips; in fact, this might almost be considered as the normal condition in Ontario and it is not serious as the canes are usually cut back somewhat at pruning time. What is serious however, is the killing of half or even whole canes and often the most vigorous ones at that. Just what causes these canes to die in this manner is not clear. Intense cold does undoubtedly have a considerable effect on the canes but it does not

Winter injury in red raspberry. Note that canes are leafing only at base. Upper parts are dead.

seem to be the only cause and probably not the chief cause of injury. Various observers, both growers and experiment station workers, are inclined to think that it is more a matter of drying or desiccation rather than freezing. While there appears to be little or no actual experimental evidence to support this idea yet it is a common observation that where canes are protected from drying by being covered with earth or deep snow or even with wax there is practically no killing. If it were a case of absolute cold only, it would be impossible to grow raspberries on the prairies where temperatures of thirty and forty degrees below zero are fairly common every winter and as a consequence the ground freezes to a depth of five or six feet and more. Of course the canes are covered with earth so that they are protected from the drying winds but certainly not from low temperatures. Probably the most severe injury is due to a combination of low temperatures and drying. In the Niagara District the damage seems to be most pronounced when there is little or no snow on the ground and the condition is aggravated when the plantation is in an exposed location so that strong winds may continually sweep through it.

While nature may not favour every locality with sufficient snow yet it is possible for man to counteract this deficiency to some extent. If at all possible a site should be chosen that is somewhat sheltered naturally from the prevailing winds. Failing this, shelter may be provided by planting windbreaks; this means time and money, but in the long run it would undoubtedly pay and pay well. It is not however, the intention here to discuss the matter of windbreaks, except to say that with the destruction of so much of the natural bush, the replanting of windbreaks and shelter belts should receive more thought and consideration than it does at present.

Perhaps an ideal location and site for a raspberry plantation is hard to find and usually it will no doubt be necessary to compromise more or less between the various factors concerned.

These remarks on location and site for the red raspberry apply also to the black and purple raspberries and to the blackberry.

SOILS

As noted under the section 'Location and Site' the 'bramble' fruits require a soil that is well drained and yet holds plenty of moisture. This condition is best found perhaps in a moderately light sandy loam soil that is well supplied with humus. Depth of soil is also important, as a deep soil is more likely to encourage deep rooting which would help to prevent injury from drought and from careless cultivation. On the other hand a shallow soil, especially if underlaid with a 'plow sole' or with hard-pan, will tend to cause shallow rooting and consequent injury; also drought is likely to have more serious effects on this type of soil. A coarse gravelly soil also is very undesirable. This type allows water to run away too freely and in all probability will also be found to be lacking in fertility. Even a moderately heavy clay, if properly drained, would be preferable to a coarse gravel as it would be naturally more fertile and its physical condition could be improved by the addition of organic matter.

SOIL PREPARATION AND FERTILIZATION

As raspberries and blackberries are comparatively permanent crops the preparation of the soil before planting is of considerable importance. As previously mentioned it is particularly desirable that it be well supplied with humus or organic matter and also that it be free from perennial weeds such as 'quack' grass and perennial sow thistle. In order to ensure that there shall be a good supply of humus in the soil when the young plants are set out it may be necessary to start building it up for a year or two previous to planting. If plenty of farmyard manure is available this may be applied in liberal quantities for other crops that may be grown on the land previous to setting out the raspberries. Twenty or thirty tons per acre would not be too much to use in this way. If manure is not available at a reasonable price, other means of building up the humus supply must be adopted. The most feasible means of doing this is to plow under green manuring crops for several years before the raspberries are to be set out. This does not mean that the land would not be used for revenue producing crops for this length of time, as by a proper system of management annual green manuring crops, such as rye, oats, buckwheat, millet, etc., may be grown when the land is not occupied by a 'pay' crop. If biennial or perennial crops such as some of the legumes, are to be grown for plowing under then, of course, the land will be kept out of cultivation for a longer time as these need more time to make sufficient growth to be worth plowing under. It is believed too, that this type of plant is really more satisfactory for the purpose on account of the larger bulk of material produced for plowing under and also on account of the deeper penetration of the roots which tends to open up the lower layers of the soil. The crops of this type most generally used are some of the clovers, principally sweet and red clover, and also alfalfa. Sweet clover is preferred by many as the seed is relatively cheap and it usually gives a better catch than the red. If sown any time up to midsummer it will give a lot of growth for plowing under the following spring. It should not however, be left too late before plowing under as being a biennial it goes to seed the second year and if it does this the stalks become very tough and woody and hard to handle. Also a heavy crop like this will draw much water from the soil which would be better left there. For some cause, unknown at the present time, sweet clover is failing to give the catch it used to and if this condition continues it may perhaps lose favour as a green manure crop. Red clover and alfalfa are both excellent for plowing under where a good catch can be obtained. Another point in favour of using these legume crops is their ability to gather nitrogen from the air by means of bacteria in the root nodules which nitrogen in time becomes available to other plant growth.

If the ground is at all weedy it would be better to grow 'hoe crops' such as, potatoes, tomatoes or sweet corn for a year previous to planting the raspberries. The cultivation given to these crops would help to clean the land of weeds and put it in better condition. Land that is infested with 'quack' grass, perennial sow thistle and other perennial weeds should not be used for raspberries on account of the difficulty in controlling such weeds in a raspberry plantation.

The commercial fertilizers such as acid phosphate and bone meal and the various forms of potash which would be used on the 'hoe crop' would probably have a 'carry over' effect on the young raspberry plants. It is not likely, however, that there would be much if any of the quickly available nitrogenous fertilizers such as nitrate of soda and ammonium sulphate left over for the raspberries as these are very soluble and any that was not used by the hoed crop would pass out of the soil in the drainage water.

Further discussion of fertilizers will be taken up under the heading 'Subsequent Care of the Plantation.'

PLANTING

Time of Planting. There apparently is a difference of opinion amongst growers as to the best time to plant red raspberries but it seems that the majority favour planting in the fall. By planting at this time of year they claim that the plants get a better start in the spring as they are in the ground ready to start growth as soon as conditions are favourable.

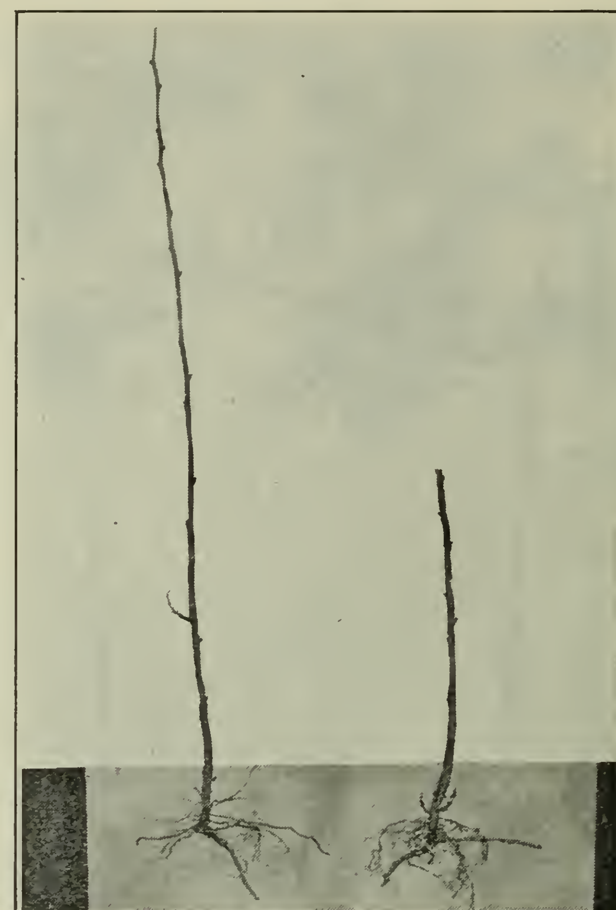
Spring planting also has its advocates and if green spring suckers are to be used the planting cannot well be done at any other time. Some growers prefer planting in the fall simply because they seem to have more time then. Black and purple raspberries and blackberries are best planted in the spring.

Type of plant to use. The type of plant to use depends somewhat on the individual growers preference though the majority of growers seem to favour the mature sucker canes to the new spring suckers. Probably under most conditions the former are preferable. They have the advantage of being more easily handled especially if they have to be brought in from a distance; another advantage is that they can be planted either in the fall or spring, however, quite a number of growers use the spring suckers with success.

Spring sucker plants.
A. Good type to use for planting although smaller plants could be used to advantage.
B. Poor type; sparse roots and no underground stem.

As black and purple raspberries do not throw up suckers some other means of obtaining plants must be employed. In both of these types the ends of the branches which bend down to the ground take root and it is these rooted ends or 'tips' that are used. In order to facilitate the rooting of these 'tips' the longer branches or canes are bent down and the ends held in place by covering them with a little earth. This is usually done in late summer when the ends of the canes show some thickening. These covered ends have rooted usually by late fall and in the spring they may be dug up and cut free from the mother plant with about a foot of cane attached. Larger quantities of tips may be obtained from a plant by pinching back the main shoots in early summer which will induce the formation of laterals. These laterals will usually make enough growth by early fall to permit of them being 'tipped.'

Perhaps it is hardly necessary to say that healthly plants only should be used for planting a new plantation but as the success of the grower



Mature cane plants for planting. Cane on right cut back ready for planting.

depends so much on using only disease free stock it is well to emphasize this point as much as possible. Plants infested with crown gall, mosaic and anthracnose, etc., should not be used.

Systems of Planting. Red raspberries are usually grown on the 'hedge-row' system, that is, the plants are allowed to spread along the row, no attempt being made to keep individual plants separate. Some growers prefer the 'hill' system. This term would seem to have two interpretations. In one it means that the plants may be set in rows seven or eight feet apart and about three feet in the row and the plants kept more or less apart by removing the suckers between them. In the other it means that the plants may be set on the square, being four or five feet both ways or at various modifications of these distances, such as four by five feet or four by six feet, etc. This latter system would permit of cross cultivation which would no doubt minimize hand hoeing and it would seem that individual plants would have a better chance to develop owing to better distribution of light, air and rooting space. In order, however, to get as many plants to the acre as by the common eight feet by two feet distance of the ordinary row system the plants would have to be set four feet by four feet which would necessitate single horse cultivation instead of team cultivation and so what might be saved on hand hoeing would be lost by the extra amount of single horse cultivation. It is quite probable that at the greater distances the individual plants would yield better than those that were grown in rows but it is a question whether the yield per acre would be as great. Unfortunately comparative yield figures on these systems are not available. Another point to consider is that it is not so convenient to set out plants on this 'hill' system as in the ordinary row system.

Distances of Planting. With any of these fruits planting distances vary somewhat with the individual grower. The distance between the row varies from five or six feet up to twelve feet. The former distance is perhaps rather close except for a small garden plantation and the latter seems unnecessarily far unless other things are grown between the rows or the rows themselves are exceptionally wide. If a tractor is to be used for cultivation then nine feet is not any too far, while seven or eight feet is usually sufficient to permit of horse cultivation.

Distances of plants in the row run from one and a half feet to three feet for red raspberries while purples, blackcaps and most varieties of blackberries may be set from two to four feet apart depending on the vigour of the variety and the preference of the grower.

Marking the land and planting. In the row system of planting it is not necessary to do much marking out. All that is needed is a few stakes such as plowmen use for marking the distance apart of the rows. Furrows are then plowed in line with these at the required depth; it is not necessary to mark the distance apart for the plants in the rows. If the square "hill" system is to be followed then it will be necessary to mark the land in both directions as the rows must be straight both ways to facilitate cross cultivation. The depth of planting for the red raspberry should be about four or five inches but the blacks and purples should not be set too deep at first or the "tips" may be smothered. A good way is to cover them at first with, say, two inches of soil and to gradually increase it as the shoots grow so that the plants are finally covered with four or five inches of soil. Blackberries may be set in a similar way to the red raspberries

Care must be exercised in handling plants of all the bramble fruits; they should not be allowed to become dry through exposure to sun and wind. Also, when firming the soil about the roots particular care must be taken not to injure the young growing tip of the black and purple sorts.

SUBSEQUENT CARE OF THE PLANTATION

The subsequent care of the plantation will be discussed under the following headings:—Cultivation, Fertilization, Pruning and Training, Winter Protection and Plantation Renewal.

CULTIVATION

If the plantation is set in the fall the usual practice is to plow towards the rows and leave it thus until the spring. In the spring the earth is levelled more or less by plowing or discing away from the rows and cultivation is carried on during the growing season. If set out in the spring cultivation is carried on as required until late summer. Although cultivation is a simple operation much damage may be done by a careless worker. Continued use of the disc may result in cutting soil and roots away from the rows leaving much of the base of the plant exposed to sun and wind. Also, too deep cultivation will cause damage to young feeding roots.

Contrary to popular belief cultivation may be overdone; this is shown by recent experimental work. In the opinion of the writer it is not advisable to try to cultivate at certain definite times such as once or twice every week or ten days but rather to do it after each good rain. If there is no rain for a couple of weeks it is perhaps just as well to keep the cultivator away unless the ground gets packed or weeds begin to get ahead. Everytime the ground is disturbed fresh moist earth is brought to the surface which of course soon dries and so moisture is lost instead of being conserved. It is hardly necessary to add that cultivation should begin just as soon as the ground is dry enough.

There is a difference of opinion as to how late cultivation should be continued and there seems to be no definite experimental evidence on this point. In a fruiting plantation, however, most growers cultivate until the fruit is picked. Some cultivate during picking while others do not. It is perhaps just as well to cultivate occasionally during picking to keep the ground from becoming too packed providing it can be done without damaging the fruit. In any case the plantation should be given a good clean up after the fruit is off, with the spring tooth cultivator and the harrow. After this practically no cultivation need be given until the ground is plowed towards the rows in the late fall in which condition it is left until the spring.

FERTILIZATION

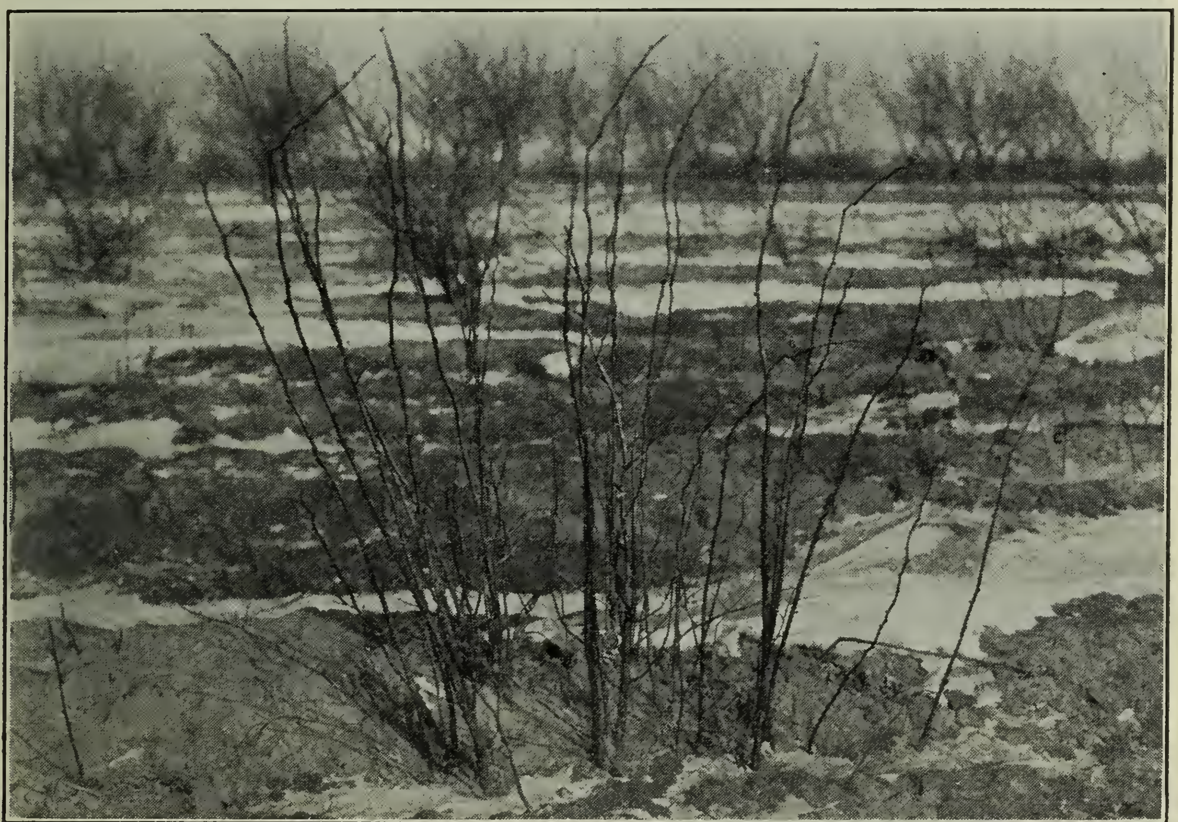
The use of green manuring crops after the plantation is established does not appear to be at all common in Ontario although, here and there, a grower may be found who is giving it a trial. One man reports sowing oats right after picking. A foot or more of growth may result which is plowed under in November.

Farmyard manure is undoubtedly the best form of fertilizer for raspberries providing it is not used to excess. It not only supplies food elements but also keeps up the all important humus supply. As a yearly dressing on the better types of soil ten tons per acre would be sufficient. With this amount added each year it is doubtful if commercial fertilizers would be needed. Of course smaller quantities of manure could be supplemented by commercial fertilizers. Where green manure crops are used in place of farmyard manure the addition of fertilizers is usually necessary. However, it is well to emphasize again the importance of starting off with plenty of humus or organic material in the soil. Light dressings of manure will then be sufficient to maintain the humus supply during the life of the plantation. When commercial fertilizers are used it is usually some form of phosphatic fertilizer that is applied, such as acid phosphate or bone meal. Wood ashes were used years ago with beneficial results and so potash, which is one of the main constituents of wood ashes would seem to be of value. If the plants are not making sufficient growth some form of nitrogenous fertilizer such as nitrate of soda or ammonium sulphate may be used to advantage. It is almost impossible to make definite fertilizer recommendations that would apply to all soils and so the individual grower must experiment for himself in order to find out what his soil needs. It has been found, however, that on some soils the following has given good results: Equal parts of acid phosphate, bone meal and muriate of potash applied at the rate of five hundred lbs. per acre. If nitrate of soda or ammonium sulphate are used they must be applied sparingly, say one hundred to two hundred lbs. per acre. When using commercial fertilizers it is better to apply a moderate quantity each spring rather than heavy applications at infrequent intervals.

The results of some field experiments with fertilizers on red raspberries just recently reported from Western Oregon would seem to indicate that nitrogen helps to increase yields as well as plant growth while potash and phosphorus tend to improve the colour and texture. Also one experiment in which the following treatment was given—1,000 lbs. acid phosphate per acre one year followed by annual applications of 100 lbs. acid phosphate plus 100 lbs. potash plus a light dressing of manure—showed very much less winter injury than where no fertilizer was applied.

PRUNING

The pruning of each type of raspberry and the blackberry is generally similar in each case but with modifications due to the habit of growth of each. Each kind forms canes one year which produce fruiting shoots in the next. After fruiting these canes are of no more use and so should be removed. There is some difference of opinion as to when "bramble" fruits shoud be pruned. The majority of growers prefer to remove the old fruiting wood just as soon after picking as they can get at it although some prefer to leave it in until the next spring, thinking that it helps to protect the new canes from the drying winds. For the same reason some



Red raspberry plant before pruning.

do not thin out surplus young canes of the red raspberry until spring. The old fruiting canes and the surplus new canes undoubtedly do afford some protection but it would seem that any advantage is more than offset by the poorer growth made by the canes, due to crowding, and to the harbouring of insect and disease pests.

The red raspberry as a rule produces so many young canes or suckers that it is necessary to thin them out. In thinning it is best to remove all the weak canes and leave enough strong ones so that they are about six inches apart. These should be spaced as evenly as possible over the width of the row which may be from twelve to eighteen inches. If this is done just after fruiting it is as well to leave a few more than are actually required in case of accident or loss from winter injury. These surplus canes may be removed in the spring when those that are to be left are headed back.

Opinion is not unanimous on the matter of heading back. The old recommendation among growers was to head back to 'hip-height.' This probably would be about right with some varieties that did not grow overly tall and in certain seasons when growth was not very strong but it would seem that this might be too severe with strong tall canes. There is some evidence both from experimental work and from growers' experience which indicates that the crop may be considerably reduced by cutting back the canes too much; in fact, in several experiments the greatest quantity of fruit has been obtained from canes that were not cut back at all. One of these experiments conducted at the Central Experimental Farm at Ottawa with the Herbert variety gave results in favour of no cutting back

Red raspberry plant after pruning.

of the canes. Canes that were cut back yielded at the rate of 3,772 boxes per acre while those that were not cut back yielded at the rate of 5,274 boxes per acre. An experiment at the Ontario Horticultural Experiment Station, which was carried on several years ago using the Cuthbert variety gave similar results. It was noted, however, that although the unpruned canes gave a greater total number of fruits than the pruned yet there was a much greater proportion of good marketable berries on the latter. Where pruning was more severe the crop was considerably reduced although practically all the berries were of good size.

Apart altogether from its effect on yield, some cutting back of the canes is undoubtedly desirable as it results in stockier plants which are not so subject to wind injury and which will remain upright under a load of fruit. Canes that bend over to the ground will not carry their load of fruit to advantage. We may assume, therefore, that a moderate heading back of the canes is desirable. Probably it is better to say that a certain *proportion* of cane should be cut away rather than that the cane should be cut to a certain height irrespective of the amount of growth. From observation it would seem that one third would be about the right amount to remove.

Summer "tipping" of the new canes is practised by a few growers who claim that it produces stockier plants. The majority, however, do not see any particular advantage in the practice and claim that the new side growths or laterals that come from the "tipped" cane are more subject to winter injury than the original cane would be. If this tipping was done early enough it probably would be more worth while; a stockier plant would result and the young laterals would have time to mature before winter set in. Experimental work along this line seems to indicate that tipping should be done when the young canes are only twelve to fifteen inches high. This offers a practical difficulty as canes at that height would be awkward to get at in the middle of the row and many could not be seen. The usual method is to tip the young canes as soon as they show above the fruiting canes but this would seem to be later than the optimum time.

Viking red raspberry at Macdonald College, Quebec. This variety seems to be perfectly hardy in Eastern Ontario and Quebec province.
(*Courtesy of Professor T. C. Bunting, Macdonald College, Que.*)

In the black and purple raspberries and the blackberry the young canes are pinched back when they are two to three feet high. The laterals that are forced into growth usually ripen sufficiently so that they are not winter killed except sometimes in the case of the blackberry which is probably the most tender of the "bramble" fruits. These laterals may grow from twelve to thirty inches or more in length and the usual practice is to shorten them considerably in the spring. In the black and purple raspberries eight or ten buds per lateral is enough to leave while in the blackberry it depends somewhat on the fruiting habit of the variety. Some varieties produce fruiting wood nearer the main stem than others, but at least half of each lateral may be removed. With this system of pruning no trellising is required as the plants are low and stocky.

In a newly set plantation of any of the "bramble" fruits no pruning is necessary except the initial shortening of the canes at planting time; these canes may be shortened to about a foot.

WINTER PROTECTION

Protection from winter injury was discussed under the heading "Location and Site" where the desirability of protection afforded by a windbreak and a blanket of snow was stressed. With these two factors present there is usually very little injury and so other protection is not considered necessary, except perhaps in more northern scetions where it may be advisable to bend over the canes and cover them with earth. This covering with earth is commonly practiced on the Prairies where heavy drying winds and very low temperatures together with comparatively light snowfall prevail in winter.

PLANTATION RENEWAL

Plantations of "bramble" fruits are more or less permanent, although less permanent now than formerly. Years ago it was not at all uncommon for a plantation to remain profitable for fiften or twenty years but now owing principally to the prevalance of virus diseases, winter injury and probably to depletion of humus in some soils about half that time would seem to be the limit; in fact, some growers consider that six years is about the profitable life of a plantation. It is impossible however, to set any exact time for renewal of a plantation as so much depends on the grower himself and on his own particular conditions. Under favourable conditions of soil with freedom from winter injury and disease it is quite possible to keep a plantation in profitable condition for considerably more than six crop years, but as a general rule it would seem better to take off six good crops and then discard it. This would necessitate setting out plantations oftener, perhaps every year, so that newer ones would be coming on all the time. To carry out such a system as this would require more careful planning to make it fit in with the rest of the farm operations. The above remarks apply to all the "bramble" fruits except as otherwise noted.

PICKING AND MARKETING

The necessity of being able to secure sufficient help for picking has been spoken of under the section "Location and Site." Having the necessary help on hand the grower must have everything organized so that picking can begin just as soon as enough berries are ready and continue smoothly until the picking season is over. He must have a supply of berry boxes, the pint size for preference, also carriers for use in the field and crates for shipping. As pickers are usually paid piece work some means must be provided for keeping track of the quantity each person picks, this is often done by means of tally cards on which the quantities are punched by the person in charge.

The supervision of pickers is of great importance. They must be instructed to place the berries carefully in the boxes and not to drop them in and they should not be allowed to hold too many in their hands at once. Another matter that is apt to give considerable trouble is that of picking berries at the proper stage of ripeness. Berries that may be termed "soft" ripe are too mature for shipping and so it is essential that they be picked while still quite firm though well coloured of course. Also pickers must be urged to pick clean as they go, because berries that are ready to pick at one picking will certainly be too ripe at the next.

The frequency of picking is determined more or less by weather conditions but as a general rule picking should be done two or three times a week. A common practice is to pick on Mondays, Wednesdays, and Fridays; picking on Saturdays is not to be recommended unless for a special purpose such as delivery to a canning factory.

The method of marketing depends on a grower's location. If he is near a city he can usually dispose of a large part of his crop direct to the consumer through the public market or by peddling or he may sell to dealers and stores, etc. If at a considerable distance from a city he may sell through commission men or to a canning factory. Very often the latter offers the best outlet for much of his crop. In this case the grower usually delivers to the factory direct. While the factory may not pay as much as other markets yet it would seem that the net returns would be as good as it is usually the cheapest and easiest means of disposing of large quantities of fruit.

YIELDS AND RETURNS

Yield is of course one of the main factors to be considered in the commercial success of berry growing. Just what is a satisfactory yield is a little hard to determine and each grower has his own idea of what yield he should get in order to make a profit. Profit, however, does not depend altogether on yield but, as in other farming operations, cost of production and price obtained are just as important. These three factors in fact are so interdependent that they must be considered together. In a bulletin of this nature it is not proposed to discuss the economics of berry growing but a few figures from growers will be of interest. The following remarks apply more particularly to the red raspberry as very few figures are available as to yields and prices for the other types, although one man reports 3,000 to 4,000 quarts of black raspberries to the acre and the price was set at fifteen cents per quart. Also about the same yields seem to be expected for blackberries. Yields of red raspberries run from as low as 2,160 pints up to nearly 6,500 pints but the majority of growers placed the amount at 4,000 to 5,000 pints. Price per pint ranged from as low as seven and a half cents up to twelve and a half cents and the writer knows of cases where growers received twenty cents or more for early berries on local markets, but the average was around about ten cents per pint. It would seem that less than 3,000 pints could not be considered as a very profitable yield unless the highest prices were obtained.

It is interesting to note the difference in yield obtained in different sections. Clement in 1910 reported an average yield of 4,450 pints per acre for 68½ acres in Ontario. Bailey in New York State found that the yields ran from 3,200 pints to 6,400 pints per acre and Davis at the Central Experimental Farm at Ottawa reports some rather high yields from limited areas as follows: In 1904 the Herbert variety on thirty-six feet of row gave 50 lbs., 12 oz. which was at the rate of about 10,234 lbs. or 12,595 pints per acre—assuming that one pint is about equal to 13 ounces—this would seem almost to be a record. An average yield for two years for the same variety on a ninety foot length of row was at the rate of 6,586 lbs. or about 8,336 pints per acre. The Brighton variety, on a thirty-six foot length of row, yielded at the rate of 5,602 lbs. or about 6,740 pints per acre. These Ottawa figures are given to show what the possibilities are in the matter of yield.

FALL BEARING RASPBERRIES

The question is often asked as to the value of fall bearing raspberries. Opinions differ somewhat on this point but the great majority of growers do not consider that this type is worth bothering with. It would seem, however, that it has its place, not so much in the commercial plantation as in the home garden, although several growers who are favourably situated have reported good returns from their fall bearers. The method of growing the fall bearers is almost the same as for the summer bearing type the chief difference being in the manner of pruning. One grower cuts the canes quite low in the spring so as to induce the formation of new growth as it is this new growth which produces the fruit. Instead of being borne on small side branches or laterals the fruit is produced at the ends of the young canes. The principal fall bearing varieties are Erskine Park and St. Regis (Ranere) which give a summer crop when treated in the ordinary way.

INSECTS ATTACKING RASPBERRIES AND BLACKBERRIES

By L. CAESAR, Provincial Entomologist.

The chief insects attacking raspberries are,—the striped tree cricket, the raspberry sawfly, the red spider, the red-necked cane borer, the raspberry fruit worm, the raspberry cane borer and the blackberry leaf miner.

THE STRIPED TREE CRICKET (*Oecanthus nigricorns* Walker)

The striped tree cricket, also called the snowy tree cricket, is a greenish-white cricket about three-quarter of an inch in length. Nearly all the injury it causes to raspberries is brought about by the female laying eggs in the canes and causing the part above the eggs either to die or to become weakened. The eggs are laid in a continuous longitudinal row and extend from near the surface into the centre of the pith. A scar on the cane reveals to the eye where the eggs have been deposited. These

Tree cricket egg scars; one cane split open to show the eggs.
(*Courtesy of W. A. Ross*)

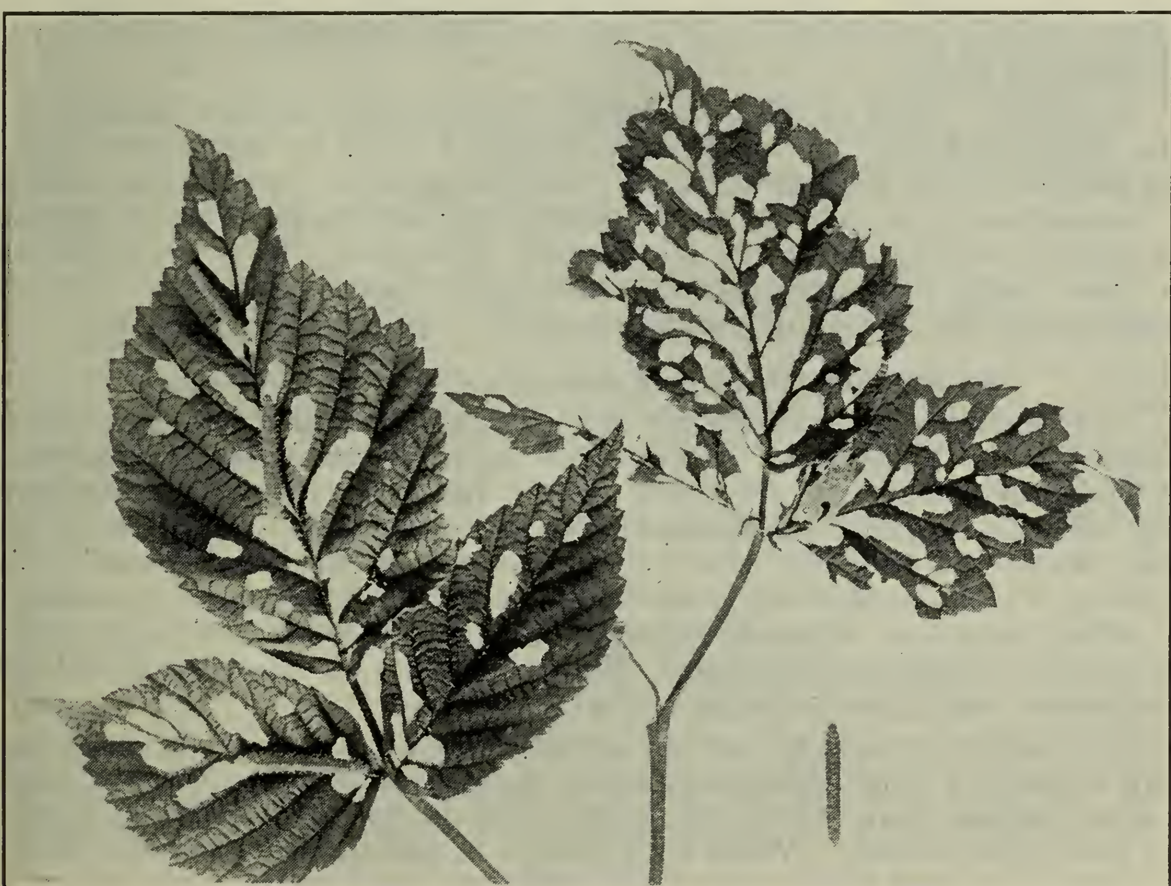
scars vary in length from half-an-inch to three inches or more, and there may be several scars on the same cane. The scars are sometimes near the ground but most of them are about a foot and a half from the top. The disease known as raspberry blight may enter through these scars and be a factor in the cracking open of the cane along the punctured area, and the dying of the part above. The eggs hatch around the middle of June and the young crickets, and later the adults, feed partly upon other insects that come within their reach and partly upon the foliage and upon spores of fungi found on the plant. The young crickets become full-grown in August and egg-laying takes place in September and October. Eggs are laid not only on raspberries but also on stout weeds such as golden rod, fleabane and lamb's quarters, and a few on currants, grapevines and branches of fruit tres. The adults perish before winter. There is just one generation a year.

Control. The habits of the nymphs and adults of feeding to a considerable extent upon the raspberry plants themselves indicates that they may be killed by spraying with 1½ lbs. of arsenate of lead and 4 lbs. of hydrated lime, to 40 gallons of water. It is probable that dusting with a mixture of 1 part arsenate of lead and about 4 parts hydrated lime would also give control. The poison should not be applied until after the middle of June or shortly before the blossoms come out, so that all the eggs may have hatched. Spraying or dusting soon after the crop has been harvested and after the old canes have been removed should also be effective and would be necessary if other raspberry plantations or weedy places were nearby.

The destruction by cutting low and burning in late fall or spring all wild raspberries close by and all sout weeds in or near the raspberry plot itself would help greatly, as would also the removal and burning of all infested canes seen when pruning the plants.

THE RASPBERRY SAWFLY (*Monophadnoides rubi* Harris)

The larvae of the raspberry sawfly are small caterpillars about half an inch or a little more in length when full-grown and of the same green color as the leaves. They can be identified easily by their green color and



Raspberry saw-fly larvae and their work.
(*Courtesy of W. A. Ross*)

the numerous spines over their bodies. The larvae feed upon the foliage and when abundant strip the plants bare leaving only the midrib and coarse veins. The injury takes place in June and may occur before the owner is aware that the insects are present; hence the importance of inspecting the plot occasionally during June.

Where the plants are defoliated the crop for that season will be ruined and for the next season greatly reduced as a result of the weakening of the canes.

The larvae when fully grown enter the soil and remain there until next spring, when they pupate and emerge in late May and June as four-winged black flies about a quarter of an inch long with black head and thorax and a reddish abdomen. There is only one generation a year.

Control. As soon as the larvae are seen to be numerous enough to justify treatment, spray the plants with 1½ lbs. arsenate of lead and 4 lbs. hydrated lime to 40 gallons of water or dust with 1 part arsenate of lead and 4 parts hydrated lime.

THE RED SPIDER (*Tetranychus telarius* Linnaeus)

The same red spider mite which is common in greenhouses and on currants, phlox and many other plants, attacks raspberries. It lives on the under side of the leaves and is more or less protected by a thin web of silk. Here it sucks the juices out of the plants and when very numerous, causes the leaves to have a pale, sickly color. Infested plants are weakened and the crop reduced. The mites are worst in dry seasons; for rains wash many of them off the plants and moisture tends to produce disease among them. From the name "red spider" we should expect these mites to be red but the great mass of them are pale yellowish. Most of them, however, turn red in fall before entering the ground beneath the plants, where they winter. There are several generations a year and eggs, immature spiders and adults may be found on the underside of the leaves all through the season.

Control. Unfortunately no really satisfactory control method has been discovered yet; for while lime sulphur 1 to 50 or certain oil sprays will kill any mites hit and the latter sometimes also the eggs, the foliage of raspberries is so delicate that these sprays are liable at times to burn the leaves severely and so do more harm than good. It is probable that the best spray is water, applied with high pressure—200 lbs.—to the underside of the leaves and repeated once a week for three weeks.

THE RED-NECKED CANE BORER (*Agrilus Ruficollis* Fab.)

The larvae of the red-necked cane borer causes the enlargements or so-called gouty galls found on the canes of raspberries and blackberries. These swollen areas are from one to two inches in length and the bark over them is ruptured longitudinally in several places. The part of the plant above the swelling either dies or becomes much weakened. The insect is widely distributed over the province but fortunately is seldom abundant enough to do much damage, though occasionally plots are found with many of the canes attacked. Some varieties, so far as observed, are much more liable to attack than others.

The adults are bluish-black or almost black, slender beetles about one-third of an inch long. They appear on the bushes in June, July and early August and lay their eggs in the canes. The larvae are white and slender and have brown heads. When fully grown in spring they are about three-quarters of an inch long. After hatching they work in the sapwood, making spiral burrows around it and causing the affected portion of the cane to become swollen as stated above. The winter is spent in the pith and in spring the larvae pupate and the adults begin emerging in June. There is only one generation a year.

Control. As the adults feed readily upon the leaves there seems little doubt that most of them could be killed by spraying with arsenate of lead, 1½ lbs., and 4 lbs. hydrated lime to 40 gallons of water. The spray should be applied as late as possible before the blossoms open and should be thoroughly done. Cutting out and burning in late fall, winter or spring plants showing the characteristic swellings would also help greatly. Wild raspberries nearby should be destroyed so far as possible.

THE RASPBERRY FRUIT WORM (*Byturus unicolor* Say.)

The raspberry fruit worm is the small white worm about one-quarter of an inch long which is found from time to time in the ripe fruit of both cultivated and wild raspberries. The worm is the larva of a small brown beetle about one-seventh of an inch in length. The beetles appear in spring when the flower buds are forming and if numerous, do considerable damage by eating into and destroying these buds and by feeding upon the opening leaves. This damage is more serious than that done by the larvae to the fruit.

Eggs are laid on the stems and the bases of the blossom buds. The larvae on hatching work their way into the base or receptacle of the forming berry and feed their until the berry is ripe, by which time the larvae themselves are full-grown. Soon after this they drop to the ground and pupate either in the soil itself or under rubbish. Next spring the beetles emerge and feed as described.

Control. It is not often that the insect occurs in sufficient numbers to justify any control measures but when it is seen to be abundant enough to cause serious loss the best method is to spray at once with 1½ lbs. arsenate of lead and 4 lbs. hydrated lime, covering every side of the buds and opening leaves. Repeat the application in a week's time or less. Do not spray, however, when the blossoms are open.

THE RASPBERRY CANE BORER (*Oberea bimaculate* Oliv.)

The raspberry cane borer seldom does much damage, though it occurs all over the province and arouses the interest of growers by the peculiar habits of the adults. These are slender, cylindrical, long-horned beetles about two-thirds of an inch in length. The black body and yellow neck or prothorax make this an easy species to identify. The beetles appear on the plants in late May and June and when ready to lay an egg the female cuts two rings around the stem about two to five inches from the tip. These girdles are about half an inch apart. The egg is then laid in the cane between the girdles. The part above the girdles wilts and later dies. The larva on hatching works its way down the stem a short distance and winters there. Next year it continues boring down the cane until it reaches the crown. Here it winters as a full grown whitish grub about an inch long with a brown head. Next spring the beetles appear. Canes in which the grubs lived long enough to work far down perish.

Control. Whenever the wilting tips are seen in spring cut or pinch them off about two inches below the injured area. This will result in the death of the grubs.

Cane girdled by the raspberry cane borer.
(*Courtesy of W. A. Ross*)

THE BLACKBERRY LEAF MINERS (*Metallus bethunen* MacG. and *M. rubi* Forbes)

Blackberry leaf miners are grayish-white larvae with black heads. When fully grown they are about one-third of an inch long. They injure blackberry plants by feeding between the upper and lower surface of the leaves. Sometimes they occur in enormous numbers and almost every leaf will have from three to a dozen mines or more in it, with the result that all green tissue is soon devoured and the foliage over the whole plot turns brown and dies. Soon, however, new leaves appear. These after a few weeks are in turn attacked by a second brood of larvae and are likewise killed. The result is a poor crop that year and weakened plants the second year. Sometimes these insects are very numerous for three to six years in succession, then they almost totally disappear for several years. This is largely due, so far as observed, to the attacks of several parasites.

There are two species of miners but they look so much alike that only a specialist can distinguish between them. Their habits and life histories are almost identical. The adults begin to emerge early in June and continue doing so for several weeks. They are small black four-winged flies about one-fifth of an inch long with white legs. In a couple of hours after emergence the females begin laying their eggs in the leaves. The larvae on hatching begin mining in the leaves. Most of the first brood larvae are full-grown and enter the ground by the end of July. Here they make tough little cocoons an inch or so below the surface. A second brood of adults begins to appear about the middle of August and larvae from these may be found in the leaves as late as November. These second brood larvae winter over in cocoons in the ground.

Work of blackberry leaf miner in leaf of blackberry. The mines in nature are brown not grayish as shown here.

Control. In spite of much study by the writer and by members of the Dominion Entomological branch no satisfactory method of control has at the date of this publication been discovered.

RASPBERRY AND BLACKBERRY DISEASES

J. E. HOWITT

The raspberry and blackberry are subject to several troublesome diseases against which the grower of these fruits must be constantly on his guard. Neglect in taking precautions against these diseases is almost sure to lead to serious loss. Disease is the chief factor which brings about the so-called "running out" of raspberry and blackberry plantations. Growers therefore should make themselves well acquainted with the more important diseases with which they may have to contend. They should understand the cause of these diseases, know their symptoms and the best methods for their control. It is hoped that the following account of the more important diseases of the raspberry and blackberry may help those who are interested to acquire such knowledge.

VIRUS DISEASES

Mosaic and Leaf Curl are two of the most important diseases of the raspberry in Ontario. They are what are known as virus diseases. They are so named because there is something in the juice of a diseased plant which for want of a better name has been called a virus, which if transferred to healthy plants, will cause the disease. Certain characteristics are common to both of them. A plant affected with either of these diseases the whole bush—leaves, canes and roots—is infected and will develop the disease. All stock propagated from plants affected by either of these diseases will also be infected and eventually suffer from the disease. Both these troubles cause a dwarfing of the plants and a reduction in the yield of fruit.

RASPBERRY MOSAIC

This disease has been observed in most of the raspberry growing areas of the Province. In the Niagara penninsula and eastward along the northern shore of Lake Ontario it has been very abundant and severe. All varieties of raspberries grown for commercial purposes in Ontario appear to be susceptible to Mosaic. It is one of the chief factors causing reduced yields and decreased profits from raspberry plantations.

Symptoms. The symptoms of Mosaic are most marked on new growth, especially the suckers. Leaves of affected shoots are at first somewhat lighter green in color than is normal for the variety. Later they become mottled with light yellowish patches among the green and more or less dwarfed. In newly infected plants this mottling is very faint but as the disease progresses it becomes very distinct. Affected leaves also generally show a puckering or roughening on the surface. If one leaf on a shoot becomes mottled all the new leaves developing on this shoot will show the mottling if the plant is affected by Mosaic. Very little dwarfing is to be observed the first year the plants are affected with Mosaic. The dwarfing becomes more pronounced each year until one of the most striking symptoms observed on entering a badly diseased plantation is the stunted sickly plants in the rows. Very often a considerable portion of a row will consist of these diseased plants which stand out in marked contrast to the healthy ones. These dwarfed mosaic plants produce much less fruit than healthy ones and it is of inferior quality, the berries usually being soft, crumbly and insipid.

How Mosaic is spread. Mosaic is very frequently introduced into new plantations by planting stock which has been propagated from diseased plants. It is spread from plant to plant in the rows by raspberry aphids (plant lice) of at least two genera. These aphids feed on the leaves of infected plants and then move to healthy bushes infecting them with the mosaic virus as they suck the juice from the leaves. In Ontario the spread of Mosaic is not rapid. It is slow but sure if nothing is done to check it.

Control of Mosaic. Old plantation which have become unprofitable owing to the prevalence of Mosaic should be plowed up. Berkeley states: *"It is not advisable to attempt to rogue a plantation over two years of age that has more than five percent mosaic. A two-year-old plantation that has a small percentage of mosaic may be put in a fairly healthy condition by careful and continued roguing."

In setting out a new plantation use healthy certified raspberry stock and carefully and systematically inspect and rogue it. A raspberry inspection and certification service is carried on by the Dominion Laboratory of Plant Pathology, St. Catharines, Ontario. Growers can secure from this laboratory a list of the names of the men who have inspected certified raspberry stock for sale. A new plantation of healthy stock

*Pamphlet No. 72, New Series. Dominion Department of Agriculture.

should be located at least three hundred feet from other raspberries either cultivated or wild. The hill system of planting is recommended as an aid in controlling mosaic. Inspect the new plantation several times during the growing season and dig up all diseased plants—roots and all—and remove them immediately from the patch before the foliage has time to wilt as the aphids will soon leave the wilted foliage of diseased plants and migrate to healthy ones, carrying the disease to them. In removing mosaic bushes do not drag them along the ground or brush them against healthy plants as aphids carrying mosaic are very likely to be scattered to healthy plants by such means. It is advisable to burn all the plants that are removed on account of mosaic. Owing to the danger of spreading mosaic when removing diseased bushes, the scorching of these to kill the aphids is sometimes practised. This is done with a kerosene torch or by burning them after they are sprinkled with gasoline. After this burning they are dug up by the roots and removed from the plantation.

Careful inspection and roguing should be continued the following seasons in order that the plantation may be kept free from disease. Such inspection and roguing has been found to be effective and to require but little labour if the plantation has been started with certified stock. Empty spaces in the rows caused by the roguing may be reset with healthy stock at any time. Care must be taken, however, to see that all the roots of the diseased bushes have been removed from the soil first.

LEAF CURL

This is another virus disease which is very frequently seen in Ontario. The symptons of leaf curl are very distinct and characteristic. It is, therefore, very easily recognized by the grower. It is comparatively easy to rid a plantation of leaf curl by systematic roguing. In those sections of the Province where raspberry plantations have been carefully rogued each year, leaf curl has become a disease of comparatively minor importance. In neglected plantations it is conspicuous and causes considerable loss.

Symptoms. The leaves of badly diseased plants are conspicuously wrinkled and curled, and dark green in color. The curling of affected leaves is downward and inward at the edges. This curling is very slight on newly infected bushes but becomes pronounced as the disease progresses. Suckers from badly diseased plants are shorter than normal and have their leaves conspicuously curled and dwarfed. The fruits of diseased plants are dry and seedy. Diseased plants never recover. They are useless and a source of infection for healthy bushes near them.

How Leaf Curl is Spread. It is spread from diseased to healthy bushes by plant lice (aphids). The Aphis (*rubiphila*) is the chief carrier of the virus of Leaf Curl. This aphis is very small and usually does not move about a great deal unless disturbed. Consequently Curl usually spreads slowly from bush to bush along the row. It is said to spread more rapidly in Cuthbert and Cumberland than in King or Gregg. Curl is frequently introduced into new plantings by using stock from diseased plantations.

Control of Leaf Curl. In starting a new plantation use certified disease-free stock (see control of Mosaic). Inspect the plants frequently and remove and burn all showing symptoms of Curl, taking care to get the entire plant including all the roots and suckers. Even if a plant has only one diseased cane every shoot connected with this root system should be removed. If the plants are growing in rows and not in hills that are distinctly separated, it is advisable to dig out all the other plants for three feet on each side of the diseased one. These plants are almost sure to be infected and develop the disease the following year. The rogued area should be kept free from sprouts during the remainder of the season. It is not considered advisable to attempt to rogue an old plantation in which Curl is well established. Keep such plantations only as long as they give a profitable crop of fruit, then discard. Never use planting stock from such diseased plantations.

ANTHRACNOSE

This disease is common in Ontario. It is of economic importance only on black raspberries and blackberries. It is, however, often seen also on red raspberries.

Symptoms. All parts of the plant above the ground are affected. The conspicuous and most characteristic symptoms are on the canes. In Ontario it is primarily a disease of the canes, both young and old. It may often be observed on young canes a few inches high. On the canes distinct spots may be seen. These are at first purplish, later greyish-white. They run into each other forming irregular blotches. These may be an inch or more long, and often girdle the canes. Badly diseased canes are stunted and the fruit fails to form, or dries up prematurely.

Cause. Anthracnose is caused by the fungus *Plectodiscella veneta.* This fungus passes the winter in the spots on the canes. In the summer it produces spores on the surface of the spots which are liberated and scattered during rainy periods.

Control. If Anthracnose is so severe that the plantation is not yielding a satisfactory crop, it should be discarded and a new plantation started. In setting out a new plantation use only disease-free stock. Watch the bushes carefully and if Anthrancnose appears cut out and burn old canes and badly affected new ones as soon as the fruit is picked.

*Mr. C. W. Bennett of the Michigan Agricultural Experiment Station recommends the following sprays for the control of Anthracnose in black raspberries: (1) When the buds begin to break spray with commercial lime sulphur of the strength of from 2-4 gallons, to 40 gallons of water. About a week before the blossoms open spray again with Bordeaux mixture 2-4-40. It is not safe to spray raspberries after the blossoming period. Sprays later in the season sometimes produce severe injury. Such spraying has not been experimented with here in Ontario but the results obtained from it in Michigan would warrant giving it a trial.

SPUR BLIGHT

This disease occurs almost everywhere that raspberries are grown in the Province. During the past few years it appears to have become more prevalent and to have caused serious injury in many raspberry plantations.

Symptoms. Spur blight may be seen on old or new canes almost any time during the year. On new canes the symptoms usually begin to appear in the early part of July. Chocolate brown or dark red spots develop on the leaf stalks and on the skin of the young canes at the nodes or where the leaves are attached. The tissues around the buds turn brown; the buds shrivel and may die. If they live over the winter they produce small yellowish leaves but no spurs. The leaflets fall off leaving the brown stalks on the canes. The disease spreads from the affected leaf stalks into the nodes. The lesions on the canes may dry out and crack.

Cause. Spur Blight is caused by the fungus *Mycosphaerella rubina.* This fungus passes the winter chiefly on the old canes and is spread dur-

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*Agricultural Experiment Station, Michigan State College of Agriculture and Applied Science, Special Bulletin No. 178, "Michigan Raspberry Diseases" by C. W. Bennett.

ing the growing season by means of countless spores produced in the discolored bark of the diseased canes.

Control. Prune out and burn the old canes as soon as the fruit is picked. In certain of the States spraying has been found helpful in the control of this disease, but no extensive spraying experiments have yet been carried on in Ontario and therefore no recommendations concerning spraying for Spur Blight can be made at this time.

ORANGE RUST

This is a common disease in Ontario, especially on black berries. It affects both wild and cultivated blackberries, black raspberries and dewberries.

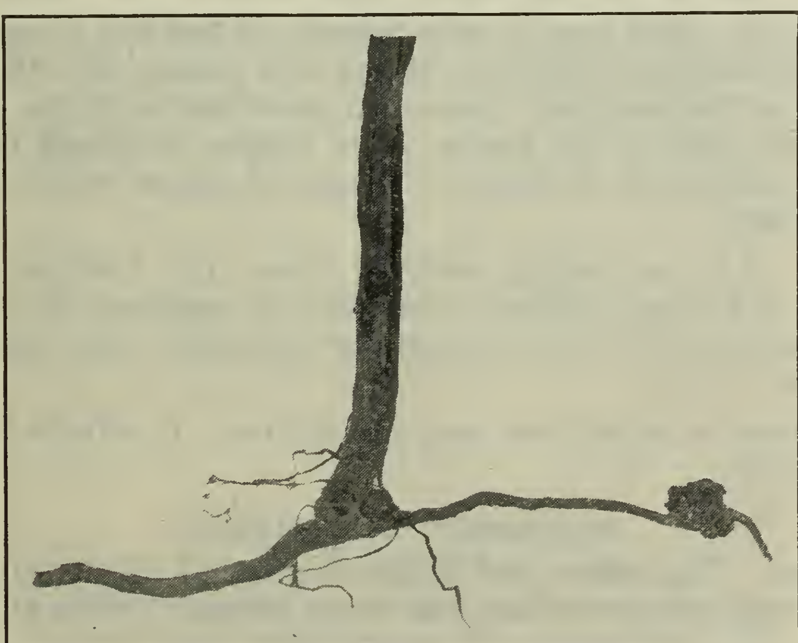
Symptoms. In the early spring (April and May) a distinct yellow glandular coating is seen on some of the leaflets and young shoots by a careful observer. Two or three weeks later the under surface of the leaves becomes covered by a conspicuous bright orange blister-like coating. Affected leaves are usually dwarfed and mis-shapen. Diseased plants are noticeably stunted. Once a plant is infected it never recovers.

Cause. Orang Rust is caused by the fungus *Gymnoconia interstitialis.* The threads (mycelium) of this fungus winter over in the bark and wood of the stems, crowns and roots of affected plants. On the lower surface of affected leaves this fungus produces innumerable spores which serve to spread the rust to healthy plants.

Control. Watch the plantation carefully and dig out early in the season just as soon as they can be recognized, all bushes affected with rust. Such plants never recover and if they are left for any length of time the rust spores produced on their leaves will be spread to healthy bushes. New plantations should be carefully inspected as Orange Rust may be carried in nursery stock. It is also advisable to destroy any rusted wild blackberries, dewberries and raspberries growing in the neighbourhood of the raspberry plantation.

CROWN GALL

This is a common and destructive disease of red raspberries in Ontario. It is seen on the roots of red raspberries and on the crowns and



Crown Gall on root of red raspberry.

canes of black and purple varieties. Crown gall also affects the blackberry, dewberry and our tree fruits, such as the apple, peach and plum.

Symptoms. Red raspberry bushes seriously affected by Crown Gall have a stunted unthrifty appearance and if they are dug up and the roots examined, round, white, slightly roughened knots will be seen on them. These galls become brown with age and decay. The seriousness of the disease apparently varies with varieties and the condition of the soil. On black raspberries the galls are chiefly near the crowns and on the fruiting canes, usually towards the base. On the latter conspicuous warty growths are frequently observed.

Cause. This is bacterial disease caused by *Bacterium tumefasciens.* This organism appears to occur abundantly in orchard and garden soils in Ontario. It enters the tissues of the plants through wounds made by cultivating implements and insects.

Control. Dig and burn sickly plants. In setting out new plantations secure healthy disease-free stock. Never plant a cane showing the least sign of galls on the root or other parts. Put fresh plantations on new soil if possible, or at least do not put them on ground which has been recently used for raspberries, blackberries or fruit trees. It is thought that soils which have grown such crops as clover, corn or beans for three or four years should be comparatively free from the crown gall organism.

WILT

This disease is sometimes called Blue Stem. It is found throughout the Province in red and black raspberries. It appears to cause most injury to black raspberries.

Symptoms. The lower leaves of affected plants turn yellow, wilt and fall. The falling of the diseased leaves progresses from the ground upward until the canes are bare or nearly so. This loss of leaves is usually accompanied by a bluish or purplish discoloration of the canes. These defoliated bluish canes are very conspicuous in a badly diseased plantation and can hardly be overlooked even by a casual observer.

Cause. Wilt is caused by the fungus *Verticillium ovatum.* This fungus is capable of living on decaying organic matter in the soil. It lives for some time in the dead stems amid roots of the plants which have been killed by it. How long it may remain in the soil is not known. It penetrates the roots of raspberry plants and passes into the water conducting tubes of the roots and stems and interferes with the movement of water from the roots to the leaves. The fungus is spread from place to place in crop refuse and probably by means of spores which are produced in great numbers.

Control. (1) Use healthy certified stock; (2) Practice a crop rotation; (3) Do not plant potatoes, tomatoes or eggplant etc., between the rows of raspberries; (4) Cut out and burn all canes that have been killed by the disease.

This disease is sometimes seen in Ontario. It affects both red and black raspberries.

RASPBERRY CANE BLIGHT

Symptoms. The leaves and fruits of affected plants wither and dry up from the tops downward and the canes become brittle and frequently broken. The diseased canes are occasionally seen in the rows and are often mistaken for those destroyed by the Snowy Tree Cricket, or injured in cultivation. If the affected canes are examined the bark is seen to be lighter in color and near the base will be found discolored dead areas in which numerous black dots (the fruiting bodies of the fungus) may be seen. Frequently these diseased areas are discolored and smoky due to the presence of immense quantities of exceedingly small spores.

Cause. Cane Blight is caused by the fungus *Leptosphaeria coniothyrium.* This fungus is carried over from season to season in affected canes and produces numerous spores on the surface of these. Blighting often does not take place until the season following infection. Rainy weather is conducive to infection and the fungus grows best at rather high temperatures.

Control. Results from spraying have not been satisfactory. Fortunately the disease is rarely severe enough to justify spraying. It is advisable to remove and burn old canes immediately after the fruit is gathered. In setting out a new plantation use only disease free stock, and avoid planting where raspberries or other related plants have recently been grown.

ACKNOWLEDGMENT

The writer wishes to acknowledge that in the preparation of this account of raspberry and blackberry diseases, the following sources of information have been freely drawn upon.

Pamphlet No. 72, Dominion Department of Agriculture, Special Bulletin No. 178, Agricultural Experiment Station, East Lansing, Michigan, Farmers' Bulletin No. 1488, United States Department of Agriculture.

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Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

Revised April 1930

Insects Attacking Fruit Trees

Lawson Caesar, Provincial Entomologist.

In the following pages we have not attempted to discuss all the insects that attack fruit trees in Ontario, but have limited ourselves to those that are commonly found and that, except in an occasional year, do almost all the damage. These we have discussed somewhat fully in order that we might meet the needs not only of the fruitgrowers themselves but also of public and high school teachers and agricultural representatives.

Changes or Transformations Undergone by Insects.

Many insects, such as moths, beetles, flies and bees, pass through four main stages in their life history; namely, adult, egg, larva and pupa. The adults are usually, though not always, winged. The female adults lay the eggs. These hatch into what are called the larvæ. Larvæ of moths are commonly called caterpillars, those of bettles grubs, and those of flies maggots. The larvæ cast their skins from time to time to allow for growth. When full-grown they change into what are known as pupæ. These are usually either brown or white, and do not eat but remain stationary until they are ready to transform into adults. Many, but not all, larvæ before pupating spin about themselves a protecting case of silk, often mixed with hair. This is called a cocoon. Insects with the above four stages are said to have complete metamorphosis.

Another great class of insects, such as grasshoppers, tree-hoppers, leaf-hoppers and plant bugs, have only three main stages; namely, adult, egg and larva. As a rule the larvæ of these insects are called nymphs. There is usually no pupal stage. The nymphs in most cases resemble closely the adults but never have fully developed wings, though the older ones have wing pads, which in the adults have developed into wings. Nymphs, like ordinary larvæ, moult from time to time, and at the last moult become adults. Such insects are said to have incomplete metamorphosis.

A considerable number of insects, as for example the San José scale, never lay eggs, but give birth to living young; while some other insects, such as aphids, give birth to living young throughout the most of the season, but in late fall lay eggs. Quite a number of female insects are capable of producing young without mating with a male. This is known as parthenogenesis, or virgin birth.

Kinds of Mouth Parts and Methods of Feeding.

One great division of insects has biting mouth parts and feeds by biting off little particles of the leaf, fruit, bark or wood and chewing these. We call such insects *biting insects.* Caterpillars and beetles are examples.

A second large division has not biting mouth parts, but instead has four bristles fitting closely together and forming a sucking tube, enclosed in a soft protecting beak or sheath. With these bristles, which are sharper than a needle, they pierce the skin or epidermis of the part of the plant fed upon and suck up the juice from within. We call these *piercing* and *sucking insects.* Leaf hoppers, aphids and scale insects are examples.

A third class of insects has a sucking tube with a broad, expanded lip at the tip. With this lip they lap up liquids, and, as it is furnished with a rasping device, also rasp solids and absorb them. Such insects may be called *rasping* and *lapping insects.* Examples are the housefly, the apple maggot and the two cherry fruitflies.

General Principles for the Control of Insects.

What has been said about the different kinds of mouth parts of insects is very important when we come to consider their control. It is clear that insects which bite out little particles of plant tissue and swallow them give us an opportunity to kill them by placing poison on the part of the plant attacked. *Hence for biting insects we spray the plant with arsenate of lead or arsenate of lime,* these being at the present time our most satisfactory poisons. These poisons are known as *stomach poisons,* because they kill by being taken into the stomach along with particles of food.

Piercing and *sucking* insects do not remove the tissues, but only extract the juice from beneath the skin or epidermis; *hence spraying for them with a stomach poison would be useless. They must be killed by some substance that comes into contact with their bodies, such as strong lime-sulphur or oil emulsions for scale insects, or tobacco extract for aphids.* We usually call such insecticides *contact poisons,* because they kill by contact.

Rasping and *lapping insects,* since they move around over the surface of the plant absorbing both liquids and solids, *may be killed by spraying with arsenate of lead.*

Some insects, as leaf rollers and the European red mite, *can be controlled best by destroying their over-wintering eggs* by one of the lubricating oil emulsions or miscible oils applied in spring while the trees are still dormant or almost dormant.

There are other ways besides spraying by which we may help to control some of our worst orchard insects. One is by removing all sorts of rubbish in and around the orchard. The reason for this is that some insects winter under the protection of this rubbish and would perish if it were removed. Another helpful means is good cultivation. This aids by destroying pupæ that are in the soil and also by destroying weeds and grass on which some insects, as for example, the buffalo tree hopper nymphs, feed. A third way is to burn all prunings and brush early in the spring each year and thus destroy the insects within, such as fruit tree bark beetles or shot-hole borers, before they can transform into adults and emerge.

Natural Forces Which Help to Control Insects.

Man is greatly assisted by nature in the control of insect pests; in fact the control of insects by natural forces is wonderful and affords a most interesting field of study. The following are some of the ways in which this is accomplished:

Climate checks the progress of some insects; for instance, the San José scale is unable to make any headway in the colder fruit-growing portions of the Province, and the codling moth, owing to a smaller percentage of a second brood in such districts, is also much less abundant. Late spring frosts sometimes kill great numbers of delicate, recently hatched larvæ. Heavy downpours of rain wash many small insects from trees and many of these never get back. A very cold wet spring destroys countless insects in their early stages: a cold backward spring may almost annihilate the pear psylla. And very hot dry spells in spring or summer often cause the disappearance of innumerable aphids.

Diseases of various kinds are very important factors in holding some of our worst insects in control. These diseases are usually favored by wet seasons.

Predaceous insects such as ladybird beetles and their larvæ, syrphus fly and lace-wing larvæ, assassin bugs and many kinds of beetles prey upon insects and aid greatly in control, especially of aphids.

Parasitic insects, such as tachina flies and ichneumons, lay their eggs upon or in caterpillars or other pests and the larvæ from these feed upon and destroy their victims.

Birds and several other vertebrates do their share to help and are sometimes of great assistance.

All the above natural factors are a great help in preventing more injury than is even now the case, yet even so they are not sufficient to allow fruitgrowers to trust to them alone to keep the foliage healthy and the fruit free from injury or disfigurement; hence it is necessary to resort to spraying.

The Importance of Spraying.

No single orchard operation is so important as good spraying. It is almost every year the big factor that determines whether the orchard pays or not. In many orchard practices one may economize a good deal and suffer little, but in spraying the man who wants to make fruit-growing a success must not be satisfied with half measures: he must do the job well, stinting neither time nor material. *The reasons why spraying is so important* are easy to understand and are as follows:

(1) A high percentage of clean, marketable fruit, free from disease and insect injuries cannot be obtained to-day without good spraying. Every grower should aim at 95 per cent. at least of absolutely clean fruit. Many are obtaining this and higher.

(2) Spraying not only gives clean fruit but prevents to a large extent the fruit from dropping off the trees. Any one can easily prove this for himself.

(3) Spraying helps greatly to keep trees healthy and by so doing is a great factor in insuring good annual crops: an orchard that has poor, sickly foliage

because of insects or disease one year, is almost sure to have little or no crop the next year. Hence spraying is not only an insurance for the present but also for the future. No amount of cultivation, fertilizing or pruning can give beautiful, healthy, green foliage in a year when either insects or diseases are abundant, but spraying can. The other things just mentioned help of course, combined with spraying.

Spray Machines.

There are many makes of spray machines, almost all of which are advertised in the various agricultural journals and magazines of the Province. It is not the duty of the writer to say which of these is the best, even if he could be sure. Intending purchasers should make inquiry among fruitmen as to the merits of any particular machine before buying.

The type of machine required will depend upon the number of acres and the size of the trees to be sprayed. If there are only a few dozen trees a barrel outfit with one line of hose will suffice. It very seldom pays to get any outfit smaller than a barrel. These barrel sprayers cost from $35.00 to about $50.00.

For any orchard of more than about four acres of large apple trees or about eight acres of cherry, plum, or peach trees a power outfit driven by a gasoline engine is advisable. Such an outfit will save time and labor and will make it much easier to do a good job.

Gasoline power outfits are of different kinds: some have duplex pumps and are intended to be used with only one line of hose and one spray gun; others have triplex pumps and more powerful engines than for the duplex, and will supply sufficient power for two lines of hose. The duplex type is much cheaper, and, if a good make is secured, is satisfactory for all but large orchards. The triplex type is well adapted for large orchards but the most powerful makes are sometimes too heavy for soft soil.

The cost of a duplex power outfit usually runs from about $300 up to $600, and of a triplex from $600 up to $1,000.

In addition to the above there is now a new type of machine, called a liquid duster or a liquid blower. This is constructed much after the pattern of a true duster, a fan and a powerful current of air being used to distribute the spray. One man and a driver can operate the machine and cover the trees about as fast as two men and a driver can with the best makes of triplex outfits. They are not so satisfactory, however, if the wind is not quite in the right direction or if the trees are very large and not well pruned.

Suggestions on Equipment.

The Machine. Good spraying cannot be done without a good outfit. How important a factor a good, leakless, easy running machine which gives all the power required without any strain on itself is, compared with a poor, leaky, machine, which half the time fails to give the right amount of pressure, only those who have used both know. With the good outfit spraying is interesting and not unpleasant work, but with the other it is about the most disagreeable task a man can undertake. Moreover with the good outfit it is vastly easier to secure clean fruit. Hence do not economize in buying a spray outfit, but purchase the best for your size of orchard; if the orchard is too large for one machine, buy two.

The Hose. On any make of outfit high quality hose should always be used. All power machines should have hose guaranteed to stand at least 350 lbs. pressure; otherwise, if the nozzle of the gun or rod becomes clogged, the hose is liable to burst. If there is only one line of hose, it should be about thirty feet long. If there are two, the one for the man on the tank may be about twenty feet long and the other for the man on the ground forty feet. This allows the ground man to keep far enough away from the man on the tank to avoid being drenched. Hose should be so firmly clamped to the spray outlet that it will not pull off and cause loss of time. Special clamps may be secured which are excellent for this purpose. Wire, such as is used for baling hay is fairly good in an emergency to supplement poor clamps.

The Spray Guns and Rods. There are several kinds of spray guns and spray rods and no doubt new types will be devised from time to time in the future. Hence all growers should try to become familiar with these and purchase the kind likely to be most satisfactory for their outfit and orchard.

A barrel spray machine should not be equipped with any of the common spray guns, because such an outfit cannot generate pressure enough to work one of these properly. No spray gun should be used with less than 200 lbs. pressure. Hence barrel outfits should have instead a bamboo rod 6 to 8 ft. long and two angle disc nozzles on a V.

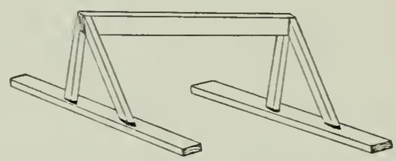
Power outfits may use either spray rods or spray guns. If two lines of hose are being used and the machine will not maintain more than 200 lbs. pressure it is a good plan for the man on the tank to use a single gun and the man on the ground to use a 6 or 7 ft. bamboo pole with two angle disc nozzles. This will mean less burning of foliage by the man on the ground and also less missing of parts of the tree.

The larger and more powerful machines should be equipped either with two double guns or with two of the new style of short rods with four nozzles, or with one of these and one of the double guns. A double gun or one of these short rods will not send the spray so far as a single gun but will spread it out wider, give a finer mist and cover the tree more quickly.

The size of the opening in the disc of the nozzles of either a rod or a gun is a matter of importance. If the pressure is high one of the largest openings may be used, but if the pressure is at all weak a smaller opening. The openings of course enlarge with use; hence a supply of discs should always be kept on hand and a new one substituted whenever the old becomes too large.

Filling Devices. Many fruit growers lose a great deal of valuable time in their spraying by not having a rapid device for filling their spray tank. These men take 20 minutes or more to fill a 160 gallon tank where only 5 or at the most 10 minutes should be required. The best device for rapid filling is an elevated supply tank from which the spray outfit can be filled by driving up alongside it, opening the stop cock and letting the water run into the spray tank by gravity through a hose or pipe two inches or more in diameter. The supply tank itself may be filled as often as necessary by means of a force pump or rotary pump driven by a gasoline engine, or sometimes by a windmill. The self-filling devices usually provided with the spray machines are slower than the supply tank but fairly satisfactory, if the water is close at hand, especially if it is right in the orchard.

A Support for the Operator on the Tank. Since it is often desirable to spray from the top of the tank some sort of support is necessary to prevent the operator from falling. The handiest and simplest is the sawhorse type made of a piece of 2 x 4 inch planed lumber running almost the full length of the platform, high enough for the operator to stand astride, and held in position by



A handy type of support for the man on the tank.

two wooden or iron braces near each end. These braces can be mortised into or bolted to a board about six inches wide and just long enough to fit across the top of the tank. Then the whole structure can be firmly secured to the top of the tank by stout screw nails through the ends of the boards. Such a device will not catch branches when passing between two rows of trees and can be removed easily when necessary.

Suggestions on Spraying.

To get clean fruit each spray must be applied thoroughly and at the time recommended in the Ontario spray calendar. Each application is meant to protect the fruit until the next is given. Hence if any particular application is omitted, or poorly done, diseases or insects may get a start before the next spray can be given and no amount of later spraying be able to compensate for the damage done. Therefore the necessity for promptness and thoroughness. By thoroughness is meant the covering of every leaf and fruit on all sides. If only one side of an apple is sprayed we should not expect all that apple to be free from scab. In actual spraying, especially of large trees, most men, unless there attention is drawn to it, spray only one side of most of the fruit; for they spray only the outside of the trees and forget about the inside. It is the inside however that needs the spraying most, especially to keep off apple scab; because the inner side of each apple is the shaded part, receiving least sunshine, and therefore remaining moist longer and thus being more favorable for the development of apple scab. Hence, for example, when going down the east side of a row of trees make sure that the spray goes right through the tree and covers the east side of every leaf and fruit. Then when spraying the same row from the west make sure that the west side of each fruit and leaf is likewise covered all through the tree. To do this in either case, if the trees are large, will often require that the man on the ground go in half way under the tree and do the farther half first and then step back and do the nearer half. The man on the tank should help him to make a thorough job by not forgetting to send enough spray over the top to fall down and cover all the foliage in the upper part of the tree.

Another mistake that sprayers commonly make is failure to spray the tops of the trees heavily enough. Special care must be taken to see that all the leaves and fruit there is well covered. Let the spray fly into and over the top longer than on any other part of the tree, because it is farther away and harder to cover well.

Different sprayers have different general methods of spraying, but the experience of the best men is that the most satisfactory method of applying the spray in most cases is to begin well in at the side of the tree when coming to it and spray slowly up from the bottom to the top in a straight line, then slowly straight down parallel to the strip just done and repeat the process until about two-thirds of the tree has been covered from that side. Treat the other side in its turn the same way. Such a method is much more systematic and less likely to leave missed areas than any other. It also wastes less material.

The question is sometimes asked, whether there is any need of spraying trees from both sides. There certainly is need; for it is impossible to cover the fruit in any other way.

Another question is, whether one should spray in a high wind. A high wind so long as it is blowing in the direction desired is usually an advantage; for it allows the operator to stand well back and let the wind carry the spray right through the trees. But to spray against a high wind is impossible. There are times, however, when the wind remains for a week or more in the same direction and thus makes it hard after doing one side of the trees to do the other. In such cases it is necessary either to do the spraying early in the morning or late in the evening when the wind has gone down, or else to drive up the rows facing the wind and shoot the spray in at right angles to it. Then go back and come up the other side of the row and shoot it in from the opposite side. This means spraying the trees from three sides, but it often has to be done.

Another question is whether spraying should stop when the trees begin to drip. The answer is: Pay no attention to the dripping but watch to see when you have wet every leaf and fruit or, in the case of a dormant spray, every branch and twig; then stop at once.

Care of the Spray Outfit. During the spraying season the engine and pump must always be kept well oiled and greased, and any nuts or parts that become loose tightened up. Whenever the machine is to stand idle for a day or more it should always have the tank drained and washed out and clean water pumped through the nozzles. It should also be put into a shed or some place out of the sun and rain. At the end of the season the hose and nozzles should be cleaned by pumping water through them, then drained and put away in a dry place. A little oil should be pumped through the pump and poured over any part likely to rust. The water should be drained out of the engine, the pipes, and any other place where it might remain and do damage by freezing. Each spring, a month or more before the season begins, the whole outfit should be thoroughly overhauled and tested to see that it is in good condition.

Dusting vs. Spraying. Dusting trees with a fungicide and an insecticide to control diseases and insects is a much more rapid and easy method than spraying. The writer, after making many tests of this method over a period of ten years or more and observing the results obtained by various persons who have used the dust, is convinced that dusting is not nearly so reliable a method as spraying, especially in a season very favorable for the development of apple scab. There are also several insects, such as, the fruit tree leaf rollers, red mite and certain scale insects which the dust does not control. Hence if only one kind of outfit is to be used in the orchard it should in most cases be a sprayer and not a duster. A duster, however, is very convenient and desirable for a man with a large orchard to help him out in an emergency and to use in making late applications wherever such are necessary. If a late application is given with a sprayer it stains the fruit but with a duster, especially if the sulphur dust is used, it does not.

The above remarks refer chiefly to apples and pears but hold true for the most part also for plums, cherries and peaches.

Dusting fruit trees for insects and diseases.

Insecticides for Fruit Trees.

Insecticides change from time to time; hence some of those which we now recommend will, we hope, be superseded in a few years by better. At the present time the following are the most efficient:

(1) *For biting insects*—arsenate of lead and arsenate of lime (commonly called calcium arsenate).

(2) *For sucking insects*—

(a) Nicotine-sulphate 40%, used chiefly against leaf-hoppers and plant bugs.

(b) Lubricating oil emulsions and miscible oils, used chiefly against scale insects, leaf rollers, European red mite and pear psylla.

(c) Lime-sulphur, used against San José and oyster shell scales.

(d) Soluble sulphur, used sometimes as a substitute for lime-sulphur.

Arsenate of lead is the most popular and the safest poison known at present for biting insects in general. It is a fine, white powder and is commonly used at the strength of 1½ to 2 lbs. to 40 gals. of water or of lime-sulphur or Bordeaux mixture. With lime-sulphur it may be used alone but usually it is considered wise to add first 3 lbs. of hydrated lime to 40 gals. of the diluted lime-sulphur and to put in the poison just before applying the spray.

Arsenate of Lime or Calcium Arsenate is also a fine white powder and looks exactly like arsenate of lead. It is much cheaper than arsenate of lead, costing usually only about half as much per pound. It also contains more arsenic; so that 1 lb. of it is as effective against most, but not all, biting insects as 1½ lbs. of arsenate of lead and is the strength recommended to every 40 gals of spray. The chief reason it does not supersede arsenate of lead as an orchard poison is that it is not safe to use with water alone and not always safe with lime-sulphur. We recommend anyone who decides to combine it with the lime-sulphur to add first 3 lbs. of hydrated lime to every 40 gals. of the liquid to lessen the danger of foliage injury. With Bordeaux mixture it is quite safe and therefore recommended in most cases in preference to the more costly arsenate of lead. With lime-sulphur arsenate of lime, unlike arsenate of lead, does not cause the black sludge which tends to clog nozzles.

Either arsenate of lead or arsenate of lime if stored in a dry place may be kept indefinitely without losing strength.

Nicotine-sulphate 40% is a dark brown liquid extract from tobacco plants. It is sold chiefly in tin cans varying from 1 to 10 lbs. in weight. It may be used with either lime-sulphur, Bordeaux mixture or water alone, though it is almost always better in the last case to add about 2 lbs. of soap to every 40 gals. of the water; for this makes the liquid spread better and also helps to make the nicotine act more quickly. The chief objection to this insecticide is that it is somewhat too costly to use except at critical times. The usual strength for aphids is 1 pint to every 100 gals. of spray.

Caution.—Soap must never be added to nicotine sulphate when combined with lime-sulphur, as it will break down the latter and make a curdled mixture.

Nicotine sulphate may be mixed with hydrated lime or with sulphur and arsenate of lead dust and applied to the trees with a power duster. The usual strength necessary to kill aphids and plant bugs is 2%.

Lubricating Oil Emulsions and Miscible Oils. Lubricating oil emulsions have recently become popular, especially as they can be made readily by any fruit-grower whenever needed, and as they are cheaper, easier to apply and more effective than lime-sulphur for the insects mentioned under them above. Anyone wishing to make these emulsions should write for a circular on them to the Department of Entomology, O. A. College, Guelph. This circular gives not only the simplest methods of manufacture but also information on their use and the precautions necessary to prevent injury.

Miscible oils are commercial oil sprays which mix readily with water. They are in most cases no more effective, and sometimes less so, than the lubricating oil emulsions and are much more costly.

Caution. Most emulsions and most miscible oils may be used with Bordeaux mixture but not with lime-sulphur as the latter frees the oil and thus renders the mixture dangerous.

Lime-sulphur may be purchased either as a liquid or as a powder, the latter being called dry lime-sulphur. The liquid may, if desired, be made by the grower himself by following the directions given in Bulletin 198 of the O. A. College, Guelph, which may be obtained free. Most growers, however, prefer to buy the commercial product. As an insecticide lime-sulphur is not nearly so much used as some years ago, lubricating oil emulsion having gradually displaced it. It is, however, a good insecticide against oyster-shell scale, San José scale and blister mite. Against these it is applied at the strength of 1 gal. to 7 or 8 gals. of water, when the buds are read to burst. The chief use of lime-sulphur to-day is as a fungicide to control apple scab and several other diseases. (See under fungicides where dry lime-sulphur will also be discussed.)

Soluble sulphur is a soda-sulphur compound and is sold as a greenish yellow powder which readily dissolves in water. It is not much used but may be substituted for lime-sulphur against scale insects and blister mite.

Fungicides.

As the best time to apply insecticides coincides in most cases with the best time to apply fungicides they are usually combined and thus much time, labor and expense are saved; hence some reference to fungicides in this bulletin is desirable.

The chief fangicides are lime-sulphur, Bordeaux mixture and sulphur dusts.

Lime-Sulphur. As already mentioned, this mixture is sometimes used as an insecticide but its main function now is as a fungicide. It gives excellent control of most orchard diseases, is cheap, does not russet the fruit to any appreciable extent but leaves it with a good finish. Its one big drawback is its tendency to burn foliage, especially in hot weather or when the foliage is delicate as after winter injury to the trees or after unfavorable spring weather. This burning sometimes is so severe, especially when the trees have been oversprayed, that much of the fruit drops off and the next year's crop is lessened. To overcome the danger of burning, the trees should be fertilized in spring or late fall with manure or commercial fertilizer, so that the foliage will be vigorous; and care should be taken, when spraying, to cover the trees well but not to overspray, and not to spray in the middle of a very hot calm day. Moreover spray guns should not be held close up to the foliage but moderately far back.

Dry Lime-Sulphur. This is merely the liquid lime-sulphur after the water has been removed by an evaporating process and the residue powdered very fine. A certain amount of chemical change takes place in the evaporation process, so that dry lime-sulphur when added to water is not identical in all respects with the liquid lime-sulphur from which it is made. Dry lime-sulphur has only one advantage over the liquid form; namely, that it is much lighter and so easier to handle and less costly to ship. The writer has tested it on several occasions and has found it to be fairly good as a fungicide but not so good as the liquid lime-sulphur, and therefore he prefers the liquid. Dry lime-sulphur is used on foliage at the rate of 4 lbs. to 40 gals. of water.

Bordeaux Mixture. This is a very efficient fungicide, perhaps the most efficient known. The great drawback to it as a spray for apples is that it often causes conspicuous russeting of some varieties such as Ben Davis and Baldwin and dulls the finish of many others. It also, if applied three or four times heavily, tends to cause yellowing and heavy dropping of the foliage. This dropping, however, does not occur if only one or two applications are given. On cherries it has the drawback that it sometimes lessens the size of the fruit considerably and therefore reduces the yield. Nevertheless it is so good a control for leaf spot of cherries that some growers use it in preference to lime-sulphur in spite of the above fact.

We advocate Bordeaux mixture in preference to lime-sulphur for the pre-pink spray on apples because it is much less likely at that stage to cause foliage or bud injury and because the fruit is not then far enough advanced to be russeted to any appreciable extent.

Arsenate of lead, arsenate of lime or nicotine-sulphate may be used with Bordeaux without lessening the efficiency of either component.

Dusts. Two kinds of dusts—sulphur and Bordeaux, have been used as fungicides but in Ontario only the sulphur dust is used in orchards at present. Sulphur to be a good fungicide must be ground very fine, in fact it should all be fine enough to pass through a screen of 300 meshes to the inch. Sulphur dust may be purchased with or without a poison. The only poison used with it up to the present in Ontario is arsenate of lead and the proportions of the mixture are usually 90% sulphur and 10% arsenate of lead. This is the so-called 90-10 dust.

If the fruit-grower is using a duster it is always wise to purchase some of the sulphur without any poison so that he can make extra applications for diseases at a lower cost than if it were combined with the arsenate of lead. Usually sulphur dust without a poison should contain about 10% of a diluent such as talc or hydrated lime; for this makes it spread and carry better.

Spray Calendars.

From time to time improved methods of combating insect pests and plant diseases are discovered. These new methods are incorporated in the spray calendars from year to year. Hence every fruit-grower should each spring write to the Fruit Branch, Toronto, and request copies of the latest spray calendars, so that he may have the most up-to-date information available.

INSECTS ATTACKING THE APPLE.

Codling Moth (*Carpocapsa pomonella* Linnaeus.)

Injuries from the codling moth larvæ are familiar to everybody, since by far the most of the worm holes so commonly found in apples and pears are caused by them.

The adult moth is grayish-brown with a well-marked golden-brown area near the apex of each front wing and a wing expanse of about ¾ of an inch.

The full grown larvæ are moderately stout, about ¾ of an inch long, white or often pinkish in colour with a brown head. Young larvæ have the head black.

Full-grown larva about natural size. The dark spots on the body are not often so conspicuous. (Reduced from Simpson.)

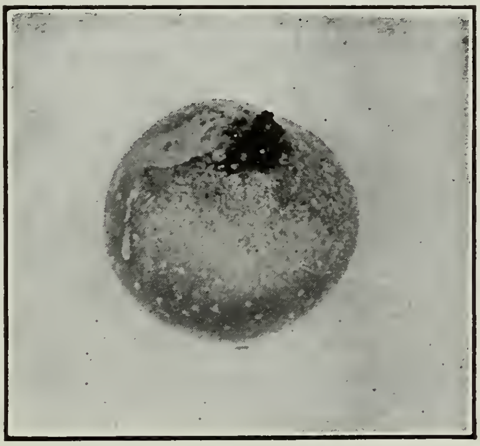
Adult codling moths, natural size. (After Slingerland.)

The larvæ attack chiefly apples and pears though occasionally the other orchard fruits and haws are slightly infested.

There are two main kinds of injury. The first is caused by the larvæ working its way into the core of the apple and feeding there upon the seeds and pulp, and then working its way out again. The result is a large, brown, filthy tunnel in the fruit, usually with dark brown castings at the entrance. The infested fruit drops prematurely. Dropping may begin early in July and continue until the crop has been harvested. Apples thus attacked are of course unsaleable. The second form of injury is the formation of small brown scars chiefly on the side of the fruit. These are caused by tiny larvæ eating their way through the skin into the pulp for a short distance and then either dying or deserting the place. Such injuries are often spoken of as stings or sideworm punctures. They do not injure the fruit for eating but force it to be graded as culls. In unsprayed orchards, especially those in the warmer parts of the province, loss from the two kinds of injuries is very high, sometimes 75 per cent. or upward of the crop; in others, especially in the colder parts, it may be as low as 10 per cent. The average loss for the province in unsprayed orchards is probably about 33 per cent.

Life History. The winter is passed in the full-grown larval stage in a little nest or cocoon under the shelter of loose bark or in crevices or holes on the trunks and main branches of the trees, or in packing houses or storage buildings or any other fairly dry, good hiding place near the apples from which the larvæ emerged. In spring the larvæ change to pupæ in the cocoons and the earliest moths begin to emerge about the time the blossoms begin to fall. Emergence continues for a month or more, so that the earliest larvæ of this first brood may be more than a month older than the latest. A few days after their appearance the moths begin to lay their eggs, placing most of them at first on the leaves and after on both leaves and fruit. The eggs hatch in about eight days and the young larvæ almost at once seek the fruit. On finding it the majority work their way into the interior through the calyx end, this being the easiest place of entrance at this stage of the fruit. Here they feed for a few days and then proceed to the core and feed on the seeds and pulp. In about 27 days the larvæ are full-grown and then make their way out of the fruit usually by the same place as they entered. The apples in the great majority of cases fall before the larvæ leave them. After emergence the larvæ seek the sort of places mentioned above as winter quarters and make their cocoons. In the warmer part of the province many of these earliest first brood larvæ soon pupate and transform into moths, which lay eggs for a second brood. The larvæ of this brood begin to enter the fruit about August 1st and continue doing so for several weeks. As a much larger percentage of the new brood enter the fruit by the side instead of by the calyx they sometimes cause great loss. When these larvæ are full-grown they, along with the larvæ of the first brood which did not pupate, remain over winter in the larval stage in their cocoons.

Natural Enemies. The downy woodpecker and to a lesser extent the hairy woodpecker and the chicadee destroy the larvæ and pupæ. These birds should, therefore, be encouraged to live in the orchard. A few meat bones hung out in winter for them to feed upon will help. The larvæ and adults of two or more species of bettles prey upon the larvæ and pupæ. An egg parasite sometimes destroys many eggs. Diseases help some. Very wet springs or wet or cold summers also help in control; and the complete failure of a crop owing to early frosts or other causes will at times destroy nearly all of the pest in an orchard.



Castings at calyx end, showing clearly where a codling moth larva entered the apple. (Original)

Control. The best method of control in this province is by spraying. In the colder districts one thorough application is in most cases sufficient; in the warmer parts two applications are often required; and in a few places, such as the extreme south-western part, three may be necessary. The first, and usually the most important, should be given just as soon as nearly all the blossoms have fallen and before the calyces have closed, so that the poison may be driven into these and by remaining there kill any worms that at any time in the season attempt to enter that part.

The second application should be made about four weeks after the first, because at about that date the majority of the worms of the first brood which enter by the side will be hatching. If a third application is given it should be about two weeks after the second, so as to destroy the late hatching first brood larvæ.

We are often asked when to spray to kill the second brood. Our answer is that the best method to follow is to spray so thoroughly for the first brood that there will be no second.

The best mixture to use is given from year to year in the spray calendar. At the time of writing it is 1½ to 2 lbs. of arsenate of lead to 40 gals. of water containing 1 gal. of commercial lime-sulphur for the first application. For the second application the lime-sulphur may be omitted and 2 lbs. of arsenate of lead used with water alone. For the third, if given, use the same mixture as for the second.

Dusting with sulphur and arsenate of lead (90-10 mixture) is a fairly good substitute for spraying, but, if the weather is wet, washes off easier and so may require one or more extra applications.

Other helpful measures in control are: First—Prevent moths escaping from packing sheds or fruit storages near the orchard by keeping the windows and doors on these closed from about May 10th to July 10th and killing, from time to time, the moths present on the windows. Tanglefoot may be used for this purpose. Second—Scrape the rough bark off the trunks and main branches in winter or early spring, and about July 1st put a double-ply burlap or a tar-paper band around the trunk. Examine these once every 12 or 14 days until September 1st and then again at the end of the season and kill by cutting through with a knife all larvæ found beneath them.

In a year when the crop is small and the number of moths normal it is harder to obtain a high percentage of clean fruit than when there is an average or large crop. It is well to remember, however, that good spraying one year makes it easier to get good results the next.

Lesser Apple Worm (*Enarmonia prunivora* Walsh).

The adult of the lesser apple worm is a small, dark-gray moth about half the size of the codling moth. Its larva resembles so closely the codling moth larva that very few fruitgrowers even suspect that it is a different insect. The larva is, however, much smaller, being when full-grown never more that 2/5 of an inch long, whereas the codling moth larva is about ¾ of an inch. The color is deep flesh or reddish, whereas that of the codling moth larva is either a white or light pinkish. An easier way to distinguish the two insects is by their work. The codling moth larva makes a definite hole in the fruit from which it throws out its castings and from this hole it makes a tunnel to the core where it feeds on the seeds and pulp; the lesser apple worm larva as a rule leaves no definite hole, but feeds on the pulp just under the skin. This part of the surface then wrinkles, turns brown and forms a large blotch which badly disfigures the fruit. These blotches may occur on almost any part of the apple but are usually most numerous at the calyx end.

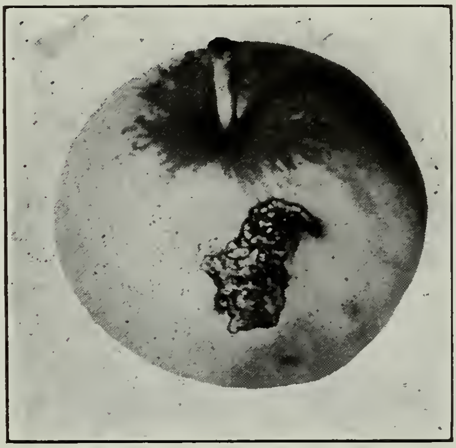
Apples are much worse affected than any other orchard fruit; in fact it is only occasionally that plums, cherries and other fruits are infested.

The native food plants of the insect evidently are the various kinds of haws. From these it has spread to the apple.

The total amount of injury to apples in the province is not nearly so great as that from the codling moth; in fact some years the insect almost disappears, and even in the most favorable years it seldom attacks more than 5 or 10 per cent. of the fruit.

Life History. The life history is so similar to the codling moth's that it need not be given. The only important difference is that there is apparently a full second brood. The larvæ of this brood are often found in the fruit even when the winter apples are being picked.

Methods of Control. Experience shows that the same spraying as for the codling moth will control this pest satisfactorily. Spraying should be supplemented by the cutting down of all hawthorn trees near the orchard, as the fruit of these is even more of a favorite with the insect than apples, and therefore these trees serve as a breeding place.

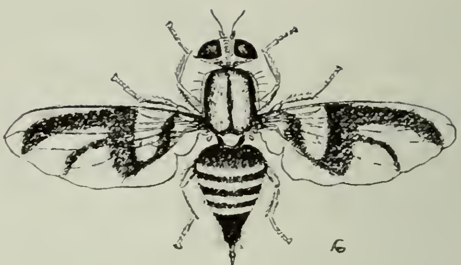


Work of lesser apple worm.
(Original)

The Apple Maggot (*Rhagoletis pomonella* Walsh)

The apple maggot or railroad worm, as it is sometimes called, occurs in all the fruit growing counties of the province. Sometimes it is limited for several years almost entirely to unsprayed or poorly sprayed orchards and to trees in towns and villages where conditions seem specially favorable to it; at other times it spreads out widely and attacks sprayed orchards as well as unsprayed and ruins much of the crop before the necessary measures are taken to combat it. The worst general outbreak on record occurred in the period between the years 1926 and 1929 and was probably caused by favorable weather conditions.

A female adult of the apple maggot on the fruit, natural size. (Original)



A female adult of the apple maggot or railroad worm, much enlarged. (Drawing by Cory.)

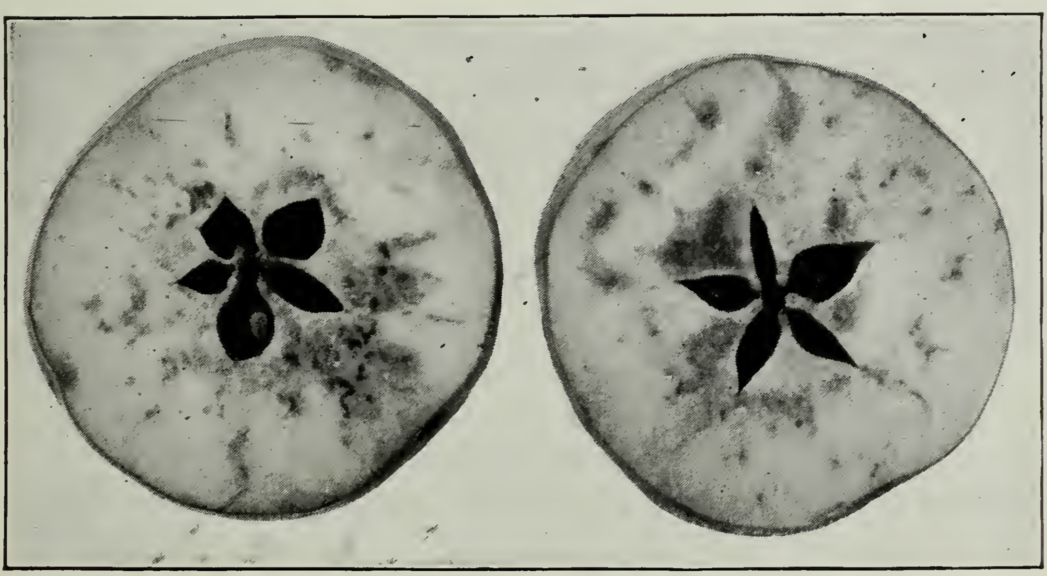
The adult insect is a pretty, two-winged fly, a little smaller than a house fly, and of a general blackish color, but with the eyes golden-green and the head and lower part of the legs yellow. The abdomen of the female is crossed by four conspicuous white bands, and that of the male by three. Near the middle of the back is a small, distinct, triangular white area. The wings have conspicuous black cross bands arranged on the definite plan shown in the illustration. The fully grown larva is a small, legless and headless white maggot, about one-fifth

Apples showing the egg punctures of the apple maggot, natural size. (Original) of an inch long. One end of the body is blunt and the other pointed. At the latter end are two little black hooks which are used to rasp and tear the pulp of the fruit and to free the juices, which are then absorbed through a small opening close to the hooks.

The food plants are apples and haws. Almost every variety of apple and some crabs may be attacked, but the common varieties worst infested are: Early Harvest, Sweet Bough, Astrachan, Golden Sweet, St. Lawrence, Gravenstein, Alexander, Wealthy, Cayuga, Snow, Tolman and Spy. Of these the sweet varieties usually suffer most, but the summer and early fall apples, owing to the fact that a much larger proportion of the larvæ mature in these than in later apples, are the chief breeding sources for the insect.

The injury to the fruit consists chiefly in the brown tunnels made in every direction by the maggots (hence the name "railroad worm"). The extraction of so much juice leaves the flesh tough or woody and often unfit either for private use or for sale. In addition, the surface of the apple is disfigured by the small depressions produced where the eggs are laid and by the ridges that result where the larvæ feed close to the surface. Badly infested apples usually drop prematurely. When the insects are abundant practically every apple in the orchard may be so severely infested as to be useless. To sell such apples is to ruin one's market, for no one would eat them.

Life History. The winter is passed in the pupal stage in the soil a short distance below the surface. In the warmer parts of the Province the flies begin to emerge about the last week in June or the first week in July. In the colder parts emergence is a week or more later. Emergence continues through July and the



Cross-section of apples showing the work of the Apple Maggot before the apples are ripe.

most of August. In a cold backward spring emergence may be retarded as much as two weeks. In about a week after appearing the females begin to lay eggs in the fruit. The ovipositor resembles a bee's sting and is thrust to its full depth through the skin into the fruit and the egg deposited a short distance below the surface. The eggs hatch in about five days and the larvæ work their wav through the apple, rasping the pulp and absorbing the juice. They grow slowly until the fruit is nearly ripe, and never become full-grown or emerge until the apples are over-ripe and often not until they have begun to decay. By this time of course all but a very rare apple will have fallen. After working their wav out through the skin, the larvæ enter the soil and pupate. There is practically only one brood a year, though some years in the warmer districts a very few adults emerge from the new pupæ and produce a small second brood. By far the most of the pupæ that overwinter emerge the next July and August as adults, but a small percentage remain dormant in the soil over a second winter and emerge the succeeding summer. The flies have extensible mouth parts with a large, nearly circular structure at the apex. This they use as lips to gather their food. They may easily be observed moving about on the leaves and fruit with their mouths protruded, searching for juices or anything that they can devour. This manner of feeding is very important, for it enables us to take advantage of it to poison them before they lay their eggs.

Method of Control. The apple maggot flies, as stated above, move about on the trees and feed upon any kind of liquid or even any tiny solid particles thev happen to find upon the leaves or fruit. Moreover, no eggs are laid for a week and so this gives an excellent chance to kill them by spraying the trees with a poison as soon as the flies begin to appear. Usually this date will be four weeks or a little longer after the blossoms have all fallen. If, however, the grower does not know the flies and is doubtful as to the right time, he should consult the spray supervisor for his district.

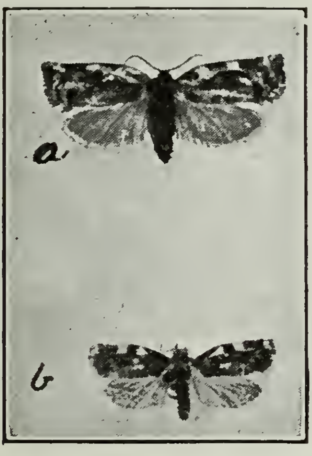
The best spray mixture to use is arsenate of lead, 2 lbs. to 40 gals. of water. Lime-sulphur at this date is very rarely needed. It can, however, be added, if desired, at the strength of 1 gal. to 60 gals. of water, not stronger Every tree in the orchard must be sprayed; for the insect will not be controlled if part of the orchard is left unsprayed, because the flies before laying eggs wander around more widely than growers suspect and many would not be killed until after they had laid eggs unless the whole orchard was treated. So spray every tree and do so from both sides of each row. If the spraying has been well done and the season is dry or fairly dry afterwards, one application will be sufficient. If, however, the weather becomes wet and nearly all the poison has been washed off at the end of two weeks, give another application. This one need not be nearly so heavy as the first, and early apples, as yellow transparent and duchess, should be omitted lest the poison remain on them after they are marketed and be a source of danger to the consumers.

If neighbouring infested orchards are within 200 yards they will interfere to some extent with the success of the work. Therefore it is well for the grower to urge his neighbour to spray his orchard for the pest and, if he refuses, it will pay the interested party to do the spraying gratis. One moderately heavy application in this case will be sufficient. In towns and cities owners of apple trees should club together and get all the trees treated at the same time, otherwise they will find it difficult to protect their own fruit.

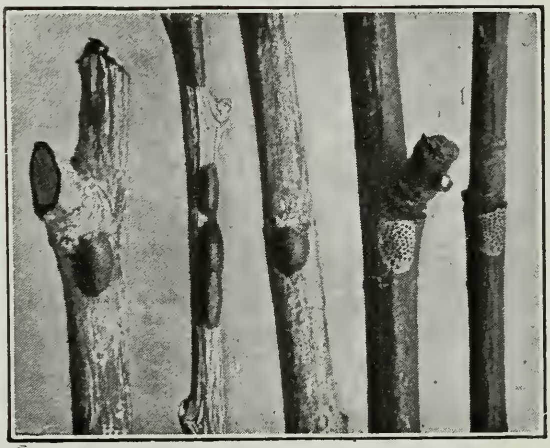
FRUIT TREE LEAF ROLLER (*Cacoecia argyrospila* Walker).

There are several species of leaf rollers the larvæ of which resemble each other closely, and have the same general habit of feeding and of rolling the leaves. By far the most destructive of these is the so-called fruit tree leaf roller. The adult of this insect is a moth with a wing expanse of nearly an inch. The front wings are rusty-brown with several silvery-grey markings which are most prominent along the front margin. The hind wings are light ashy-brown. The larvæ are somewhat slender caterpillars about an inch long when full-grown and of yellowish-green color with a brown head. In the younger stages the head is black.

The insect attacks all kinds of fruit trees, and also some shade and forest trees, but it does most damage to apples, and after these to pears and plums. An interesting peculiarity about it is that though it is found in almost all orchards of the province severe attacks have been limited to a few dozen orchards distributed over widely separated districts. Other orchards close to these are often almost entirely uninjured. In badly infested orchards the loss has been heavy, sometimes 50 per cent. of the crop. The chief injury is caused by the larvæ eating cavities out of the fruit while this is still small—not more than about two-thirds of an inch in diameter—and causing it either to fall or to become badly deformed and unfit for sale. The foliage is also much eaten and presents a very tattered appearance, especially in the upper part of the tree.

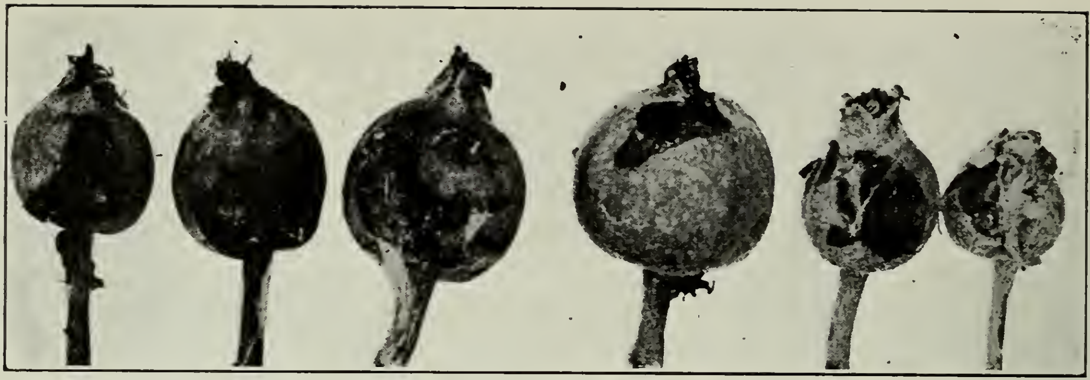


(a) Adult female; (b) adult male of fruit-tree leaf roller, both natural size. (Original)



Egg masses of fruit-tree leaf roller. Those on the twigs to the left are unhatched, those to the right hatched, natural size. (Original)

Life History. The winter is passed in the egg stage, the eggs being laid in small, brown, oval clusters one-quarter of an inch or less in length. The clusters are situated chiefly on the upper surfaces of the twigs and small branches. The eggs hatch about the time the leaf buds of the apple have opened. The tiny larvæ work their way into the opening buds and feed on the inner parts, and often retard the opening of the leaves by fastening them together with silken threads. They attack the fruit buds in the same way, and web together and destroy the opening blossoms. On opened leaves they fold one edge over and fasten it there with silken threads. From this rolling of the leaves they get their



Fruit injured by larvæ of fruit tree leaf roller, natural size. (Original)

name of "leaf-rollers." The larvæ hide inside the rolled leaf, sometimes feeding on the leaf itself and sometimes coming out to feed on other leaves and especially upon the fruit; for as soon as this appears they prefer it to everything else, and soon eat out large areas, thus forming cavities that may reach even to the core. About the time the apples average two-thirds of an inch in diameter most of the larvæ are full grown and have begun to pupate. This takes place for the most part inside the rolled leaves, though many pupæ may also be found on the ground among the weeds and grass; for many larvæ drop by means of a silken thread to the ground and complete their development upon any kind of succulent plant, they find there. In about two weeks the pupæ change to moths which soon begin to lay eggs. The moths hide during the day and fly around late in the evening and at night. If disturbed in their hiding quarters by day, they fly away in a rapid zig-zag manner.

Methods of Control. This insect cannot, if abundant, be controlled by spraying with arsenate of lead or arsenate of lime, though these poisons in the pre-pink, pink and calyx sprays help to keep it in check. The only known way at present to bring a severe outbreak under control is to kill the eggs by spraying them with a 7% or 8% lubricating oil emulsion or a miscible oil at double the strength recommended for San José scale. *The spray must always be applied in spring before the buds begin to show green at the tips, otherwise the oil mixture will injure these and sometimes cause serious loss.* Moreover spraying should not be done on a very cold day but only when the weather is mild; because oil sprays applied when the temperature is below 40° F. are likely to injure the buds. Great care is necessary to cover all the egg masses. To do a good job the operator should remember that the eggs are on the upper side of the smaller twigs and branches and that he will miss many unless he sees to it that the spray reaches right through to the farther side of the tree in each case. To do this it will be necessary either to take advantage of a wind or to use high pressure and spray from a tower or the top of the tank or else to go in beneath the tree as far as the trunk and cover the part beyond it first, and then stepping back spray the part next to the tank. Equal care must be taken to do the same thorough work when spraying from the other side of the row.

It is often possible to tell whether an orchard should be sprayed with oil for the leaf roller by looking carefully at the picture shown here of the eggs on the twigs and then examining numerous twigs to see if egg masses are at all numerous. If a dozen of these masses can be found on each tree it will usually pay to spray; for each mass contains about 50 eggs and many masses will be overlooked. Another method is to go by the extent of the injury the previous year; if 10 per cent. or upwards of the fruit was injured, spray.

Larvæ of fruit tree leaf roller, all full-grown and natural size. (Original)

Apple leaves infested by fruit tree leaf rollers, natural size. (Original)

San Jose Scale (*Aspidiotus perniciosus* Comstock).

The San José scale in Ontario does not, so far as is known at the time of writing, occur north of a line drawn from Sarnia to Toronto, and in this district is most abundant in the counties bordering on Lakes St. Clair and Erie and on the south shore of Lake Ontario. For about twenty years it was our worst orchard pest but since the severe winter of 1917-1918 has been of much less importance.

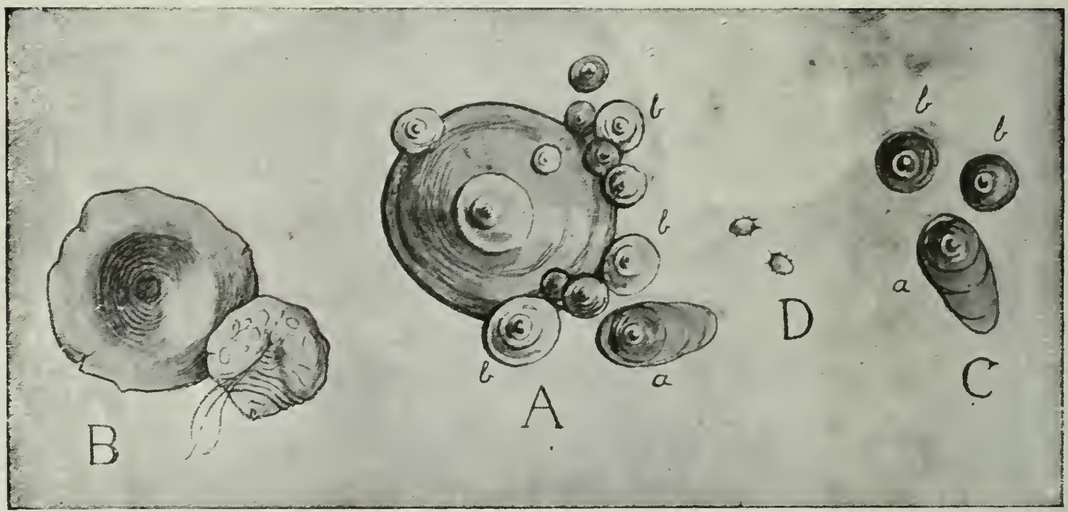
The full-grown female scale is nearly flat, circular, about the diameter of the head of a pin, ashy-brown in color with the central area usually yellowish, though often about the same color as the rest of the scale. The males are much smaller, oblong, and blackish or brownish in color. The most common stage, and the one by which the scale is most readily identified, is the so-called black immature stage. This is in size a mere dot, but when examined with a hand lens is seen to be circular and to have a little nipple in the centre with a depression or groove around it. These characteristics separate it from most other closely allied scales. The insect itself in all cases lies beneath this scale covering, and is yellow, soft and pear-shaped.

The scale in its various stages attacks all kinds of orchard trees except sour cherries, though Kieffer pears and some varieties of sweet cherries seem to be nearly immune. It also infests many shade trees and shrubs, such as mountain ash, hawthorn, Japanese quince, currants and roses.

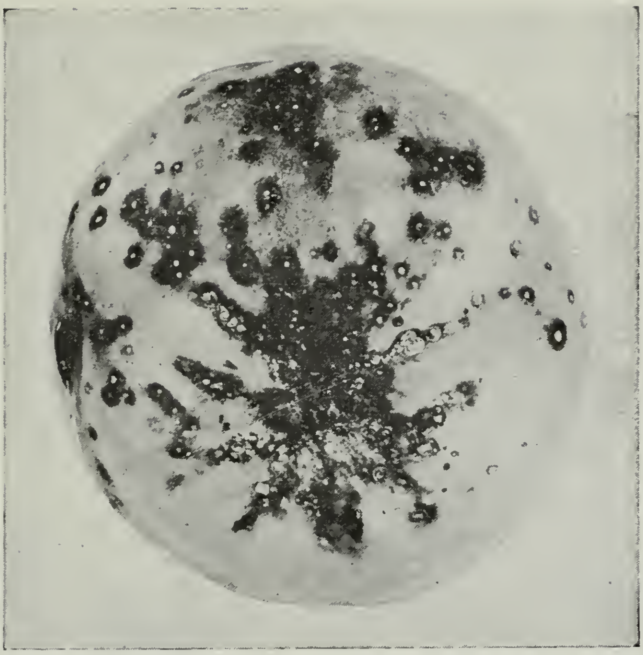
The injury is caused by the tiny insects in almost countless numbers—often sufficient to cover completely the bark—inserting their long, slender, bristle-like mouth parts through the surface of the bark, leaves and fruit and extracting the sap. At the same time they seem to insert a poison which in many cases stains with a reddish-color the inner bark and the part of the fruit around the insect itself. The result of these two kinds of injury is that not only is the fruit rendered unfit for sale, but the trees themselves are killed in from two to about six years, depending largely upon their size. Any severely attacked orchard is doomed to destruction in a short time if left untreated.

Life History. The winter is passed on the bark of the twigs, branches and trunks in the immature black stage described above. About May 24th the males are full-grown and begin to come out from under their scale covering, fly around and fertilize the females. In a month, or about the last week of June, these have become full size and now begin to give birth to little butter-colored larvæ which run about for a day, then settle down, insert their sucking mouth parts, begin to feed and to produce a wax which forms their covering or scale. Each adult mother in the course of about 40 days may produce a total of 400 or more offspring. About the time the last of these are born the first are full-grown and beginning to produce a new generation. In Ontario we have one full brood, a large part of a second brood and probably at times a partial third brood in a year; so that the total offspring from one fertile female by the end of the season may reach into hundreds of thousands or possibly even to a million.

Natural Enemies. Until lately this insect has had comparatively few insect enemies in our province, and the chief controlling factor has evidently been the weather, especially our severe winters, cold late springs and wet autumns. The winter of 1917-18 destroyed a very high percentage of the scale. The last few years parasites have begun to help and it is hoped that they will increase and play a more and more important role in holding the pest in check.



Various stages of San José scale, all enlarged about fifteen times: A. Adult female scale with immature young of various stages settled down around or upon her (a) an adult male scale; (b, b, b,) three small black scales, winter stage. B. An adult female scale turned over, revealing the insect herself beneath with bristle-like mouth parts exposed. C. (a) an adult male scale; (b, b,) two immature black winter stage scales. D. Young active larvæ soon after birth. Note the nipples and little grooves around them in A (b, b, b,) and in C (b, b,) (B redrawn from Alwood, the remainder original drawings by Miss A. Hearle.)



San José scale on apple, showing both the scales themselves and discoloration caused by them, natural size. (Original)

Methods of Control. The San José scale can be successfully controlled by spraying with lime-sulphur or home-made lubricating oil emulsions or commercial oil sprays made by reliable firms. Much the cheapest of all these sprays, and as effective as any, is a 3 per cent. homemade lubricating oil emulsion. (Write to the Department of Entomology, O. A. C., Guelph, for a circular on making these emulsions.) The strength to use the commercial oil sprays is stated on the containers. The only objection to the commercial oil sprays is that they cost several times as much as the homemade emulsion and are no more effective. Where a fungicide is desired in combination with an oil spray, as in the case of peach trees to control leaf curl, Bordeaux mixture (3.6.40 formula) can be used, the stock emulsion being poured directly into the Bordeaux while it is being agitated. Lime-sulphur must not be added to most oil sprays as it breaks them down and frees the oil, thus causing danger of burning and also of making the spray ineffective.

If lime-sulphur is used alone for the scale it should be at the strength of 1 gal. to 7 gals of water (specific gravity 1.035). The main objection to lime-sulphur compared with a 3 per cent. lubricating oil emulsion is that it costs twice as much and has to be applied more heavily to give as good results, because the oil spray spreads better and so reaches scales in crevices and under loose pieces of bark where the lime-sulphur would not so readily penetrate.

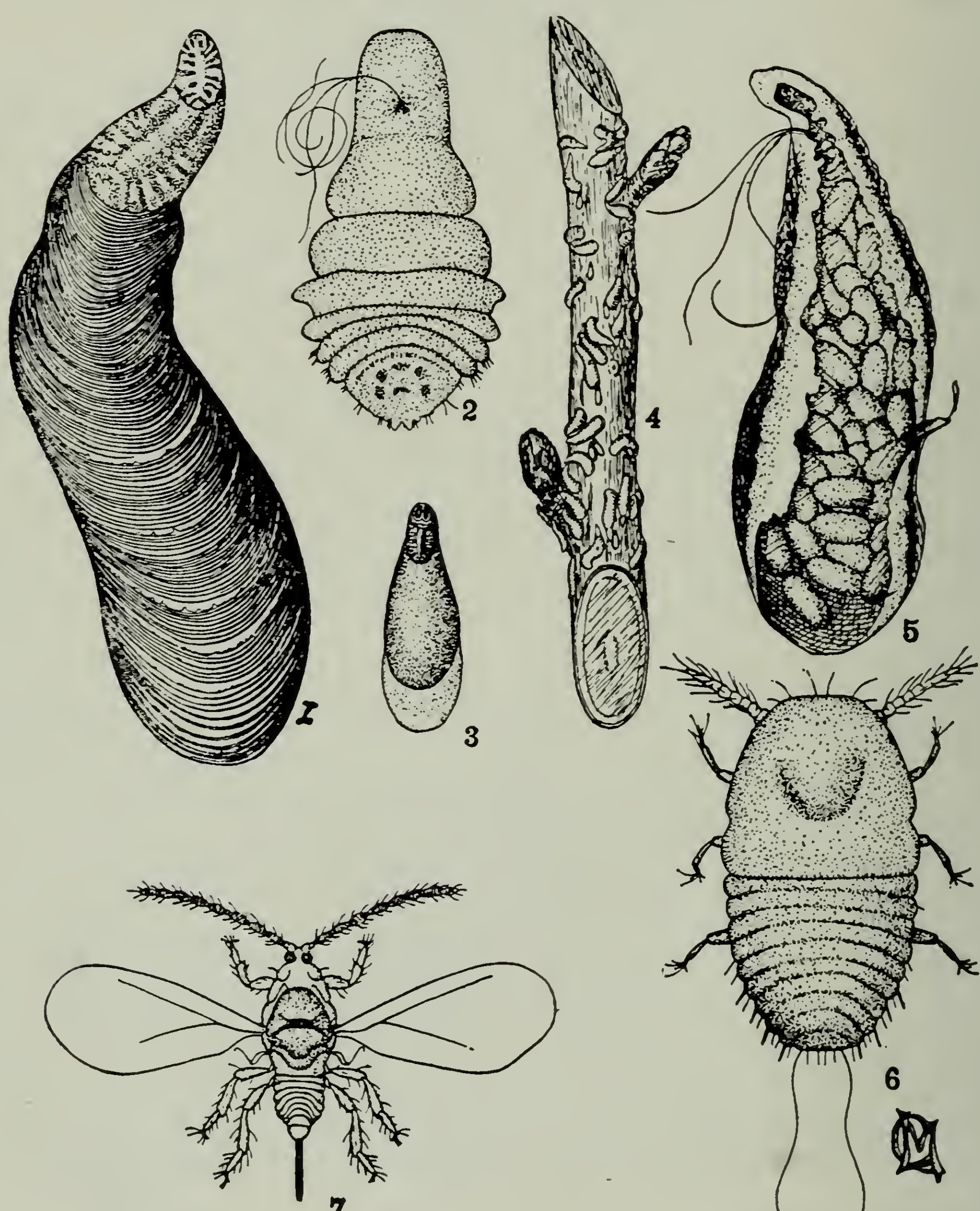
To obtain satisfactory results with any mixture on old apple trees it will help greatly if the trees are first well pruned and the loose bark scraped off the main branches and trunks. This will also lessen the amount of mixture required. Great care should be taken in the spraying itself to see that every particle of every twig, branch and trunk is thoroughly wet with the mixture from both sides: a mere light mist treatment will not give control.

The best time to apply any of the above spray mixtures is just as the fruit buds are beginning to show green at the tip.

Caution. Do not spray with an oil mixture when the temperature is below 40°F.

Oyster Shell Scale (*Lepidosaphes ulmi* Bouche).

The oyster shell scale is larger than the San José, and is easily distinguished from it by the fact that it is elongated, being about three times as long as broad, whereas the San José scale is circular. A full-grown oyster shell scale, as shown in the illustration is about ⅛ of an inch long, tapers towards one end and, as the name suggests, resembles in outline the shell of an oyster. Its color is nearly the same as that of the bark on which it is found.



Various stages of the oyster shell scale: (4. The scale slightly enlarged on a twig. The little holes in the scales indicate where parasites emerged. 1. The female scale very much enlarged, showing general shape. 5. A similar scale turned over to show the eggs beneath. The shrivelled body of the female herself is beyond the eggs at the small end. 2. A female removed from beneath the scale before she has laid all her eggs. Note the bristle-like mouth parts similar to those of San José scale. 3. A male scale. 6. Young larva, dorsal view. 7. Winged male. All except No. 4 much enlarged (after Sherman and Metcalfe).

This scale is very common in all parts of the province and attacks not only apple and other fruit trees, but also many shade and forest trees and many shrubs; apple trees, however, usually suffer most.

It is not nearly so prolific or so destructive as the San José scale, and though it often kills branches, it comparatively rarely kills whole trees. Badly infested trees are of course much weakened and unable to bear good crops.

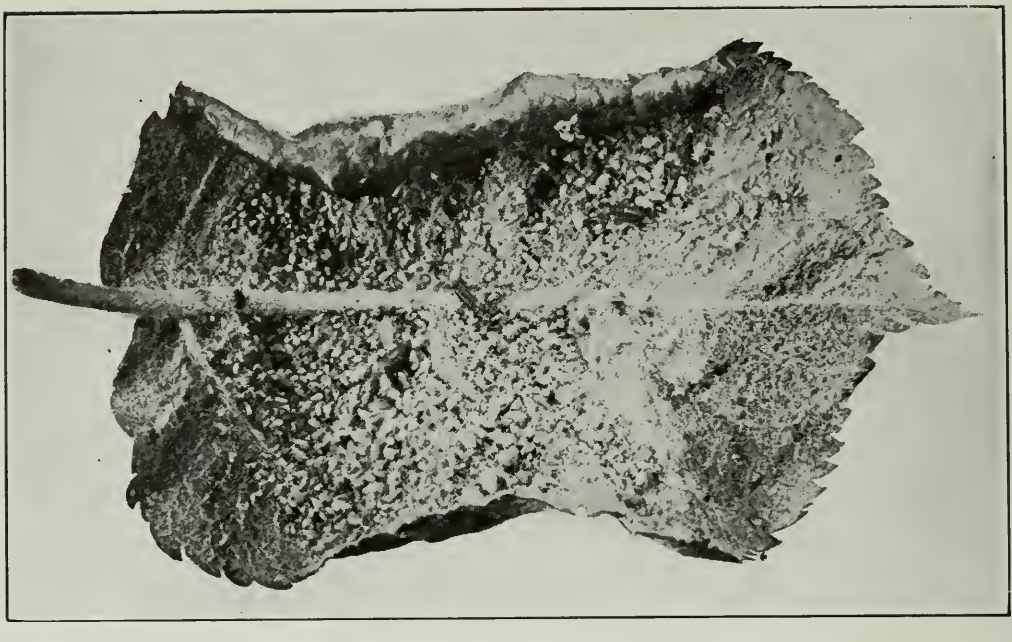
Life History. The insect winters in the egg state, there being an average of between 30 and 40 white eggs under each female scale. The eggs hatch about the time the blossoms are falling or have just fallen from the apple trees. The tiny white or cream colored larvæ move around for about a day then settle down permanently, work their slender bristle-like mouth parts through the bark, and gradually cover their bodies over with the wax that forms the protecting scale. The females become full-grown and begin to lay their eggs in August. Soon after all the eggs are laid the females die. There is only one brood a year in Ontario.

Methods of Control. Prune the trees well and scrape the loose bark off the main branches and trunks of old trees, then each spring for two years in succession spray them thoroughly just as the fruit buds are beginning to show green at the tip, using lime-sulphur, 1 gal. to 8 or 9 gals. of water or a specific gravity strength of 1.030. A 3 per cent. lubricating oil emulsion at this date has sometimes given good results but it is usually considered that double this strength is necessary and in that case it must be applied before even the fruit buds have begun to show any sign of green at the tip; otherwise it is likely to cause serious injury to the buds. No oil spray should be applied when the temperature is below 40°F.

Trees weakened by this scale will recover more rapidly if they are well fertilized in spring, when the buds are bursting, with nitrate of soda or barnyard manure.

Aphids—A General Description.

Aphids are tiny, soft-bodied, sluggish insects. There are a great many species, and so common are they that most of our plants are attacked by at least one species and sometimes by several. The different species often differ greatly in color: some are green, others black, others red, others brown, and so on. They all obtain their food by sucking the juices out of the plants after first penetrating the epidermis with their sharp needle-like lances. As they feed they exude from time to time a clear, sweetish liquid called honeydew, of which ants are very fond. When the aphids are very abundant such a large quantity of honeydew is exuded that it covers the leaves and fruit and causes them to become sticky and later to be covered by a dirty, sooty color, as the result of a fungus which grows in the honeydew. There are many generations each year, some species having thirteen or even more. Each generation except the last consists entirely of females. The last is composed of true sexual forms, males and females. These mate and the females lay eggs for winter and then die. In all the preceding generations living young instead of eggs are produced, and that too without the presence of any males. The first generation in the spring is composed entirely of wingless forms, but in the later generations winged forms also appear. These



Dense colony of rosy aphids on under-surface of an apple leaf. Three ladybird bettle larvæ may be seen among them. All are natural size. (Original)

can fly from tree to tree and so distribute the species. Some, but not all, species have what is known as an alternate host plant or plants; that is, they remain for one or more generations in the spring on the plant on which they over-wintered, and then a winged generation appears which migrates to some other kind of plant and lives and reproduces on this until autumn, when another winged generation is produced, which migrates back to the original host.

The rate at which aphids can multiply is marvellous, and far surpasses that of any other common orchard pest. This is due to the fact that there are many broods each year, and that each brood except the last is entirely composed of females. Very fortunately for us these insects have many enemies which do a great service in helping to control them. The chief of these are ladybird beetles and their larvæ, syrphus fly and lacewing larvæ and tiny four-winged parasites. In addition to these disease often destroys countless numbers, and weather has also a great influence. Cool, moist or cloudy weather seems to be favorable, and hot dry weather unfavorable to orchard aphids.

Aphids Attacking the Apple.

There are three common species of aphids which attack either the foliage or the fruit of the apple and one species, know by the name, woolly apple aphid, which attacks chiefly the bark and roots.

The names given to the first three species are:

The apple-grain aphid, (*Rhopalosiphum prunifoliae* Fitch).

The rosy apple aphid, (*Anuraphis roseus* Baker).

The apple aphid or green apple aphid, (*Aphis pomi* DeGeer).

Apple-Grain Aphid. This species gets its name from the fact that only part of its life is spent on the apple and the remainder on grains and closely allied plants. It is green in color and about the same size as the other two species.

The winter is passed in the egg stage, the eggs being very small, oval, glossy black and situated on the smaller branches, fruit spurs and twigs. The eggs hatch in spring as soon as the tips of the fruit buds show green. Although all three species may be found on the green buds, this one is almost always the most numerous at this stage. Sometimes there are so many young present that they almost cover the buds. In spite of this fact the apple-grain aphid does very little damage to the foliage or fruit. This is chiefly because about the time the blossoms have opened the aphids begin to get wings and in a short time all migrate to grains and grasses and remain on these until about October, when they fly back to the apple and after a short period lay their eggs on the trees and then perish from the severe frosts.

ROSY APPLE APHID. This species, except for a few days after hatching from the eggs in spring, can be distinguished readily from either of the other two by the fact that most of the individuals have a pinkish or purplish tinge and are lightly covered with a whitish powder or bloom. The winter is passed in the egg stage. The eggs are very like those of the apple-grain aphid and are situated largely in the same places. *They hatch, however, about a week or ten days later and so hatching is not over until about the time the fruit buds have begun to pull apart at the tip.* Adults and nymphs alike feed upon the foliage and fruit and do the damage described below. Like the apple-grain aphid this species does not remain on the apple trees all summer but has an alternate host plant, namely, the two weeds — ribgrass and broad-leaved plantain. Unfortunately they do not go to these until sometime in July and thus have time to do much damage before this date. In the fall of the year they fly back from the plantains to the apple and lay eggs for winter.

When numerous they can do more damage than any other apple aphid but fortunately it is only a rare year when there is a severe outbreak over any very large area, though individual orchards here and there may suffer considerably. The injury is caused by the aphids feeding upon both foliage and fruit. They cause the leaves to cluster and curl and often later turn yellow and die; and at the same time make the fruit dwarfed, puckered and deformed and cause it to hang on the branches in clusters throughout the season. (See illustration.) In this way, if the aphids are very numerous, more than half of the fruit, especially on the lower part of the tree, may be ruined. As in the case of most aphids great quantities of honeydew are exuded and this causes both leaves and fruit to become sticky and then to be blackened by the sooty fungus which grows upon it.

APPLE APHID. The apple aphid is green in color and is commonly called the green apple aphid by growers to distinguish it from the rosy species. Perhaps the easiest way to separate it from the apple-grain aphid is by the color of its head which, except for a few days at first is brown in contradistinction to the green head of the latter. Another important distinction is, that unlike the apple-grain aphid, it has no alternate host plant but remains on apple trees all through the season. Like the other two species it passes the winter in the egg stage on the trees. *The eggs hatch in spring about the same time as those of the rosy apple aphid.* Many generations are produced during the season and

Cluster of small deformed apples, showing the effect of aphid attacks in June and July, about two-thirds natural size. (Original)

the last of these in the fall lays eggs on the bark of the smaller branches and watersprouts.

Injury is very similar to that caused by the rosy apple aphid except that this green species usually does not cause so many of the small clusters of deformed dwarf apples, though it causes some. By feeding on the fruit it makes it pitted and dwarfed and renders the pulp woody or tasteless. It has also the habit of congregating in great numbers on watersprouts or suckers and on the terminal growth of succulent nursery stock or young orchard trees and killing these back for several inches. From time to time there are terrible outbreaks of the species and enormous losses, as in 1927, when numerous trees, all over the province, had almost all their foliage curled, the fruit and leaves sticky and black, and half of the crop ruined. Such trees were weakened and in 1928 set only a very small percentage of fruit. The greatest injury usually occurs in late June, July and early August and is most conspicuous in the best cultivated orchards.

Methods of Control. It is very difficult to outline a really satisfactory method of control for both the rosy and the green apple aphid. This is partly because in most orchards in about five years out of every six on an average neither of these two destructive species is abundant enough to make spraying necessary or profitable. Another reason is that the green apple aphid, owing to its habit of flying freely from one orchard to another, cannot be controlled by either a dormant or a delayed dormant spray, even though this killed all that were present at that date; for new individuals would keep flying in from neighboring orchards and, if the weather were favorable, would produce sufficient offspring to cause a serious outbreak in late June or July or early August. Hence in most orchards it is probably wise to omit an early special spray and watch developments. Then, if about the middle of June or later the aphids are seen to be increasing rapidly and threatening to do serious damage, spray on the first calm, warm day with nicotine sulphate, 1 pint to 100 gals. of water, to which should be added about 4 lbs. of soap to make it spread better. If it is desired to add lime-sulphur, 1 to 40 or 1 to 50, to the spray the soap must be omitted, because it will break down the lime-sulphur and ruin the mixture. A 2 per cent. nicotine dust may be used as a substitute for the spray. In applying the spray finish each row before going to the next; that is, go up one side and down the other. If this is not done many of the aphids will be missed, because they will have moved around to the opposite side of the fruit before the second side is done. Small trees may be sprayed from all sides at the one time. Dusting should be done only when the weather is calm and at least moderately warm. Wind blows the dust and fumes away before there is time to kill the aphids and heat makes the nicotine more effective. Dusting, like spraying, must be done also from both sides, but this is not always practicable on the same day.

There are a few orchards in which the rosy aphid is troublesome most years. These should be sprayed annually just as the buds are bursting with 1 pint of nicotine sulphate 40% to 100 gals. of lime-sulphur, strength 1 to 40. An even more effective but more costly method is to spray when the buds are green at the tip but have not yet burst and use lime-sulphur at the strength of 1 gal. to 7 or 8 gals. of water and add 1 pint of nicotine sulphate 40% to every 100 gals. of this mixture. This, if thoroughly applied will kill not only all aphids that are hatched but also the unhatched eggs. If lubricating oils would kill the eggs, of which there is some doubt, a cheaper spray than the one just mentioned would be 1 pint of nicotine sulphate in 100 gals. of homemade lubricating oil emulsion 3 per cent. strength, applied just before the buds burst.

As young non-bearing apple trees often suffer very severely from aphids these should be watched in spring and, if at any time there are many aphids present, should be very carefully sprayed with nicotine and either soap or lime-sulphur, 1 to 40, or else dusted with a 2 per cent. nicotine dust. The same is true of grafts on trees, because aphids often concentrate upon and kill these.

The simplest way of treating nursery trees in the nursery rows is to use a good hand duster on a calm warm day and dust them very thoroughly with 2 per cent. nicotine dust.

As aphids thrive much better on vigorous growing trees than upon slow growing it will help, if on the first signs of an outbreak all cultivation is stopped and growth thus checked.

It will also help when the suckers on trees get heavily infested to go around and cut these off and burn them.

Woolly Apple Aphid (*Eriosoma lanigera* Hausmann).

The woolly apple aphid attacks the bark and roots, and does very little injury to the foliage of the apple. It can easily be identified by its conspicuous, white, waxy covering, which looks like a little tuft of wool or of cotton-batting. If the covering be removed the insect beneath is seen to be brown or reddish-brown. In parts of the United States the wooly aphid is considered a great pest because of the injury it does to the roots of the young trees. The root infesting individ-

Woolly Aphids clustered on tender apple shoot, natural size. (Original)

uals by their sucking cause small nodules or swellings which ultimately kill the smaller roots and so either destroy or greatly weaken the tree. Fortunately, in Ontario this root injury is almost entirely absent, and it is only the insects above-ground that do any appreciable damage, but even these do not cause much harm. Occasionally a few trees in an orchard will have a good many small branches, water-suckers and wounded areas heavily infested with the insects. In such cases on the branches and water-suckers little swellings, which later may rupture and cause small cankers, are produced, while around the margins of infested wounds there is formed a conspicuous callous. These injuries, however, rarely do much permanent damage to the tree itself.

Life History. This species has a somewhat complicated life history, which we need not go into further than to say that while some few individuals winter on the apple, the most of them migrate to elm trees, where the winter is passed in the egg stage on the bark. In the spring the first two generations from these eggs feed on the elm leaves, causing them to become rosetted, but the third generation flies back to the apple trees and serves as the chief source of re-infestation of these.

Methods of Control. Wherever the insects are abundant on small trees, the easiest way to treat them probably is to take a whitewash or paint-brush and a pailful of whale oil soap or even common laundry soap (either of them at the strength of 1 lb. to about 4 gals. of rain water), and with the brush wash the aphids off the branches or trunks. On larger trees a spray machine may be used, but the nozzle must be held close to the insects, so that the spray will break through the waxy covering and reach the insect's body beneath. Only the in-fested parts of the tree should be sprayed. With the spray machine nicotine sulphate ½ pint and soap 2 lbs. to 40 gals. of water would be safer on the foliage than the soap wash.

Leaf Bugs or Plant Bugs (*Miridae*).

Six species of leaf or plant bugs have been found attacking apples in Ontario. As most of these have no common name it is necessary to use their scientific names. They are *Heterocordylus malinus* Reuter, *Lygidea mendax* Reuter, *Neurocolpus nubilus* Say, *Paracalocoris colon* Say, *Lygus communis* Knight and *Campylomma verbasci* Mey. These all have piercing and sucking mouth parts.

Work of leaf bugs or plant bugs on young apples, natural size. (Original)

It would require too much space to give a full description of the adults of each, but all except the last are about one-quarter of an inch long and of the general appearance shown in the accompanying photograph. The color varies with the species, some being nearly black, others nearly red, others gray, and others brown. The last species, Campylomma verbasci, is pale brown and very small, being only about one-sixteenth of an inch long.

Work of leaf-bugs or plant bugs on apples. This is done when the apples are very small. (Original)

The adults do some damage by puncturing the fruit and extracting the juice. They may also act as agents in spreading pear or twig blight. It is the nymphs or immature stages, however, that do nearly all the injury. These, like the adults, differ in color according to the species. The first two species are red and thus can be distinguished easily from any of the others. Their color has caused them to be known as "Red Bugs." The third, *Neurocolpus nubilus,* is greenish mottled with red. The fourth, *Paracalocoris colon,* is reddish brown with some whitish markings. The fifth, *Lygus communis,* while still very young is pale yellowish but soon becomes pale green and has a little round orange spot on the centre of the back. This insect is the same one that has caused much trouble in Nova

An adult leaf bug (Neurocolpus nubilus), and two nearly full-grown nymphs, natural size. (Original)

Scotia and is known there as the "Green Apple Bug." It attacks pears as well as apples. The nymphs of the last species, *Campylomma verbasci,* are, like the adults, very small, smaller in fact than green aphids of the apple, and are green in color.

As several of the above nymphs are either green or greenish they might easily be mistaken for aphids, but can readily be distinguished from them by the fact that aphids are very slow moving insects even when disturbed, whereas leaf bug nymphs are quite active and will run and dodge and try to escape capture.

Fruit, leaves and tender new growth are all attacked by the nymphs of the various species mentioned, which insert their sharp needle-like mouth parts into the tissues and extract the juices. As a rule the leaves and the new growth do not suffer much, though leaves, especially on water sprouts, may be killed, and the new growth die back or have little corky swellings produced at the punctured areas. The fruit, however, if the nymphs are abundant, suffers severely, sometimes almost every fruit on the tree being punctured. From these punctures drops of liquid at first ooze out but soon a hard scar forms over the injured part. The scarred area will then usually fail to grow so fast as the remaining part and in consequence there will be one or more depressions which will deform the apple and render it a cull. Sometimes instead of the injury resulting in a depression it takes the opposite form and produces a small elevation with a scar on its surface. This is particularly true of *Neurocolpus nubilis.* Some species of nymphs leave a little streak in the flesh of the apple where they punctured it, others do not. When apples are very badly attacked a large percentage of them will drop off. Hence this dropping is one of the most serious forms of leaf bug injury.

The nymphs attack apples from the time the fruit is just forming until it is about two-thirds of an inch in diameter.

Probably all of these leaf bugs have migrated from other native food plants to the apple and thus are changing their habits. From this fact there is a danger of their becoming more and more important as the years go by.

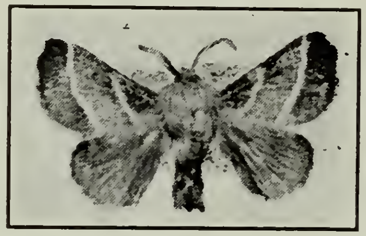
Life History. The life history of all, so far as the apple is concerned, is much the same. The eggs are laid in the twigs and all except those of *Neurocolpus nubilus* hatch about the time the blossom buds are bursting, some a little earlier, others a little later but practically all are hatched by the time the blossoms fall. The eggs of *Neurocolpus nubilus* are later in hatching, the nymphs not appearing until just after the blossoms drop. All nymphs, as already stated, feed chiefly on the young fruit but to some extent also upon tender leaves and new growth, especially on the suckers at the base of the tree and those on the main branches. They become full-grown and change into adults about the time apples are two-thirds or three-quarters of an inch in diameter. The adults feed for a while chiefly on the leaves of suckers or watersprouts, then lay eggs in the twigs and die. There is only one brood a year, and the winter is passed in the egg stage.

Methods of Control. The only satisfactory way to combat these insects is to destroy the nymphs soon after hatching from the eggs and while still very small; when they are half grown or more, sprays merely stupefy them temporarily. The best mixture to use is 1 pint nicotine-sulphate added to 100 gals. of the regular spray mixture used in the calyx spray. The spraying should be done just as soon as most of the blossoms have fallen, otherwise it will be too late to obtain satisfactory results. A 2 per cent. nicotine dust is also effective against the red bugs if applied thoroughly from both sides on a calm day. When spraying use a single or double gun or one of the new short rods with three or four nozzles, and see that every fruit and leaf is hit. Do one side of the row first and then immediately after do the other side. In this way fewer of the nymphs escape than if there is a long interval between the two sides. It is also wise before leaving a tree to spray the ground beneath it to kill the nymphs that are knocked off the tree or that are merely stupefied and drop and might otherwise recover.

The nymphs of *Neurocolpus nubilus* are hard to kill with nicotine and can be better controlled by soap-suds at the strength of 1 lbs. soap to 6 gals. of rain water. The soap-suds entangle them and stick them to the leaves.

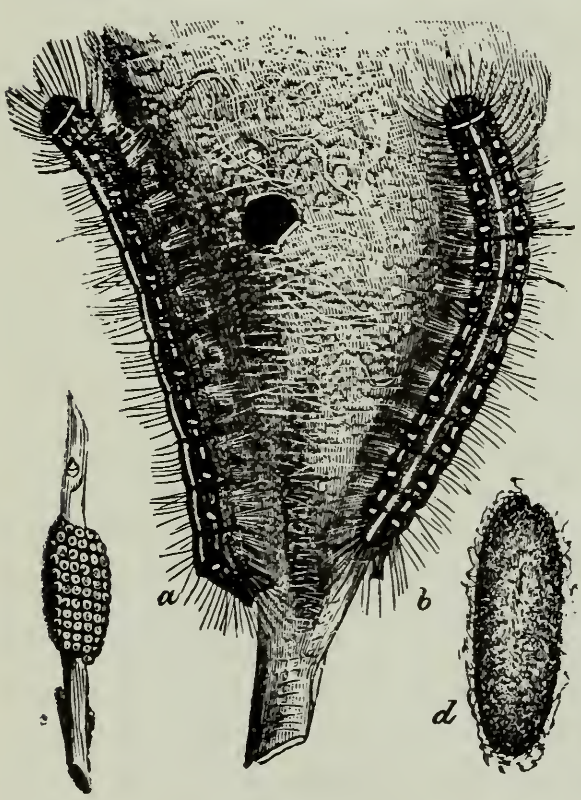
Eastern Tent Caterpillar (*Malacosoma americana* Fabricius).

The eastern tent capterpillar is the insect which causes the conspicuous grayish-white webs commonly seen in spring on the twigs of orchard trees, especially apple, plum and cherry trees. The caterpillars which make and conceal themselves in these webs are, when full-grown, stout, about two inches long, covered with brownish hair and have a broad white or whitish stripe down the back. When numerous, they often completely strip whole orchards and some forest or shade trees, especially wild cherry, of their foliage. New leaves come out later to take the place of those destroyed, but even so the crop is usually ruined and the trees weakened. When defoliation occurs for several years in succession, as sometimes happens, the trees may be so weakened that some of them die. Fortunately the insect is not numerous every year but occurs sporadically. Sometimes there will be a severe outbreak lasting for several years, then there will be very few catrpillars for several more years, when another outbreak will come. At times the insect will occur in large numbers in the eastern part of the province and be scarce in the western and vice versa.



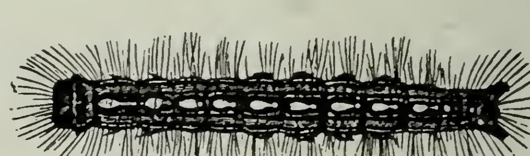
Adult of eastern ten caterpillar, male, natural size. (Original)

Life History. The winter is passed in the egg stage on the twigs of the trees, the eggs being in clusters which encircle or nearly encircle the twig. Each cluster is one-half to two-thirds of an inch long, elliptical in outline and a little darker in color than the bark. The eggs hatch about the time the apple buds are ready to burst. The young larvæ from each egg cluster remain together in a colony and soon construct a little web, increasing it in size as they grow and need more room. Into this they retire at night and part of the day when not feeding. They feed upon the foliage near their web, gradually extending their range as necessity demands. In June they become full-grown and then wander



(a) and (b), eastern tree tent caterpillars on their web; (c) egg cluster; (d) cocoon.

Forest tent caterpillar; (a) egg mass, (b) moth; (c) vertical view of much enlarged egg; (d) side view of eggs much enlarged.



Forest tent caterpillar.

in various directions from the web and often from the tree itself in search of sheltered places in which to spin their cocoons and pupate. The cocoons are elliptical and made of white silken threads covered over with a yellowish powder. During the latter part of June and the first two weeks of July the adults emerge, lay their eggs on the twigs and soon die. There is only one brood each year.

Natural Enemies. Many parasites and one or more destructive diseases play a very important part in the control of this pest. Birds also destroy many of them. The fact is that we owe to all these friends the disappearance of the great hosts of these insects before they have time to work irreparable ruin to many orchards and forest trees.

Methods of Control. Thorough spraying of the trees very soon after the leaves have begun to expand with 1½ lbs. of arsenate of lead powder to 40 gals. of water will destroy the caterpillars. They should be treated always while still small and before they are able to do much damage. Orchards that receive the first three sprayings indicated in the spray calendar never suffer any loss from this pest, no matter what the surroundings may be. Cutting down wild cherry and fruit trees along the fences and roadsides will help some, as will also the collecting and destroying of egg masses.

Forest Tent Caterpillar (*Malacosoma disstria* Hubner).

This insect is very closely allied to the eastern ten caterpillar, and like it is abundant only periodically. Though at times very numerous and destructive in orchards, it is also, as its name suggests, a great forest pest, especially in maple woods, which it sometimes almost defoliates.

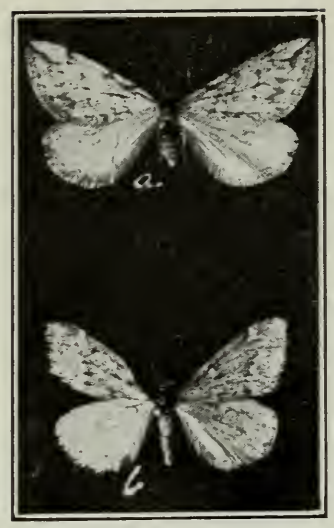
There are several points by which the two species may be easily distinguished; the moth of the eastern tent caterpillar has two white cross-bands on each front wing; that of the forest tent has two brown cross-bands. The eastern tent larva has a white stripe down the middle of the back; the forest larva has a row of white dots. The larvæ of the eastern tent form a definite web or tent; those of the forest do not, but merely spin silken threads here and there wherever they feed or travel. The cocoons of the forest species are often spun in a folded leaf or cluster of leaves; those of the eastern are not in leaves, but in any other good hiding place, such as the underside of fence rails or boards, or on the trunk and branches of trees.

The life history of the two species is very similar, as are also the natural enemies and the artificial means of control.

Cankerworms.

Two species of cankerworms infest our orchards and forests. These are the fall cankerworm (*Alsophila pometaria* Harris), and the spring cankerworm (*Paleacrita vernata* Peck). The terms "fall" and "spring" are given because the moths of the former emerge chiefly in the fall, while those of the latter emerge in spring.

The larvæ of both species are slender and usually blackish or brownish in color, with lighter stripes down the back and sides. When full-grown they are about an inch long. Both species move from place to place with a looping gait,



(a) Spring cankerworm, male adult; (b) Fall cankerworm, male adult, both natural size. (Original)

Female adults of fall cankerworm, natural size. (Original) Spring cankerworm female adults resemble these very closely.

due to the fact that they have fewer hind legs (prolegs) than most caterpillars. The spring cankerworm has only two pairs of these hind legs, the fall cankerworm has three pairs, though the first of these is not fully developed. When disturbed both species drop down on a silken thread. The moths of both species are a light greyish-brown color, with slender bodies and resemble each other closely. The male moths have wings, but the females are wingless.

Full-grown fall cankerworms and their work, natural size. (Original)

It is only once in a long time that we have a severe outbreak of these pests, but when they do become numerous they sometimes remain so for five years or more, after which they become scarce again. In years of great abundance they are very destructive and not infrequently completely defoliate whole orchards and numerous forest trees as well. They feed on most orchard trees and also on many deciduous forest trees, but their favorites seem to be the apple, elm and basswood.

Life History. The moths of the fall cankerworm appear for the most part in fall, in November, and the eggs are then laid in close irregular clusters on the trunks and branches. Each egg is set on its end and looks like a diminutive pail or flower pot. The cluster is nearly the color of the bark and the eggs are not covered over with any protecting substance. A few moths of this species do not emerge and lay eggs until early spring. The spring cankerworm moths emerge in March and April and lay their eggs in more concealed places on the bark, such as under loose bark or in crevices. They are in a looser cluster and are oval in shape. The eggs of both species hatch about the time the apple buds are bursting and the young larvæ feed on the foliage as soon as it appears. They are full-grown early in June and then drop to the ground where they pupate in the soil. There is only one brood a year.

Natural Enemies. Birds play a considerable part in the control of these pests. There are also many parasites and other natural foes that help.

Methods of Control. Cankerworms are much harder to kill with poison than tent caterpillars. To effect complete control it is necessary that the first three sprays recommended in the spray calendar for apples, namely, the pre-pink, pink and calyx sprays, contain arsenate of lead at the rate of 1½ to 2 lbs. to every 40 gals. of liquid, and that each application be thorough.

In the case of large elm trees too high to spray with any ordinary spray machine much can be done to protect the trees from a threatened attack if advantage is taken of the fact that the female moths have no wings and that after emerging from the soil they have to crawl up the trunks of the trees to lay their eggs. Wide bands of tanglefoot or several narrow bands a few inches apart near the base of the trunk will prevent the moths from ascending, but to do so must be put on for the fall cankerworm about the middle of October and for the spring cankerworm about the first of March. The bands must be examined from time to time and if they are losing their power or covered with moths they must be freshened up or renewed.

Cultivation of the soil in spring to the end of June or as late as is safe will help to control an outbreak the next year by killing the pupæ in the soil.

Whenever there is a serious outbreak of cankerworms on tall elms or other tall trees which are too high to spray, specimens should be sent to the Department of Entomology to determine which species is present and thus remove the necessity otherwise of putting on tanglefoot bands both in fall and spring.

Bud Moth (*Tmetocera ocellana* Schiff).

The bud moth is a common insect in Ontario and attacks all kinds of orchard trees and also some shade or ornamental trees and shrubs.

The adult is a grayish-brown moth with a wing expanse of about half an inch. Across the middle portion of each front wing is a broad grayish-white irregular area occupying about one-third of the whole wing. (See illustration.)

The larvæ are reddish-brown with a glossy black head and are about two-fifths of an inch long when full-grown. The color makes it easy to distinguish them from any other common larvæ on the trees.

Bud moth, natural size.
(Reduced from W. E. Britton.)

The bud moth is often numerous enough in unsprayed orchards to do much damage but in orchards well sprayed year after year is so well controlled by the ordinary sprays that it seldom causes any appreciable loss. Injury is brought about in the following four ways:

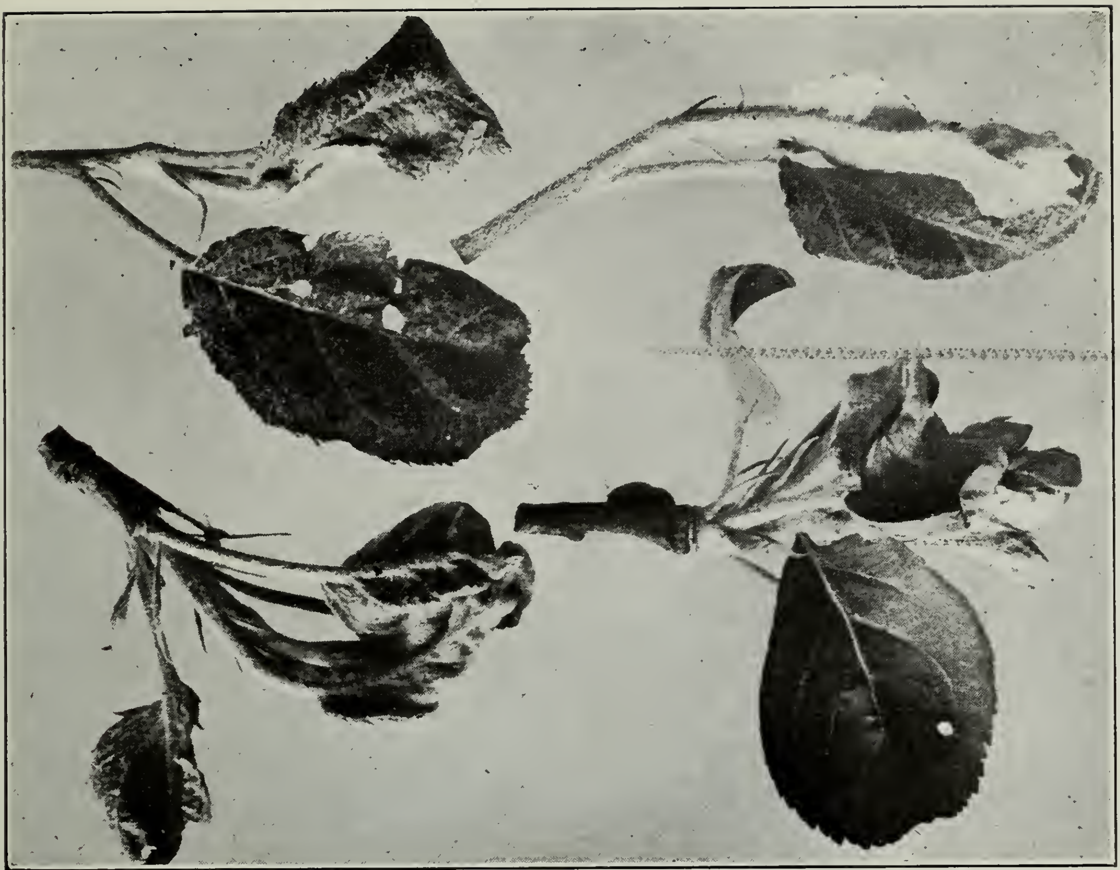
1. In spring the tiny overwintering larvæ bore into both the fruit buds and leaf buds almost as soon as these begin to show green at the tip, and feed upon the developing flower parts or leaves within, thereby destroying many blossoms and causing more or less tattered leaves.

2. When the leaves open each larva folds over part of one side of a leaf as a nest or hiding place for itself when not feeding and in most cases fastens this leaf to one or more other leaves with silken threads and feeds upon them. Very commonly the petiole of one or more of the leaves of the cluster is severed or nearly severed by the larva and the leaf or leaves die and turn brown.

3. In July and early August the new brood of larvæ after hatching from the eggs feeds for a few weeks upon the underside of the leaves before going into winter quarters. Here along the midrib or one of the larger veins each larva devours all the green tissues over an area about three-quarters of an inch long by one-sixth of an inch wide, leaving only the skeleton of veins. These feeding areas are easy to find in August because they are covered by a conspicuous white web which conceals the larva while it works.

4. The new brood of larvæ attacks the surface of the apples themselves in late July and early August, eating tiny holes through the surface and causing blemishes very like those made by codling moth sideworms. These blemishes, however, are only made where a leaf is resting upon the fruit and affords the necessary shelter and favorable conditions for the larvæ to work.

Life History. The winter is passed in the larval stage, the larvæ being only about one-third grown, and being hidden in little dark inconspicuous cases situated in the crotches of twigs or beside a bud or at other places on the bark. In spring as soon as the buds are beginning to show green at the tip the larvæ leave



Work of bud moth larvæ, natural size. (Original)

their winter-quarters, make their way to the buds and bore into them; later they feed on the leaves and other parts, as mentioned above. About the middle of June or a week or so after the blossoms are all off they become full-grown and change into pupæ in their little nests or hiding places in the leaves. Towards the end of June and during the first half of July adults emerge. After a few days eggs are laid on the leaves. The young larvæ from these feed, as described above, on the foliage and fruit. Early in September they cease feeding and go into winter-quarters.

Methods of Control. Observations in well-sprayed orchards show that if the first three regular applications recommended in the spray calendar for apples are applied systematically, year after year, there will soon be no trouble from bud moth. If the larvæ are abundant, poison, preferably arsenate of lead, should be used in all three.

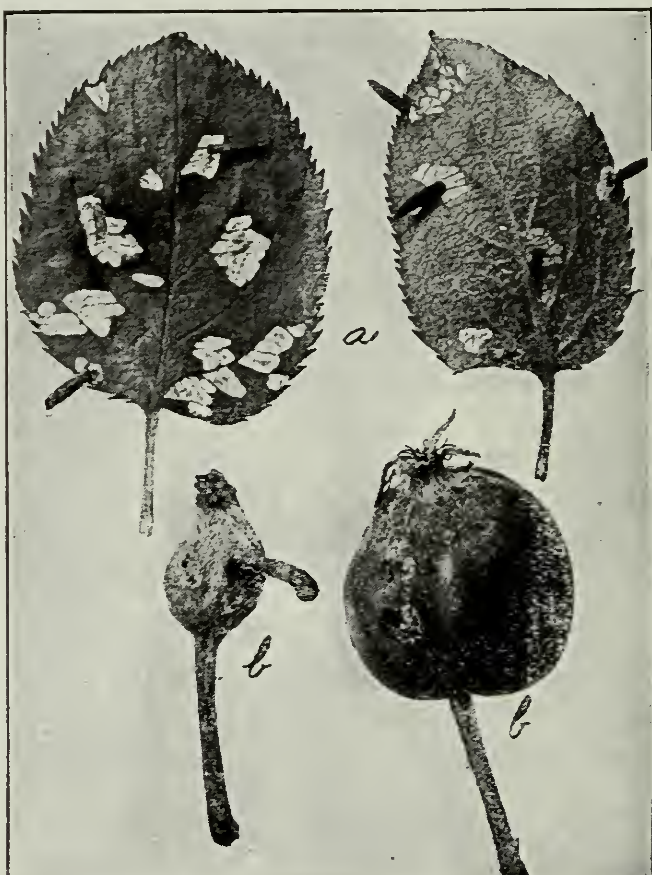
Cigar Case-Bearer (*Coleophora fletcherella* Fernald).

The cigar case-bearer can be identified easily in all but its earliest stages by the cigar shape and color of the little protecting case in which the larva conceals itself. These cases are about one-third of an inch in length and may readily be found in June and July on the leaves of apple and pear trees, especially in neglected orchards. (See illustration.)

Injury is caused by the mining habits of the larvæ, which eat little holes through the upper surface of the leaves and then as leaf miners devour all the green tissues between the two surfaces as far as they can reach without letting go their cases. At times the cigar case-bearer and the pistol case-bearer become so abundant in neglected orchards as to defoliate the trees. In 1921 thirty acres of apple orchard in one block were practically stripped of its foliage, many of the leaves being devoured before they had expanded. Such severe injury, however, is rare and in well sprayed orchards the insect is not a great pest.

In addition to feeding on the leaves the larvæ often eat very small holes through the skin of the young apples, but these are seldom of much importance and usually disappear as the apples increase in size.

Life History. The winter is passed in the larval stage, the larva being very small, less than one-quarter grown, and enclosed in a little curved brown case. These are usually situated in the axils of branches. When the buds are nearly ready to burst in spring the larvæ, still protected by their cases, move from winter quarters to the green tips of the buds and begin feeding on these; later, as already said, they make mined areas in the leaves and even feed a little on the fruit. The little curved cases are first enlarged and later abandoned for the cigar-shaped larger cases. The larvæ are full-grown towards the end of June.



(a) Cigar case-bearers and their work on apple leaves, (b) pistol case-bearer and its work on young fruit, natural size. (Original)

The adults, which are delicate steel-grey moths, with a wing expanse of less than half an inch, emerge throughout most of July. Eggs are laid singly on the leaves and the larvæ, on hatching from these, act for a few days as leaf-miners without any case, then construct small curved cases, and early in September move into their winter-quarters.

Methods of Control. Orchards which receive the regular three sprayings outlined in the spray calendar, are little troubled by this pest. If, as in the case of the bud moth, the infestation is heavy, poison should be used in all three sprays.

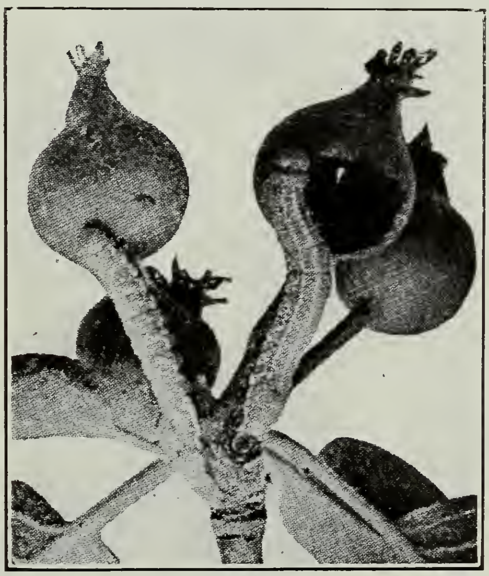
Pistol Case-Bearer (*Coleophora malivorella* Riley).

The pistol case-bearer is a very near relative of the cigar case-bearer, but may be distinguished easily from it by its case being shaped like a pistol instead of a cigar. In Ontario it seems to be almost everywhere much less common than the cigar case-bearer. It attacks the foliage and occasionally the young fruit. On the latter it makes the same sort of small feeding punctures as the other species; but on the leaves, instead of acting as a leaf-miner, it eats holes, sometimes skeletonizing the leaves or destroying all but the main veins. Occasionally like the cigar case-bearer it becomes very abundant and does much harm, but as a rule is not very important.

The life history is very similar to that of the cigar case-bearer. Control measures are also the same.

Green Fruit Worms (*Xylina spp*).

There are several species of green fruit worms. They resemble each other closely, and are stout, pale-green caterpillars, a little more than an inch long when full-grown. The head is a very light shade of green, almost white, and down the middle of the back and each side is a cream-colored stripe. These characteristics, and the fact that they do not lower themselves with a silken



Green fruit worms and their work on apples, natural size. (After Slingerland and Crosby.)

thread, easily distinguish them from the leaf roller larvæ. The adults are stout greyish-brown moths, nearly related to and closely resembling the moths of cutworms.

The injury is done by the larvæ. These feed on the leaves in spring until the fruit begins to form, then they attack this and eat deep holes about the thickness of a lead pencil into it, thus ruining the fruit and often causing it to fall. Fortunately the larvæ are seldom abundant enough to do much harm.

All kinds of orchard fruits are attacked. The larvæ feed also on the foliage of many deciduous forest trees.

Life History. The moths lay their eggs singly on the bark of the twigs and small branches in spring. The larvæ on hatching feed upon the developing leaves and later upon the young fruit. They are full-grown soon after the blossoms drop, and then enter the ground to pupate. In autumn the moths appear and hibernate in sheltered places. There is only one generation a year.

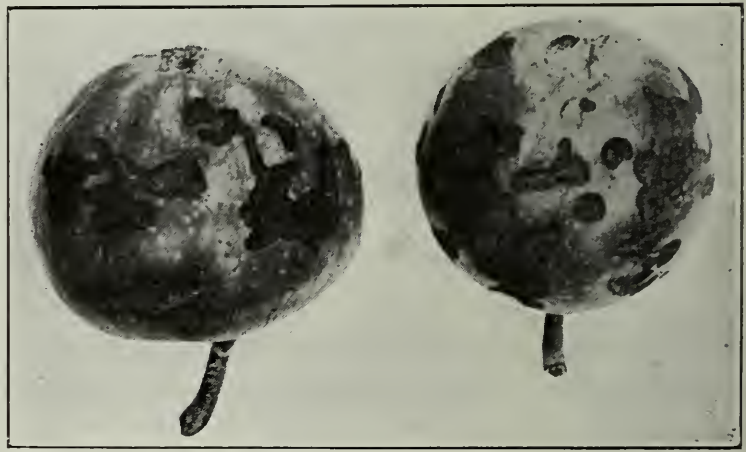
Methods of Control. No special measures are necessary for this pest further than the regular sprayings indicated in the spray calendar.

WHITE-MARKED TUSSOCK MOTH (*Hemerocampa leucostigma* Smith & Abbott).

From time to time the larvæ of the white-marked tussock moth, which are great enemies of shade trees in cities, become abundant in orchards and injure not only the foliage of apples, plums and other fruit trees, but also often eat shallow areas out of apples themselves. A brown callous forms over the injured places, but leaves the fruit disfigured. (See illustration.)

Adults of white-marked tussock moth larvæ. Note that the male is winged, the female wingless, natural size. (Original)

Larvæ of white-marked tussock-moth, nearly full-grown. (Original)



Work on apples of the larvæ of the white-marked tussock-moth, natural size. (Original)

The larvæ are pretty, hairy caterpillars, about 1½ inches long when full-grown. They can easily be recognized by the red head, the two long black tufts of hair at the anterior end and a single tuft at the posterior and the four dense, cream-colored short tufts of hair on the back.

Life History. The winter is passed in the egg stage. The eggs are laid in a mass and are covered over with a white froth-like substance. Egg masses are usually situated on the bark of the trunk or larger branches though they are often on a leaf. They hatch in late May or June, usually a couple of weeks or more after the apple blossoms have fallen. The larvæ, as already mentioned, feed on the foliage, preferably of young shoots or suckers from the main branches, and also on the fruit of apples. Some are full-grown early in July, others not until well on in August. When mature they spin a thin silken cocoon in the places where we have said the eggs are placed. In these cocoons they pupate and in a coupe of weeks the moths emerge. The males have ashy-grey wings and fly about, but the females are light grey and have no wings. These remain beside the cocoon and are fertilized by the males, then lay their eggs and soon after die. There is only one generation a year in this province.

Methods of Control. The young caterpillars can be killed by spraying with 2 lbs. arsenate of lead powder to 40 gallons of water. Spraying should be done as soon as most of the eggs have hatched and while the caterpillars are still small and easily poisoned. It is cheaper, however, and more satisfactory, if the presence of egg masses shows there is likely to be a considerable number of the larvæ, to go around in winter or spring and remove and destroy the egg masses. A wire brush about an inch wide and five or six inches long, fastened to a bamboo pole, is very satisfactory for removing egg masses from the higher branches. A broad hook, or a bent spoon, is often used instead of the brush. Eggs can be killed by saturating them with crude coal-tar creosote, darkened by the addition of a little lampblack. In removing egg masses do not overlook those in leaves fastened to the branches.

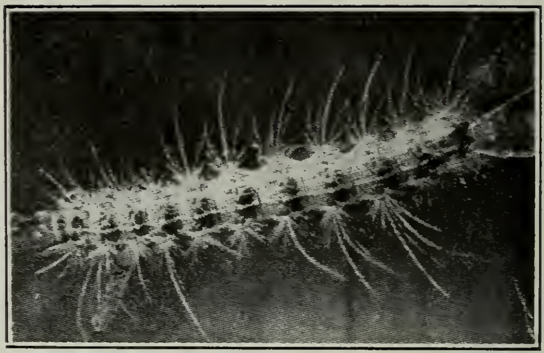
Fall Webworm (*Hyphantria cunea* Drury).

During August and September large webs, sometimes a yard long, may be seen here and there on trees throughout the orchard and also on many kinds of shade and forest trees. These webs are caused by the so-called fall webworms. The webs of the eastern tent caterpillar can be easily distinguished from these by the fact that they are made in the early part of the season and are much smaller.

The adults of the fall webworms are pretty little white moths, with a wing expanse of about an inch. The larvæ are greyish-brown caterpillars about one inch long when full-grown and thinly covered with tufts of long hair.

Life History. The winter is passed in the pupal stage in the ground or under rubbish. In the spring, towards the end of June, the moths begin to emerge, and lay their eggs in a dense white cluster on the leaves. On hatching the young larvæ all feed together, remove the green substance of the leaves, and leave only a network of veins. Soon they cover themselves over with a web and extend this as they require more food. They feed under cover of the web until

Fall webworm adults and egg mass on a portion of a leaf, natural size. (Original)



Fall webworm; full-grown larva, slightly enlarged. (Adapted after Slingerland and Crosby.)

full-grown, and then wander around in various directions and finally select a place in which to pupate. There is only one generation in a year.

Fortunately natural enemies are so effective in the case of this insect that all that is necessary is to examine the trees from time to time, and whenever an infested branch is seen, cut it off at once and destroy the caterpillars. Usually this can be done most easily by trampling them under foot. The branches or twigs should be removed while the webs are still small and before many leaves have been destroyed. Spraying is not necessary.

Red-Humped Apple Caterpillar (*Schizura concinna* Smith and Abbott).

In August and September black and yellow caterpillars with a red hump on the back towards the head end and a number of black spines on the body may be found in clusters here and there throughout the orchard. Some years there are many of these clusters, others only a rare one. Clusters are found also on some other trees besides apple, as plum, pear and walnut.

As a rule no serious damage is done because the caterpillars are not often numerous enough to strip the foliage on more than a branch or two on a tree.

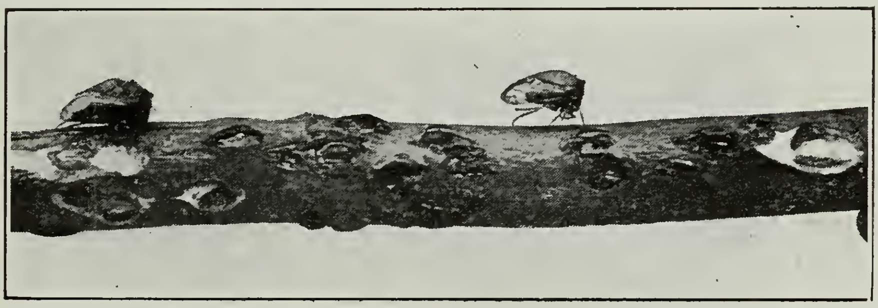
Red-humped apple caterpillar, about natural size. (Orignal) though young trees may occasionally be completely defoliated and thereby weakened.

Life History. The winter is passed in the larval stage in the ground or under rubbish. In the spring pupation takes place and in July the moths emerge and lay their eggs in clusters on the under side of the leaves. The larvæ are full-grown in September and then go into winter-quarters.

Methods of Control. Arsenate of lead, 1½ or 2 lbs. to 40 gals. water, applied as soon as the caterpillars are seen, will kill them, but it is very rarely that spraying is necessary. Usually all that is necessary is to go through the orchard and knock or pick the caterpillars off and destroy them.

Buffalo Tree Hopper (*Ceresa bubalus* Fabricius).

The buffalo tree hopper is found in all the fruit-growing districts of the province, and sometimes does much injury, especially to young apple and pear trees. The injury is almost entirely due to the egg-laying habits of the insect. The eggs are deposited on the upper side of the smaller branches and also in the case of young trees on the trunk. In each instance before laying her eggs the female with her sword-like ovipositor makes a small, more or less crescent-shaped cut through the bark and then places the eggs in this. As soon as this is done, she makes another similar slit close to and just opposite the first, and deposits eggs in it too. The wood between these two slits does not heal, but causes an ugly scar which continues to enlarge for several years. As the whole upper surface of the branches and also, in exceptional cases, the trunks of young trees may be almost covered with these slits and scars, it naturally follows that such trees are weakened, dwarfed and more likely to succumb to severe winters or disease than uninjured trees. Some forest trees and shrubs are also infested.



Buffalo tree hopper adults and egg scars on branch, natural size. (Original)

The adult tree hopper is about one-quarter of an inch long, moderately stout, triangular in front with the two upper angles projecting somewhat and suggesting the name "buffalo." The upper surface of the body slopes gradually back from the front to rear, so that from a side view also the insect has a triangular appearance. The general color is pale green.

Life History. The winter is passed in the egg stage in the slits on the bark. The eggs hatch about the time the leaf buds burst. The young nymphs after a very short time go to the ground, where they feed on almost any kind of succulent weeds, sucking the juices out of these. In July they begin to transform into adults which soon fly to trees and shrubs to lay their eggs. Oviposition continues all through August and September up to the first severe frost, which kills the adults.

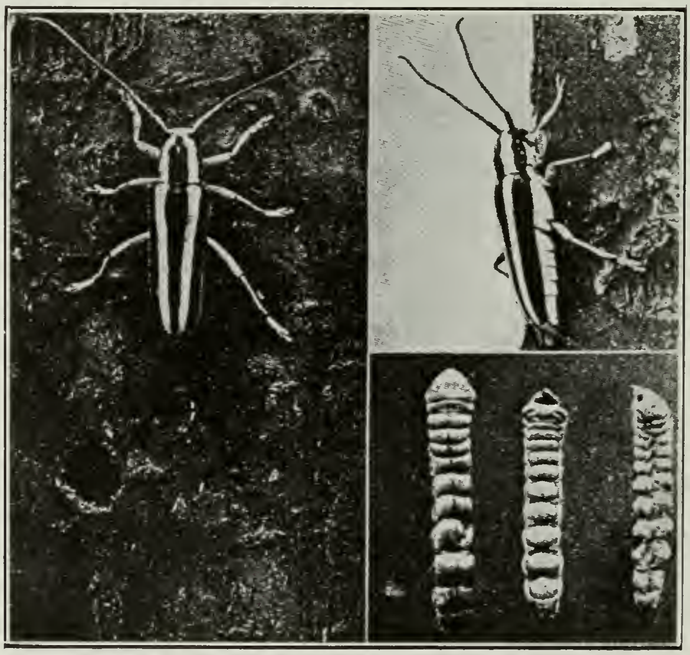
Means of Control. A simple means of control is suggested by the fact that the nymphs cannot thrive on the foliage of trees, but go to the ground and feed on plants such as thistles or other weeds; hence if the orchard is plowed and kept free of weeds during May and early June the nymphs will be starved. Trees that have already been weakened should be given good cultivation and fertilized to stimulate growth and enable them to recover more rapidly. Of course, care should be taken not to cultivate too long for fear of winter injury.

It is probable that in the case of young trees, for these are more injured than older trees, most of the nymphs could be killed by spraying the grass and weeds beneath the branches and for a few feet beyond them with ½ pint of nicotine sulphate and about 5 lbs. of soap (1 gal. of soft soap) to 40 gals. of water. Two applications would be necessary, the first just as the blossoms were ready to open and the second in warm weather a week later, or in cold weather two weeks later.

Recent experiments on the Pacific Coast indicate that a 4% lubricating oil emulsion applied as a dormant spray in spring will kill large numbers of the eggs and may be the simplest method of control in some orchards.

Round-Headed Apple Tree Borer (*Saperda candida* Fab.).

The round-headed apple tree borer works in the trunks of apple trees usually near the ground or a short distance below it. Here it feeds upon and makes tunnels in the inner bark and the wood. Trees of almost any age may be attacked, but far the most damage is done to young trees from three to ten years old. These not infrequently are completely girdled and killed. The insect



Round-headed apple tree borer, adults and full-grown larvæ, natural size. (After Rumsey and Brooks.)

is not found in all orchards but often localizes itself in an orchard here and there, while orchards not far way may be free from it. Apparently it is most numerous in the neighborhood of woods which contain such trees as hawthorn, juneberry, choke-cherry and mountain ash, all of which are host plants and so may serve as breeding quarters. In addition to these trees and the apple, it attacks also quince and pears.

The adults are handsome, nearly cylindrical, stout beetles about an inch in length and with long antennæ. They may be identified easily by the white color of the under surface of the body, the brown color of the upper surface, and the two conspicuous white bands that extend along the back the whole length of the insect. The larvæ, which do the injury, are stout, nearly cylindrical, whitish grubs, about an inch long when full-grown, with a brown head, and the segments just below this a little larger than the remaining segments.

Life History. The beetles emerge from the trees in late May and in June and in a week or two begin laying their eggs in the bark near the base of the trunk. Egg-laying continues for about two months, after which the beetles die. The larvæ on hatching feed the first season chiefly on the inner bark, though some enter the sapwood. During the winter they remain dormant, but next spring resume their feeding and work into the solid wood. Throughout the time of their feeding a considerable amount of the sawdust-like borings are thrown out through the bark. Some of the larvæ are full-grown or practically full-grown at the end of the second season and next spring pupate and emerge as adults, but others are smaller and pass a third season as larvæ, pupating and emerging as adults the next year. Where there have been several borers in a small or moderately small tree there are naturally many burrows in the wood. The writer has seen mountain ash trunks so full of burrows that a person by pushing hard could break off at the base a tree four inches in diameter.

Methods of Control. The old method of control was to dig out and kill the borers in May with a sharp knife and a fine wire with a little hook on the end. The wire was used to save cutting too much with the knife and to reach places inaccessible to it.

Recently Mr. C. Petch has discovered a simpler method: He mixes powdered calcium cyanide with castor oil to the consistency of thick paint and then smears this with a small brush over the area where the castings show that borers are present, taking care to see that all the holes are covered. The treatment should be applied in late May or not later than the first week of June so that the borers may be killed before they can emerge. Mr. Petch claims that rains do not readily wash the materials off the trees and that one application properly done is sufficient. He also states that in his experience the mixture did no damage to the trees.

As the beetles feed to some extent upon both bark and foliage it is probable that, if the trees in infested orchards had both the trunks and branches well sprayed at the calyx application with 2 lbs. arsenate of lead instead of 1½ lbs. to every 40 gals. of diluted lime-sulphur, many adults would be killed. This method would be specially adapted to young trees and nursery stock.

Other Insects Attacking the Apple, Described Elsewhere in this Bulletin.

Plum Curculio.	Fruit Tree Bark Beetle.
European Red Mite.	Pear Leaf Blister Mite.

INSECTS ATTACKING THE PEAR

Pear Psylla (*Psyllia pyricola* Forester).

The pear psylla is a very troublesome pest and a source of much worry to pear growers. Fortunately, it is not abundant every year, as some years it almost disappears, at least during all the earlier part of the season, but the next year it may again be almost as numerous as ever. These fluctuations seem to be largely determined by weather conditions.

Adult psyllas are very small insects not more than about one-tenth of an inch in length. Their general appearance resembles closely that of a diminutive cicada. (See illustration.) The wings are transparent, much longer than the body and held roof-like over it. To the unaided eye the color of the body appears brown or nearly black but closer observation shows the ground color is reddish. The hind legs are adapted for leaping, and adults when disturbed, quickly leap and fly away.

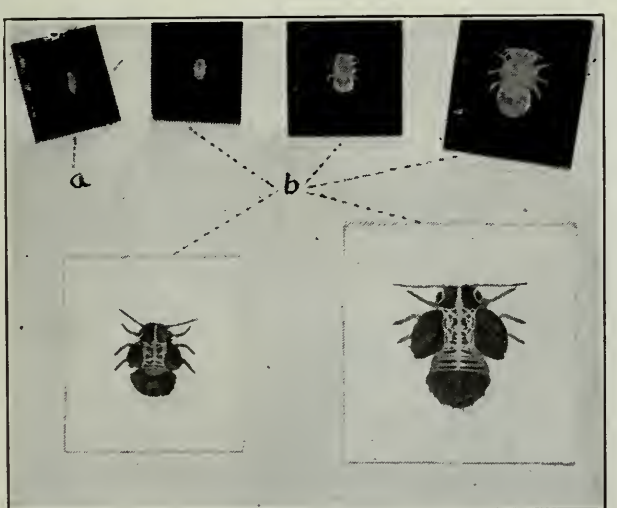
The nymphs, or immature stages, are very unlike the adults in appearance and are sluggish, remaining like scale insects in one place for a long time. At first they are a pale-yellow color with red eyes, but as they become nearly full-grown they darken and change to a grayish-brown or brown color with conspicuous broad pads or projections on each side, which in the adults become wings. All nymphs are broad and flattened and somewhat oval in outline. Nymphs are found chiefly on the upper and lower surfaces of the leaves and are often enveloped in the honeydew, which they exude in great abundance while feeding.

The injury is done by both the adults and the nymphs sucking the juices out of the leaves, leaf stems, fruit stems and even tender new growth. The consequences of this continual drain on the strength of the tree is that its vitality becomes weakened, the fruit dwarfed, the foliage pale, sickly and dwarfed, and many of the leaves get large, dead areas in them. In addition the leaves, fruit and branches become stained with a black fungus that grows in the honeydew exuded by the insects. Fruit thus stained requires to be washed to make it fit for market. Unfortunately the ill effect of a bad attack of the psylla any one year is not limited solely to that year but extends over into the following year in the form of either a total failure of the crop or a very much lessened crop, as starved trees usually do not set fruit buds to any great extent.

Life History. The winter is passed in the adult stage. These adults are hidden in crevices in the trees, or under loose bark or under grass, leaves or rubbish beneath the trees. In spring on bright sunny days towards the end of March and in April the adults come forth from their hiding places and congregate on the trees, and soon, if the weather continues warm, commence to lay their eggs on the twigs and fruit spurs. Egg-laying may continue until the blossoms have fallen. The eggs are yellowish or pale-orange in color, more than twice as long as broad and so small that they are just visible to the naked eye. They are usually placed in little crevices or leaf scars, though many are laid on the smooth bark also. As a rule they begin to hatch when the fruit buds begin to burst and most years are nearly all hatched by the time the blossoms have fallen. The newly hatched nymphs feed at first upon the blossoms, blossom stems and leaflets, and later, as mentioned above, upon leaves, leaf stems and new growth. There are two generations a year, a large part of a third generation and a considerable portion of a fourth. The eggs for these later generations are laid chiefly along the midrib of leaves and on leaf stems. When cold weather arrives in autumn the adults go into winter quarters, as mentioned above.

Methods of Control. This is not an easy insect to control and thorough work is necessary. The best method, as worked out by Mr. W. A. Ross, is to *spray in late March or early April with a 3 per cent. lubricating oil emulsion.* Every twig and branch must be thoroughly covered from both sides, especially as one of the ways this material controls is by the oily covering it leaves on the bark repelling the adults from laying eggs. The spraying should be done only on a warm or moderately warm day as oil mixtures applied on a cold day sometimes do injury to the buds.

Should this spray, because of the softness of the soil or other reasons, have been omitted the trees should be sprayed with lime-sulphur, 1 gal. to 8 gals. of water just before the blossoms open, as this will kill the eggs. Every effort,



(a) (b) Various stages of psylla nymphs. (All much enlarged.) (After Ross and Robinson.)

Adult pear psylla. (After Ross and Robinson.) (Much enlarged.)

however, should be made to get the oil spray on as outlined above because it gives the better control.

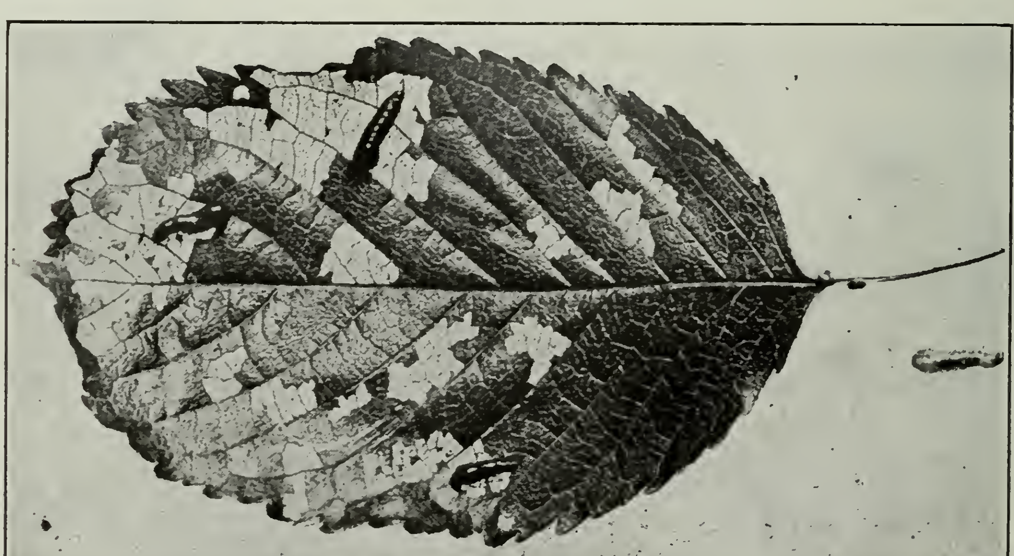
The trees should be examined as soon as the blossoms are off and if for any reason there is a considerable number of psylla eggs or young present, nicotine sulphate ½ pint should be added to every 40 gals. of the regular calyx spray.

It is also wise to observe the trees once every two or three weeks until the crop is ready to pick and, if at any time the psylla is abundant enough to do serious damage, spray at once heavily with ½ pint nicotine sulphate and 2 lbs. soap to 40 gals. of water.

Pear (and Cherry) Slug (*Eriocampoides limacina* Retzius).

The pear slug is even more common on sweet and sour cherries than on pears. It is a slimy, blackish or greenish-black larva, a little more than half an inch long when full-grown, and distinctly enlarged toward the head end, having thus the appearance of a tiny tadpole. The larva is found on the upper side of the leaves of cherries, pears, and occasionally plums, where it devours the green tissues, leaving an unbroken network of large and small veins, which, of course, soon turns brown. When very abundant, it will also attack the fruit, removing here, too, the green surface and leaving a russeted pear. Some years the insects are very abundant, and acres of sweet or sour cherries and pears may be so injured that the foliage appears as if it had been smitten by some blight and killed. Trees severely attacked for two successive years are much injured and sometimes many of the branches or the whole tree dies. These years of great abundance are not very common and some seasons the slugs are so scarce that they do almost no damage.

Life History. The winter is passed in the full-grown larval stage in a small earthen case in the ground a short distance below the surface. In this in the spring the larva pupates and soon after the blossoms have dropped from the pears the adults emerge. These are little black sawflies, about one-quarter of an inch long. They lay their eggs in the tissues of the leaves and about the middle of June the tiny slugs may first be seen feeding on the upper surface. Early in July these become full-grown, and then drop to the ground and enter the soil, where some of them soon pupate. In about three weeks new adults begin to



Pear slugs and their work on cherry leaves, natural size. (Original) appear from these and continue to emerge for several weeks. These lay eggs for a second brood of larvæ which attack the trees in August and September. As a rule the larvæ of this second brood are not nearly so numerous as those of the first brood and so do not do so much harm. When full-grown, they, too, drop to the ground, work their way below the surface, form little earthen cases about themselves and remain there over winter. A large percentage of first brood larvæ fail to change into adults. These also remain in their cases over winter.

Methods of Control. This is an easy insect to control. Arsenate of lead at the strength of 1½ lbs. to 40 gallons of water applied to the foliage as soon as there are seen to be sufficient of the slugs present to justify spraying will destroy them. Sometimes, though rarely, a second application may be necessary for the second brood of larvæ. The chief difficulty is that the injury is usually done, especially on small trees, before the owners notice the presence of the insects. This is, however, merely due to failure to look for them and not to any difficulty in determining their presence. If only a few trees are affected, dusting them several times with fine dust or air-slaked lime will kill the larvæ. Pear and cherry trees which receive the regular sprays outlined in the spray calendar are seldom injured by this insect.

Pear Plant Bug (*Lygus communis* Knight).

This insect has already been referred to under the general heading "Leaf Bugs or Plant Bugs," which attack the apple. As stated there it is the same as the green bug of the apple which has been very destructive in Nova Scotia. It also attacks pears in that province and in New York State. In Ontario it seems at present to be of importance as an apple and pear pest only in the neighbourhood of Newcastle, where in a few orchards it has done much damage.

Work of the pear leaf bug or plant bug, (Lygus communis) on young pears, natural size. (Original)

Pears seem in these orchards to be more injured than apples, in some cases almost every pear being so badly deformed as to become a cull. Injuries are caused by the nymphs and later by the adults puncturing the young fruit and then the punctured area failing to grow while the surrounding area continues its growth, thus producing a depression at the injured point. There may be numerous punctures to a single fruit.

Another form of injury is where the nymphs or adults in feeding remove part of the green surface and then later this scarred area increases greatly with the growth of the pear and leaves large, rough, brown, calloused areas which greatly mar the appearance of the fruit. (See illustration.)

Life History. The eggs are laid in late June and July in the twigs and fruit spurs just under the bark. Next spring these begin to hatch when the blossoms are bursting and have practically all hatched by the time the blossoms have fallen. The young nymphs are very small and of a pale yellowish color at first with a little orange spot about the middle of the back. Soon they become nearly green, the orange spot remaining. When a little less than a quarter of an inch in length they turn into brown adults about one-quarter of an inch long with wings which cover all the abdomen. (See illustration under the apple.) There is only one generation a year.

Control. Very heavy spraying just as the blossoms are falling, with nicotine sulphate 40% or Black Leaf 40 at the strength of 1 pint to 100 gals. of water will destroy most of the nymphs. These have to be killed while still small for it is almost impossible to kill them when nearly full-grown, hence the importance of not delaying the spray. The nicotine should be combined with arsenate of lead and a little soap may be added to make it more effective; but soap must not be added if the nicotine is added to lime-sulphur as it breaks the latter down. Spraying the weeds and grass under the trees with the same mixture will also help by killing numerous nymphs which are knocked down during the spraying of the trees themselves.

It is very probable that further study will reveal that there are other leaf bugs besides *Lygus communis* which cause deformed pears in Ontario.

Pear Leaf Blister Mite (*Eriophyes pyri* Pagenstecher).

The pear leaf blister mite is a tiny, white or pinkish, nearly cylindrical creature, about five times as long as wide, and so small that it is scarcely visible without the aid of a hand lens. It is not a true insect and has only two pairs of legs in the adult stage.

This pest is distributed all over the province and attacks apples as well as pears. The injury is done almost entirely to the foliage. On this the mites cause numerous little blisters on the under surface. Sometimes these are so abundant that there may be more than one hundred to a single leaf. As the immediate portion of the leaf where the blister is formed soon dies, this means that on badly infested trees a large part of each leaf may be killed. Many of these leaves turn yellow early in the season and drop, and the remainder, through the loss of some of their green matter (*chlorophyll*), are unable to perform fully their proper function of manufacturing food for the fruit and other parts; consequently the whole tree is weakened. The mites often attack the fruit and fruit stems while these are still very small and cause little blisters on them, but later these blisters all disappear without leaving any visible injurious effects. On the leaves blisters are at first light colored, sometimes yellowish-white, but later on the pear they turn first nearly red then nearly black, and on the apple reddish-brown. The mites have not been nearly so numerous of late years as they were about 15 years ago.

Life History. The winter is passed by the mites under the protection of the bud scales. In spring, soon after the buds have burst and the leaflets have begun to expand, they move about and soon work their way through the epidermis of the under surface and feed in the interior of the leaf, gradually causing a blister to appear. Inside these blisters or burrows they lay their eggs and produce their offspring. The young mites when mature work their way through a little hole in the blister and soon make new blisters on the same or on other leaves. There are several generations in a season. Towards the end of October the mites desert all the leaves and go into winter quarters in the buds.

Blister mite work on apple and pear leaves. (Original)

Methods of Control. This is one of the easiest of all our pests to control. The best method is to spray the orchard thoroughly with lime-sulphur, strength about 1 gal. commercial lime-sulphur to 9 gal. water, any time in the spring from the ground is fit to drive upon until the buds are actually bursting. One thorough application covering every bud will practically annihilate the pest.

Other Insects Attacking the Pear.

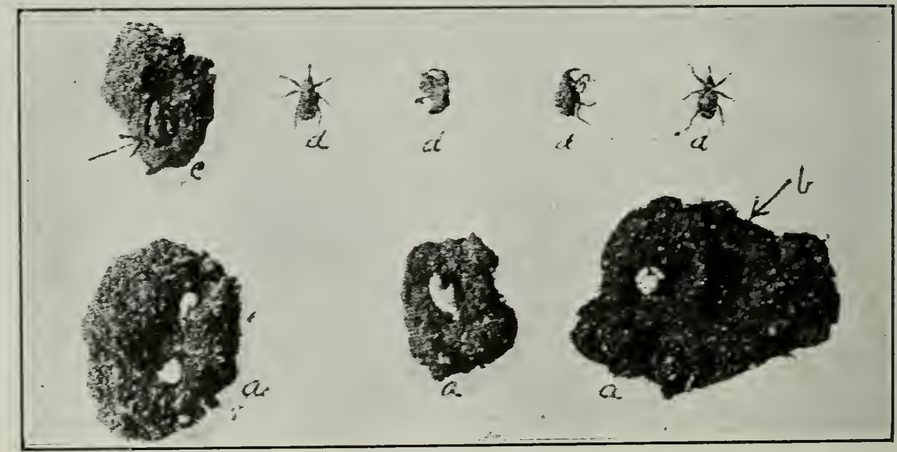
The pear is closely related to the apple and, as we should expect, almost all the insects which attack the apple attack it also. The most conspicuous exception is the Apple Maggot. Apple aphids, though found on the pear, are very seldom abundant enough on it to do any noticeable damage.

INSECTS ATTACKING THE PLUM

Plum Curculio (*Conotrachelus nenuphar* Herbst).

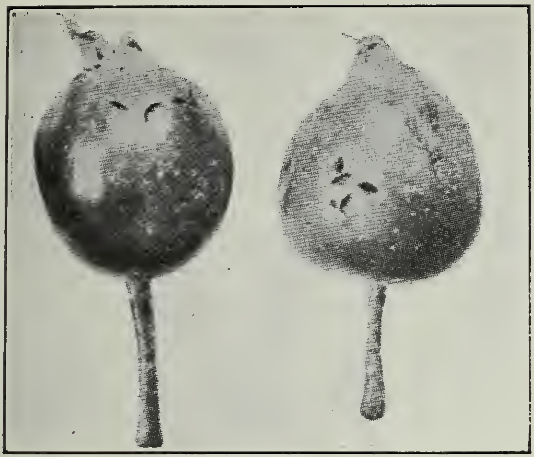
The plum curculio is a small, hard-shelled, rough-backed, grayish-black beetle about 1/5 of an inch long with a conspicuous snout, at the end of which are little, inconspicuous, biting mouth parts. The larva is a stout, curved, whitish grub about 2/5 of an inch long, with a brown head and no legs. Both the adults and larvæ injure the fruit. The insect occurs in all the fruit-growing parts of the province. It does not, as the name would suggest, confine itself to the plum, but attacks the fruit of all our orchard trees and also of wild plums, haws and occasionally gooseberries. It usually does most damage to apricots, plums and sweet cherries, but apples, pears and peaches are also often much injured. Orchards situated near woods or thickets or where long grass, weeds, brush and other rubbish abound are worst attacked, because such places afford ideal winter quarters for the beetles. For the same reason rubbish, weeds and long grass inside the borders of the orchard itself will lead to an increased infestation.

There are several kinds of injuries done to the fruit. First, many apples and pears and some peaches become knobby and deformed as a result of early feeding punctures and egg-laying injuries. Second, nearly all apples, pears, plums and most of the peaches in which the larvæ occur drop prematurely. Cherries are an exception, as they remain on the trees and usually rot. Third,



(a, a, a,) Small lumps of earth showing the pupæ in their little oval chambers; (b) a dark circular area in the lump showing the empty chamber after the pupa has been removed, (c) an adult beetle after transforming and still in the pupal chamber; (d, d, d, d) adult beetles all natural size. (Original)

the adults in late summer and autumn eat holes through the skin of apples, peaches and plums and feed on the pulp beneath, thus making cull fruit. Fourth, disease, especially brown rot, gets into peaches and sometimes other fruits through the wounds made by these beetles. In these various ways orchards in situations specially favorable for the plum curculio often suffer very heavily. Sometimes plum and cherry trees have almost every fruit destroyed. Apples and pears are seldom so severely affected as this, though the loss in their case is at times severe.

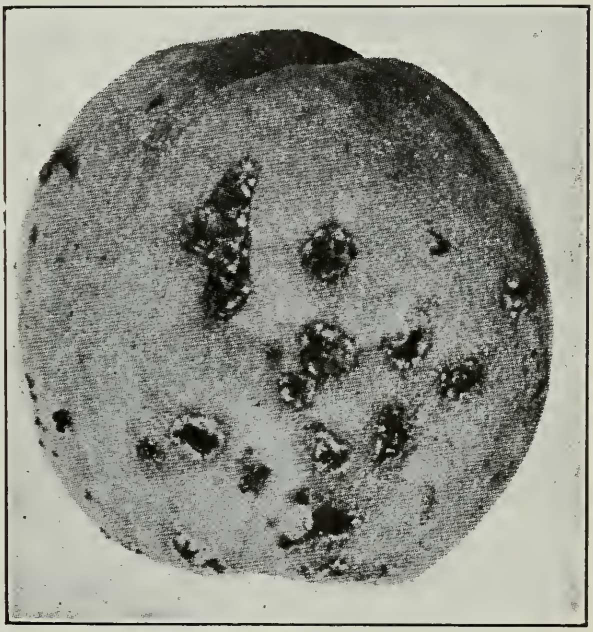


Apple showing the crescent-shaped cuts made by the females after laying eggs, natural size. (Original)

Full-grown larvæ and their work in a fallen apple, natural size. (Original)

Life History. The curculios winter in the beetle stage in any good hiding place such as long grass or rubbish or brush in or near the orchard. In Ontario they usually come out of winter quarters about the time apples are in bloom. Egg-laying begins almost as soon as the various kinds of fruits attacked are set and continues actively for a month, after which it quickly slackens off. The eggs are laid singly just beneath the surface of the fruit. After laying each egg the female makes a little crescent shaped cut around and partly beneath it. Eggs hatch in about five days on an average and the young larvæ almost at once work their way into the fruit and feed upon the pulp. If the larvæ live, the fruit, except on cherries, nearly always soon falls to the ground and the larvæ complete their development in it there. Many larvae, however, die soon after hatching, and in that case a depression often forms where the egg was laid and causes a

Fall or late summer injuries on apple made by the feeding of the new generation of beetles. These injuries, though natural size, are larger than the average. (Original)



Fall or late summer injuries made on peach by the feeding of the new generation of beetles, natural size. (Original) misshapen apple or pear. These deformed fruits are often very common in neglected orchards. The larvæ are full-grown in about two weeks. They then enter the soil from one-half to two inches and pupate there in little oval, earthen cases, which are easily broken if disturbed. In about a month the new beetles begin to emerge. These feed for some weeks on the fruit and foliage, doing the sort of damage mentioned above, and then seek good hiding places and hibernate in these. (See illustrations.)

Methods of Control. The first step in control is to secure as clean conditions as possible in and around the orchard by removing all sorts of rubbish and sheltering places in which the adults may hide for winter. It is wise, whenever practicable, to cut down and burn all shrubs or thickets nearby. The next step is to cultivate the orchard well as long as one may without fear of winter injury. Culitvation destroys the pupæ in the soil and also helps in other ways. The last step is to spray with a poison. Spraying is very important but scarcely more so than the cultivation and destruction of rubbish. The first spray on apples and pears should be with the same mixture and at the same time as the codling moth spray. If the insects are very abundant a second application should be given about ten days later. Plums and cherries should be sprayed just as soon as the fruit has set and the shucks have dropped. The mixture should be 1½ lbs. of arsenate of lead to 40 gals. of Bordeaux mixture or of lime sulphur (strength 1 gal. to 40 gals. of water). A second application should be given in two weeks or a little less. Peaches often do not require any spraying for this insect, but in a situation favorable to it they should be sprayed once with 1½ lbs. arsenate of lead to 40 gals. of water as soon as the fruit is all well set. No lime-sulphur or Bordeaux mixture should be used with the poison in this case.

The European Red Mite (*Paratetranychus pilosus* Can. and Franz).

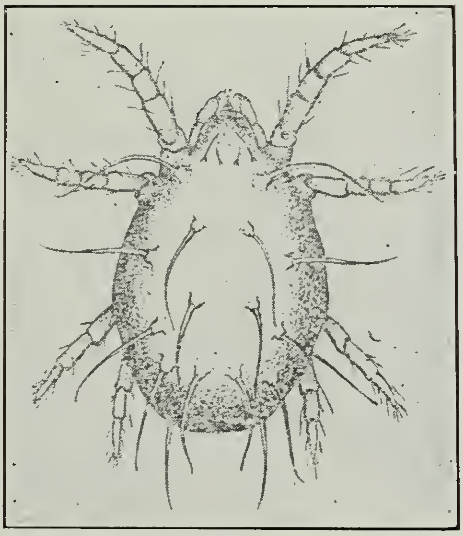
The European red mite or, as some call it, the "red mite" is one of the so-called red spiders. It is a tiny dark red creature not quite so large as the head of an ordinary pin and has four pairs of legs. It is a comparatively new pest, having been first discovered in Ontario in the year 1912, although present for several years before that time.

It attacks chiefly plums and apples, most damage having been done to European plums and comparatively little yet to apples, though there are strong indications that apples will be more severely infested in the future than in the past.

The injury is caused by the mites, both young and old, feeding upon both surfaces of the leaves and sucking the juice out of them. When very numerous the mites cause the foliage to get a pale-brownish almost road-dust color. The result is that the leaves cannot function properly and so the fruit is dwarfed. There is no doubt that the trees are also weakened and will not bear so well the following year.

Life History. The winter is passed in the egg stage. The eggs are globular and red, and are situated on the branches, especially in the axils. Sometimes there are thousands to an inch and pieces of the bark may be literally red with them. They hatch in spring about the time the blossoms begin to appear or are in full bloom. The young mites feed on the leaves and when fully grown lay eggs, but all of these until near the end of the season are laid on the leaves, either surface being chosen for the purpose. There are many generations a year and so the mites under favorable conditions increase greatly. The last generation, as implied above, lays its eggs upon the branches. This takes place in September and October. Then all stages but the eggs perish.

Methods of Control. The most satisfactory method of control is to spray the trees with a 3 per cent. lubricating oil emulsion or a well tested commercial oil spray, just as the buds are ready to burst. This, if thoroughly done, will kill all the overwintering eggs. After the leaves begin to appear lime-sulphur in the ordinary applications recommended in the spray calendar does a great deal to help, but to be highly effective should be applied to both surfaces of the leaves.



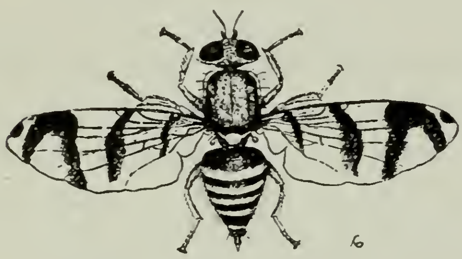
European red mite, much enlarged. (Original drawing by Miss M. Hearle.)

INSECTS ATTACKING THE CHERRY

Cherry Fruit Flies (*Rhagoletis cingulata* Loew) (and *R. fausta* Osten Sacken).

Cherry fruit flies are two-winged flies a little smaller than the house fly, and are closely related to the apple maggot. They are the insects which cause the little white or yellowish maggots often found in ripe cherries or sometimes at the bottom of baskets of this fruit. Infested fruits may appear to be sound but on opening them the maggots can be seen clearly and also the filthy brown mass that results from their feeding.

There are two species of these flies, which we have named from their respective appearance, the white-banded cherry fruit fly (*Rhagoletis cingulata*) and the black-bodied cherry fruit fly (*Rhagoletis fausta*). The former species is a little the smaller and is characterized by three distinct white crossbands on the abdomen of the male and four on that of the female, and also by the arrangement of the dark markings on the wings, as illustrated. The latter species has its abdomen entirely black without any white crossbands, and has the markings on the wings arranged as in the illustration. The larvæ of both species are so nearly alike that they cannot be distinguished easily. They are when full-grown about one-fifth of an inch long, nearly cylindrical, blunt at one end and tapering

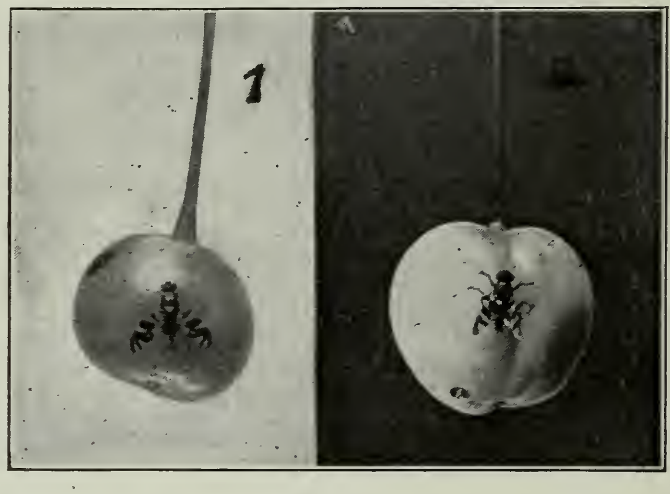


A female white-banded cherry fruit-fly, much enlarged. (Original)

A female black-bodied cherry fruit-fly, much enlarged. (Original)

to a point at the other. Their color may be either white or yellowish. There is no visible head and no legs, but at the small end are two little black hooks used to tear the tissues of the fruit and set free the juice upon which the larva feeds.

The white-banded species is much the more abundant in the province and either it or the other species has been found in almost every county where cherries are grown on a commercial scale. They do not, however, infest all or nearly

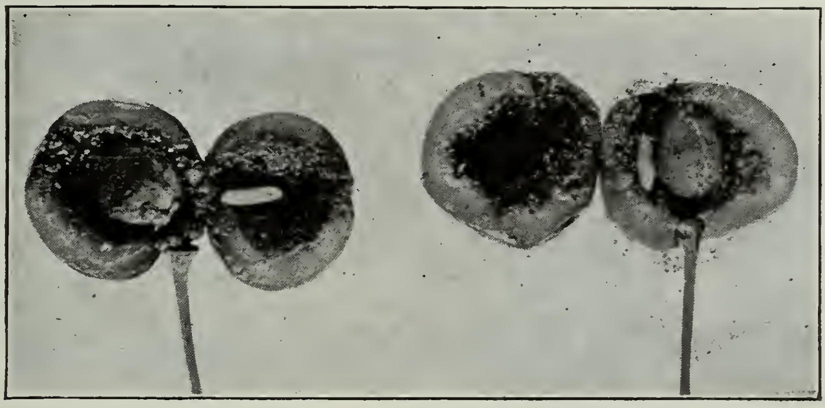


Cherry fruit-flies on the fruit: (1) the black-bodied cherry fruit-fly; (2) the white-banded cherry fruit-fly.

all the orchards in any county, but a sufficient number are infested to cause great loss from time to time. Early varieties as a rule are very lightly or scarcely at all infested but later varieties, such as Montmorencies, Morello and some of the late sweet kinds may have more than 90% of the fruit wormy and therefore not be worth picking. Wormy fruit is very subject to brown rot disease. The insects do not attack plums or other orchard fruits.

Life History. In June, when the Early Richmond cherries are just beginning to show the least sign of red, the adult flies of the black-bodied species begin to appear, followed about a week later by the other species. Both species move about upon the leaves or fruit of cherries or other fruit trees for several days before they begin to lay eggs. During this time they may often be seen to have their broad, rasping, lip-like mouth parts extended in search of juice or any little particles of food on leaves or fruit, just as a house fly may be seen seeking its food. The eggs are laid in the fruit below the skin by the sharp, sting-like ovipositor of the female. In five days or a little more they hatch and the tiny larvæ work their way at once to the pit, where they feed on the juices of the pulp. They are not full-grown until the fruit is ripe or even over-ripe. Then they work their way out, drop to the ground and burrow beneath the surface a short distance. Soon after this they change their form until they resemble a small plump grain of wheat (*puparium*). They remain in this form over winter and until they emerge as adults in spring.

Methods of Control. Extensive tests have shown that these insects can be controlled easily by spraying the trees with 1½ lbs. arsenate of lead to 40 gallons of water. The first application should be just as the fruit of the Early Richmond variety is beginning to show the first sign of red and the second application just as the Montmorency variety is beginning to show this red tint. The



Full-grown larvæ of cherry fruit-flies in the fruit, natural size. (Original)

object of both sprayings is to kill the adults before they can lay their eggs. Therefore, promptness in applying the spray at the right time is very essential. At the first application the foliage of all kinds of cherries except very early sweet cherries, should be sprayed. It will also pay to spray the foliage of any other kind of fruit tree nearby, as the flies often frequent them for a few days before ovipositing. At the second application only the later varieties should be treated as the early ones are too nearly ripe at this time. The spray may be combined with lime-sulphur or Bordeaux mixture, if desired. Neighbors should be encouraged to spray their orchards at the same time, because these insects move about freely. Moreover, all wild sweet cherry and all other useless cherry trees should be cut down that they may not serve as breeding grounds.

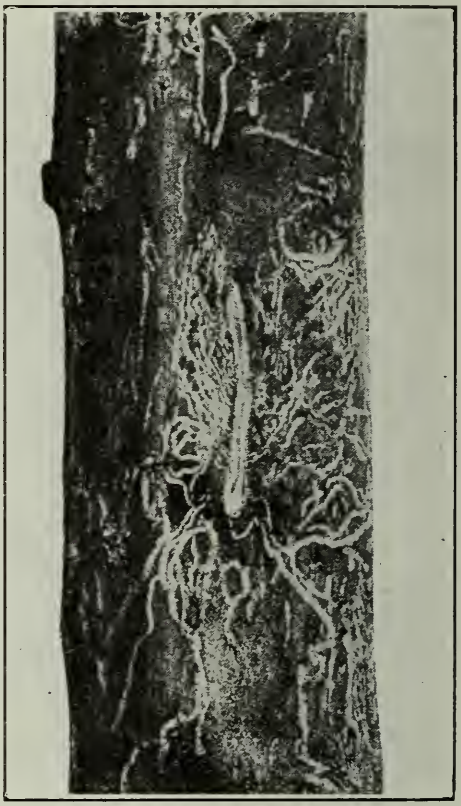
Shot-Hole Borer (*Eccoptogaster rugulosus* Ratzeburg).

Sometimes in peach, cherry and plum orchards, trees here and there will be found with numerous small gum masses exuding from the bark of the trunk and branches. If the outer bark at these spots is removed with a sharp knife and there is revealed a little eaten area through which the gum is exuding, it is evidence that the injury has been caused by shot-hole borers (Ipidæ) of which by far the most common species in Ontario is the one mentioned above. The adult is a tiny-reddish-black beetle about one-tenth of an inch long. It usually infests only dead or dying branches, attacking healthy ones only where these others are absent. Some years, moreover, the beetles seem to have a fondness for boring into the base of buds on healthy trees and killing the buds. We have frequently seen this occur on sweet cherry trees and it is not uncommon also on pears. In the latter case if the beetles have previously been feeding on the dead bark over a blighted portion of a pear tree they may transmit the blight to healthy pears.

Though the beetles may feed on healthy trees and weaken them by the great amount of gum which exudes from numerous holes, yet they cannot lay their eggs in such trees, because the gum drives them out, hence they breed only in dead or dying trees.

All kinds of fruit trees, and also wild cherry and juneberry trees are subject to attack.

Cherry aphids on underside of sweet cherry leaf, natural size. (Original)



Work of shot-hole borers and their larvæ, natural size. (Original)

Life History. The beetles appear in June and soon begin eating holes like those made by fine shot through the bark of dead or dying trees. Underneath this they construct a burrow about an inch long (See illustration) and lay their egg along each side of it. The larvæ from these eggs make little burrows more or less at right angles to the main burrow, and feed on the wood and bark as they do so. As they grow they increase the size of the burrows, and when full-grown eat a little deeper into the wood and pupate there. Full-grown larvæ are stout, white, little grubs without any legs. A new brood of beetles begins to appear about the middle of August and may be found in the orchards until late fall. These in turn eat through the bark, construct their egg burrows and produce a second brood of larvæ. All the adults die before winter, but the larvæ remain as such in their burrows under the bark until next May and June, when they pupate. Hence there are two full generations a year.

Methods of Control. The fact that the insects pass the winter only in the larval stage and only in dead or dying trees or branches, shows that the best method is to remove during late autumn or winter or early spring all dead or dying trees and branches, and burn them all before June to destroy the larvæ. It is not safe even to cut off the larger branches and trunks and pile them up as cordwood and leave them there. We have seen several severe attacks on healthy trees come from such piles. Where healthy trees have been attacked these need not be cut down unless the trees are clearly so weakened as to be dying. They should instead be pruned in spring and the ground well fertilized and cultivated. Where this is done they usually recover. Attacks on healthy trees can sometimes be warded off by promptly whitewashing the bark with thick whitewash made of freshly slaked lime and water, to every pailful of which about one-quarter lb. of salt has been added as a sticker.

Black Cherry Aphid (*Myzus cerasi* Fabr.).

The black cherry aphid, as its name indicates, is black in color. It is a great pest of sweet cherries but only rarely becomes numerous enough on sour varieties to do any noticeable damage. On sweet cherries it occurs many years in large numbers on the under surface of the leaves, preferably those which are most succulent, though others too are often attacked. Here by sucking the juice it causes the leaves to curl and cluster and ultimately to turn yellow and die. The aphids also feed on the fruit. As they all excrete honeydew this gets on both leaves and fruit and makes the latter so sticky and filthy that it has to be washed before marketing.

Life History. The winter is passed in the egg stage. The eggs are glossy black and situated chiefly around the base of the buds. They hatch in spring when the buds are ready to burst, and the nymphs at once begin feeding upon the green tips and later, as already mentioned, upon the leaves and fruit. Many of the adults remain on the foliage all the season but the others migrate to an alternate host plant, namely a common weed known as peppergrass (*Lepidium apetalum*). In autumn the offspring of these migrants fly back to the cherry trees, and late in the season eggs are laid for winter.

Methods of Control. Just as the buds are bursting spray all sweet cherries with 3 per cent. lubricating oil and Bordeaux 3-6-40 (The Bordeaux is to help ward off rot.) or with lime-sulphur, 1 to 7 (sp. gr. 1.035) and nicotine sulphate, ¾ of a pint to 80 gals. of the liquid. These substances are meant to kill the aphids when they have just hatched from the eggs and are on the green buds. Hence every bud should be thoroughly covered. This spray of course controls San José scale as well as the aphids.

If an early spray has not been given, considerable good, but not a really effective control, can be gained from spraying with nicotine sulphate, ¾ of a pint and 4 lbs. of soap to 80 gals. of water, wherever the aphids are numerous enough to threaten the crop. Dusting heavily on a calm warm day with 2 or 2½ per cent. nicotine dust should also prove fairly effective.

Other Insects Already Discussed Which Attack Cherries.

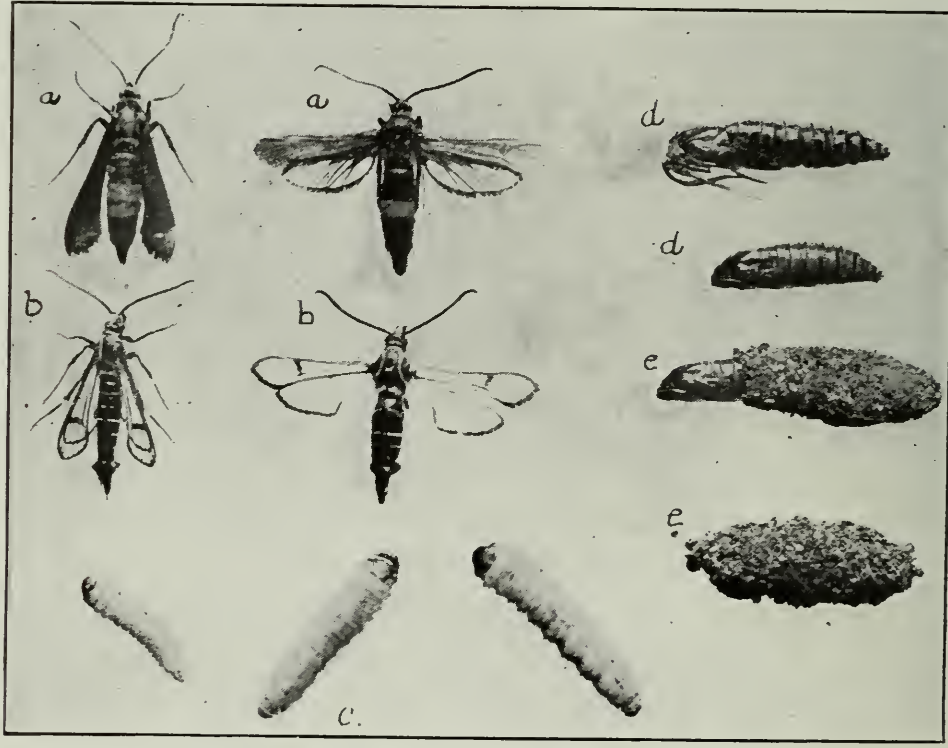
Bud Moth.
Fruit Tree Leaf Roller.
Cankerworm.
Apple Tent Caterpillar.
Buffalo Tree Hopper.
San José Scale.
Pear and Cherry Slug.
Plum Curculio.

INSECTS ATTACKING THE PEACH

Peach Tree Borer (*Synanthedon exitiosa* Say).

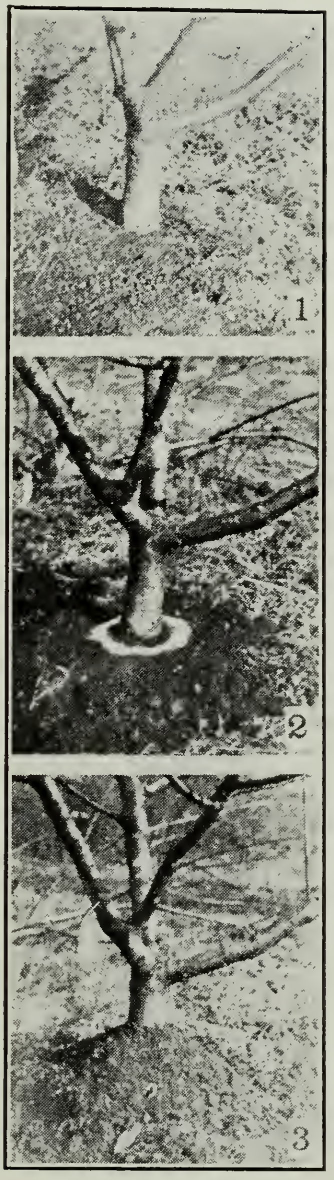
The peach tree borer is a very common insect enemy of the peach in Ontario, and occurs in almost every orchard. In some it causes much damage, but in others very little. Plum, cherry and apricot trees are also occasionally attacked, but the insect much prefers the peach to these.

The injury is caused by the larvæ. These act as borers and feed on the inner bark and sapwood of the trunk, usually at or a little below the surface of the ground. Many larvæ may attack a single trunk at the same time; for instance, we have taken twenty from a four-year-old tree. Badly infested



The peach tree borer; (a, a) adult females; (b, b) adult males; (c) full-grown or nearly full-grown larvæ; (d, d) pupæ, the upper one being empty; (e, e) cocoons or pupa cases, the pupa protruding from the upper one; all natural size. (Original) trees are either killed by the girdling of the trunk or are much weakened and are therefore liable to perish during the winter. The presence of the borers is usually indicated by large gum masses which exude from the injured area, but often these masses cannot be seen without removing the earth from around the base of the tree.

Life History. The winter is passed in the larval stage either in the burrows in the wood or in little winter cases on the bark. Some of the larvæ at this stage are quite small, while others are nearly full-grown. The larger ones are usually in the wood and the smaller ones in the little cases. A full-grown larva is about one inch or a little more in length, moderately stout, cream to pale-yellowish in color, with a brown head and with three pairs of true, or jointed, legs and five



(1) Soil about peach tree made smooth and ready for treatment with paradichlorobenzine.

(2) An ounce of paradichlorobenzine placed on soil about the tree in a continuous narrow band approximately 2 inches from the tree; which is the correct method.

(3) Dirt free from grass, large stones, sticks, etc., placed on top of the paradichlorobenzine 4 to 6 in. deep and packed down. (All after Peterson.)

pairs of prolegs, or false legs. In the spring the larvæ resume their feeding, and when full-grown pupate in silken cocoons, covered with brown casting (See illustration). These cocoons may easily be found in the soil close to the trunk. The adults, which emerge from them, are pretty, clear-winged moths, resembling considerably some of our common wasps. They fly in the daytime. The female can readily be distinguished from the male by the presence of a broad orange band around the abdomen, and by the front wings being a blue-black color. Moths, judging from our observations in the year 1915 in Norfolk County, may begin to emerge as early as July 1st, and may continue to do so until the end of August. (The writer once saw an adult female in the Niagara district as late as September 11th.) Egg laying begins soon after emergence. From 200 to 800 eggs are laid by each female. These are deposited chiefly on the trunk of the trees, but many are laid also on both surfaces of the leaves. The young larvæ on hatching work their way to the ground and there feed for a time on the bark. Gradually as they become older they eat into the sapwood. When cold weather arrives they become dormant and remain so until the next spring. There is only one generation a year. Possibly a few individuals spend two winters in the larval stage.

Methods of Control. The usual method of control is to cut out the borers with a knife, aided sometimes by a wire. This work should be done in late May or early June before pupation begins and again in October. In doing it, care should be taken not to injure the tree more than necessary and always to cut with, not against the grain. The soil to the depth of a few inches around the base of the trunk must always be removed first with a trowel or other implement to get access to the larvæ below the ground.

A simpler and more effective method than the above is to use paradichlorobenzine, often called P.D.B., to kill the borers. This is a white crystalline substance resembling granulated sugar. It produces a gas six times heavier than air and poisonous to insects but not to man. The method of using it is as follows:

First, level the soil around the trees, removing all sod and coarse stones, and if gum masses show that any of the borers are working an inch or more above the ground, mound the earth up high enough so that when the top of the mound is levelled a little it will still be an inch or so above where the borer is working. Next apply the P.D.B. in an unbroken narrow ring around the tree in such a way that none of it will be nearer the bark than one inch and none farther away than three inches. Then gently cover the substance with one or two shovelsful of fine earth so that it will not be moved out of position, and after that cover well with half a dozen or more shovelsful of the ordinary soil and finally pack this down with the back of the shovel.

The amount of P.D.B. to use per tree is ½ oz. for trees under 3 yrs. of age; ¾ of an oz. for trees from 3 to 6 yrs.; 1 to 1½ ozs. for older trees, the larger amount being of course for the larger trees.

The best time to apply it is when all the eggs have been laid and the larvæ have hatched. This in this province will usually be any time during the first two weeks in September. Later than this would be likely to be unsatisfactory, as the P.D.B. only gives off its gas when the soil temperature is about 60°F. or higher.

The mounds should be removed each spring so that they can be replaced the next fall.

This material applied at the above time will also kill many of the larvæ and pupæ of the Oriental Peach Moth.

LESSER PEACH TREE BORER (*Synanthedon pictipes* Grote & Robinson).

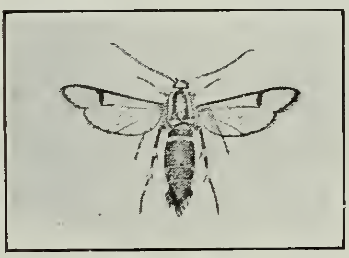
Both in the adult, and larval stage the lesser peach tree borer closely resembles the one just discussed. It is, however, in both stages a little smaller and the female has not the blue-black front wings nor the orange band around her abdomen, but resembles closely the male.

There is considerable difference in the habits of the two species, for the lesser peach tree borer does not, like the other species, confine itself to any one part of the tree, but attacks indiscriminately the trunk, crotch and branches. Moreover, it does not enter the tree through the healthy bark, but always through some wound. The more wounds there are, the more abundant the borers usually are. Consequently, orchards severely infected with cankers usually have many borers. This has led some growers to think that the borers are largely responsible for the cankers; but such is not the case. The most that can be said is that by working between the healthy and diseased tissues around the edges of cankered or wounded areas, they interfere with nature's healing process and gradually enlarge the dead area at the point where they feed. So far as our observations go, it is seldom that they actually cause the death of a tree or even of a branch; for, though many cankered branches die, their death can usually be shown to have been due chiefly to other causes than the borer.

In addition to the peach, the insect also attacks to some extent plum and cherry trees.

Life History. The chief differences between the life history of this and the preceding species is that the adults of this one begin to emerge about a month earlier (about June 1st) than those of the other species, and do not continue to emerge for so long a time, and that pupation takes place in the canker or wound near where the larva has fed. The winter is, of course, passed in the larval stage.

Methods of Control. From what has been said it is clear the best method of control would be to keep the bark of the trees free from injury of any kind, but this cannot always be done. In cases where there are many cankers much



Lesser Peach Tree Borer, adult female, about natural size. (Reduced from King.)

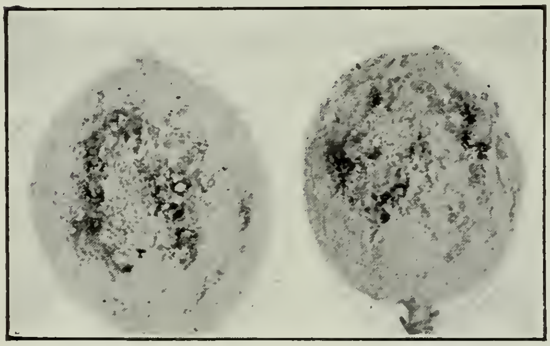
can be gained, if, when pruning, all cankered branches which can be spared are cut off and burned. The remaining cankers should be examined in spring before the middle of May and as many of them as time permits cleaned out with a drawknife and stout sharp jack-knife, care being taken of course to search for and kill the larvæ. Wounds may be painted with white lead. This cutting and painting process is also the chief way to stop a canker from spreading, even where there are no borers.

PEACH PLANT BUGS (*Lygus quercalbae* Knight) and (*Lygus caryae* Knight).

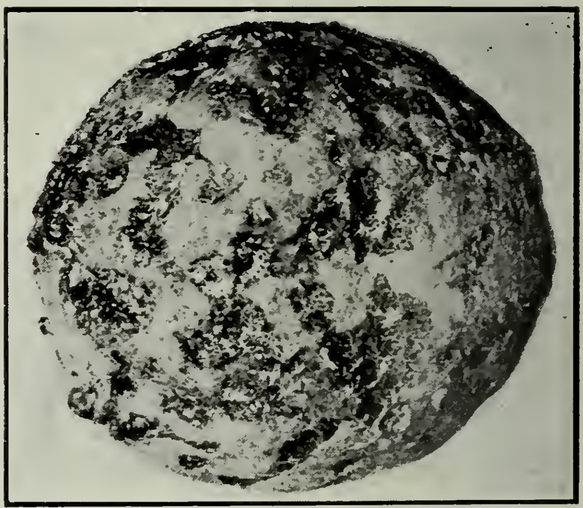
The two most common peach plant bugs in the adult stage are brown and resemble closely the common tarnished plant bug (*Lygus pratensis* Linn), and also the adults of the green apple bugs (*Lygus communis* Knight), which attack the apple and pear. (See under pear.) The damage is all caused by the adults. These fly in from their breeding trees—oak and hickory respectively— to the peach and feed upon the fruit. In feeding they puncture the surface here and there over the peach causing gum to exude and scars to form which grow larger and more unsightly with the growth of the fruit itself so that by the time it is ripe it is so badly scarred and disfigured as to be unsaleable. The injury is done during June before the peaches are quite half grown.

Up to the present only a few orchards have been injured by these bugs and a couple of closely allied species but in these orchards almost every fruit on the trees near the woods was rendered unmarketable.

Life History. After feeding for a week or two upon the peach fruit the adults return to the oak and hickory trees respectively and lay their eggs in the twigs usually close to the buds. The adults soon die and the eggs remain unhatched until growth commences the next spring. The nymphs from these feed upon the foliage of these trees until they are full grown and have transformed into adults, then these fly to the peach and attack the fruit.



Work of the oak plant bug (Lygus quercalbæ) on young peaches, natural size. (Original)



Full grown peach badly disfigured as a result of early injuries from Lygus quercalbæ, natural size. (Original)

Control Methods. The only method of control that seems possible is either to cut down oak and hickory woods near peach orchards, or not to set out peach trees near such woods. Fortunately the adults do not seem to fly far; for it is only the first five or six rows along the woods that are at all severely attacked. Trees one hundred and fifty yards away are almost uninjured.

Oriental Peach Moth (*Laspeyresia Molesta* Busck).

The Oriental peach moth is a new insect, which was introduced from Japan into the United States and was first found there in 1916. In Ontario it was discovered for the first time in 1925.

It attacks chiefly peaches and quinces and to a lesser extent apples, pears, plums and cherries.

Adult of Oriental peach moth, natural size. (Original)

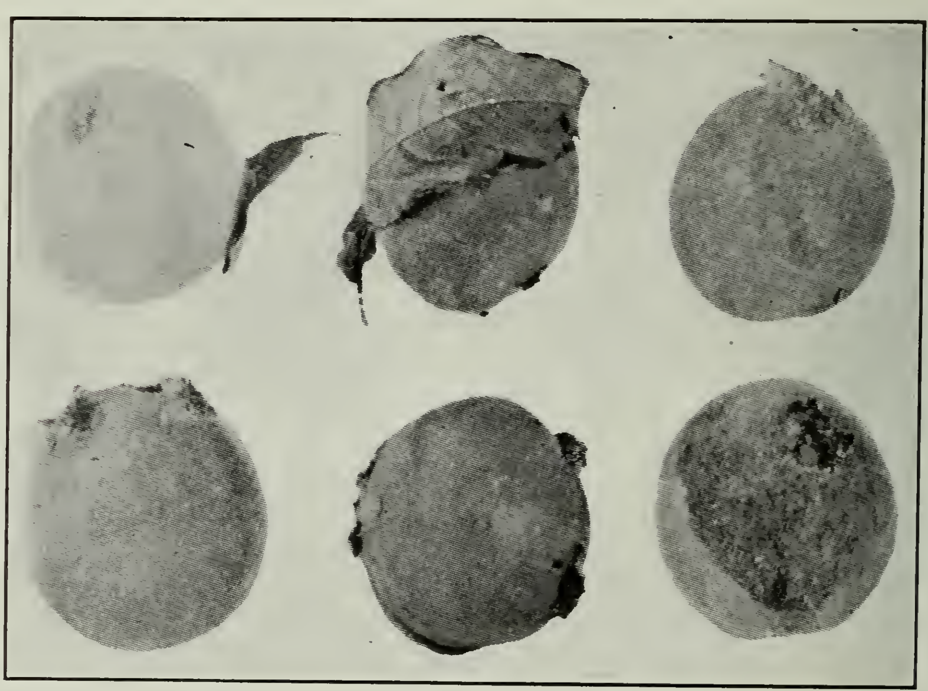
The larvæ, which do all the damage, are slender white or pinkish caterpillars with brown heads. When fully grown they are nearly half an inch long.

The adults are dark-grayish-brown moths with a wing expanse of half an inch.

Injury to Twig of Peach. (After Ross.)

There are two main forms of injury: *First*: In the early part of the season, especially in June, but also to a lesser extent throughout the remaining months, the larvæ attack the new terminal growth, boring into the apex or near it and tunnelling down the stem from one to two inches. The affected part soon dies and a gummy exudate usually forms at the tip or sometimes at the base or at both tip and base. This twig injury is most common and injurious on young succulent trees and nursery stock; because all the twigs are often attacked and their terminal growth thus stopped, with the result that the trees are forced to send out lateral shoots and thus a bushy top is produced. This makes it difficult to prune in such a way that a well formed tree may be developed; *Second*: The larvæ bore into the fruit and feed upon the pulp, especially around the pit, causing brown, filthy areas. Often there are several larvæ in a single fruit and in that case the whole of the interior may be ruined. This is particularly true of quinces, which are even more heavily attacked than peaches. On many peaches there is no external evidence of the presence of the larvæ; for most of them, especially in the latter part of the season, enter through the stem or so close to it that the opening is not noticeable. When, however, the larvæ enter through the side, gum and castings at the entrance hole show their presence, much as in the case of the codling moth larvæ. Injury to the fruit begins in June and continues to the end of the season, becoming more abundant as the season advances and the insects increase in numbers. Hence late peaches are regularly more injured than early.

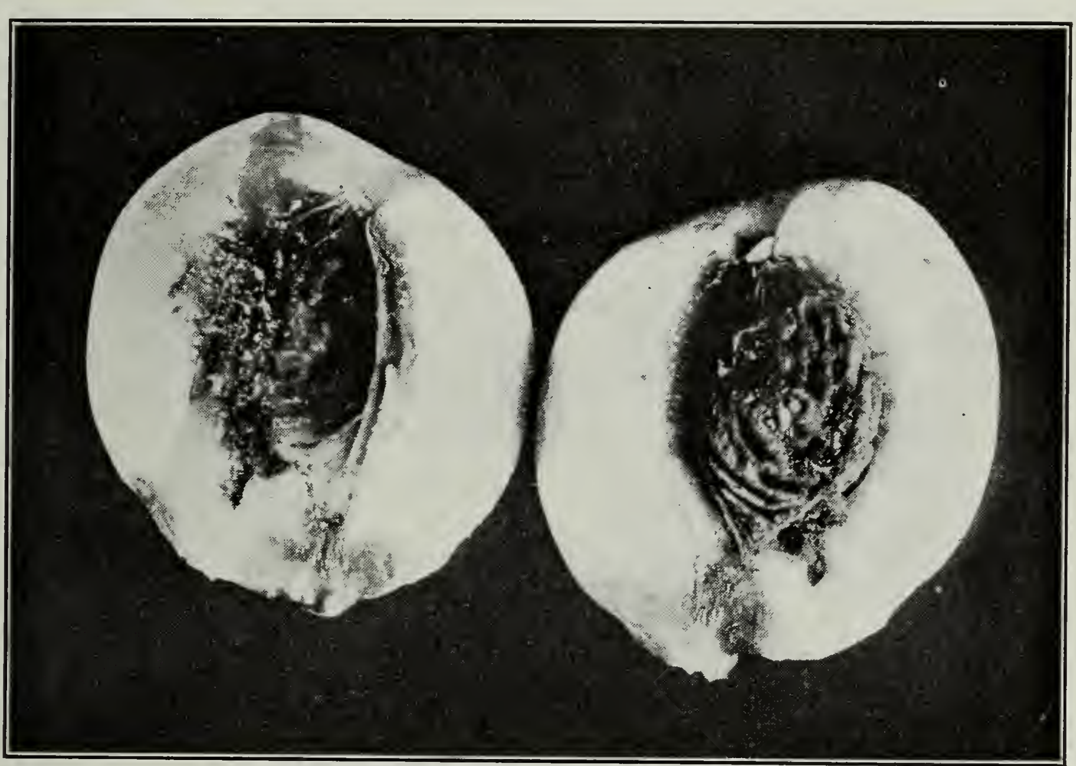
So far apples, pears and other orchard fruits have been attacked only when growing in peach and quince districts, and only after the peaches had all or nearly all been harvested. Hence there is considerable doubt whether the insect would be able to live and thrive apart from these two fruits.



Gummy exudate on young peaches caused by Oriental peach moth larvæ. (After Stear.)

Though the Oriental peach moth has been in the province only a few years, it has already spread all through the Niagara district and to almost every locality where peaches are grown. In most of this area only a low percentage of the fruit has been attacked but in the locality where it was first discovered it has become so abundant that at the date of writing, February, 1930, as high as 60 to 70 per cent. of the peaches in some orchards are infested. Hence this is much the most destructive insect attacking peaches and quince.

Life History. The winter is passed as full-grown larvæ in little silken cocoons on the bark of infested trees, on old mummied peaches and rubbish on the ground beneath the trees, in baskets or containers of any kind used in harvesting or storing peaches, in sheds where peaches were packed, and around and



Work of Oriental peach moth larvæ in fruit. (After Pettit.)

in piles of cull peaches wherever they may be. In the spring the larvæ change to pupæ and adults begin to emerge about the time peaches have begun to bloom. Emergence continues for a month or more. Soon after appearing the moths begin to lay their eggs, placing them in the case of the peach chiefly on the underside of the leaf and in that of the quince on the upper side. The larvæ on hatching attack first the new growth and later both this and the fruit, but chiefly the fruit, as described above. They become full-grown in from two to three weeks and then spin up in their cocoons. These in the earlier half of the season are made chiefly on the bark of the trees, but in the later half are in the various places where we said the insect wintered. The pupal stage lasts about two weeks. There are three broods of the larvæ a year in this province. The winter as stated is passed in the full-grown larval stage.

Methods of Control. This is one of the most difficult orchard pests to control; in fact no satisfactory artificial method has yet been discovered but many of the larvæ can be destroyed by the following measures: (1) As many larvæ winter over in cocoons in picking baskets or other peach containers, put all these into the shed or house where the peaches were packed and where there will also be many overwintering larvæ. Then screen the windows and keep the doors closed during May and June so that the moths, when they emerge, may go to the windows and die or be killed there instead of escaping. Many moths may be captured around the windows by hanging up sheets or cones of tanglefoot. If the packing house is not enclosed the baskets and other containers should all be sterilized with steam. (2) Put cull peaches into pits and pour crude oil or waste crankcase oil over them or cover them with three inches of hydrated or unslaked lime. (3) In spring before the blossoms are out plough or disc to a depth of four inches all soil beneath peach and quince trees. This buries the pupæ on the ground and prevents the moths emerging. (4) Many larvæ winter around the base of the trunks of peach trees, especially if these trees had a crop the preceding season. These could probably be killed by either of the following measures: *First*: Mound the earth up around the base of the trunk about 6 inches high and then level this off a little to make a satisfactory bed for paradichlorobenzine. Then apply this material at the same strength and in the same time and manner as recommended above under the peach tree borer (page 64). This will kill all larvæ below the top of the mound. The mounds should of course be removed the next spring. *Second*: Scrape the rough bark off the trunks of the Elberta and later peach trees with a strong, moderately sharp hoe to remove the natural hiding places for larvæ and pupæ; then in August place a double band of burlap about 6 inches wide around the base of each trunk close to the ground, so that the larvæ may crawl under these to spin their cocoons and winter. Each band can be held in place easily by means of two long stout tacks. Then in November or December, when other work is not pressing, remove the bands, kill any larvæ which can be seen on the bark beneath them, take the bands to the house and treat them all thoroughly with scalding water to kill the larvæ present. After this dry them and put them away for use the next year. (5) The above four measures will destroy a large number of the larvæ and adults but may not be sufficient alone to prevent the gradual increase of the insect. Hence we must supplement them by other measures and of these by far the most promising seems to be the use of parasites. In Ontario our native parasites have of their own accord done very little to help, but in New Jersey parasites are playing a very useful part. In 1929 a little more than 2,000 individuals of the most valuable species of parasite found in New Jersey were imported and freed in heavily infested orchards. These had increased rapidly before winter, and as they appear hardy enough to winter safely in this province, there is at least good reason to hope that by further importation aided perhaps by laboratory rearing they may after a few years help out greatly in the control of this great pest. There is also an egg parasite which is now being reared in large numbers.

Other Peach Insects Discussed Elsewhere in This Bulletin.

Green Fruit Worms.
Bud Moth.
Apple Tree Tent Caterpillar.
Forest Tent Caterpillar.
San José Scale.
Plum Curculio.
Fruit Tree Bark-Beetle.

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Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

TOP WORKING and REPAIR GRAFTING

INCLUDING BUDDING

BY

D. A. KIMBALL, M.S.

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INTRODUCTION.

Most fruit growers will at some time find a knowledge of grafting of distinct practical benefit. The large number of inquiries received from both amateur and commercial growers gives ample proof of the need for such information.

The opinion, frequently held, that grafting is intricate and mysterious is probably a heritage from the time when knowledge of this ancient practice was guarded as a trade secret. Successful work may be done by anyone moderately handy with a knife and willing to follow instructions. The operations are simple, the tools required are few, and, if the operator will pay attention to details, working slowly until the methods are thoroughly understood, the results will be satisfactory.

Methods of grafting and variations in any one method are limited in number only by the ingenuity of the individual. The beginner is well advised not to experiment until the practice and reasons therefore are thoroughly understood. It is not the intention to include in this publication a multiplicity of methods nor to deal with plant propagation, except incidentally. Only such methods and information are included as have been proved by years of trial to be the best for the intended purposes.

The need for top-working and repair grafting arises chiefly from lack of proper planning before varieties are ordered, neglect of one or many of the factors of suitable orchard management, or giving mice and rabbits free play. Grafting in the orchard is an attempt to correct a mistake, and no matter how successful it may be, the orchard is not as profitable as it would otherwise have been.

TERMS USED

Top-Working—Grafting done in the branches of a tree of considerable size or the trunk of a young tree. It does not apply to grafting at the roots of a tree or for purposes of increasing the number of individuals (propagation).

Stock—That part of the tree into which the scion is inserted. The stock supplies the root, trunk and sometimes the main branches of the completed tree.

Scion—The bud or piece of wood containing several buds, which is grafted into the stock so that it may grow thereon. It provides the bearing surface or top of the grafted tree and produces the same variety as the tree from which it was taken.

Cambium Layer—A thin layer of cells between the bark and wood. This is the growing part of the tree, building up bark on the outside and wood on the inside. It is too thin to be seen with the naked eye. The film that can be scraped from the wood when the bark peels off consists partly of these cells. The success of all grafting depends on contact between the cambium layers in the stock and scion.

Bud Stick—A piece of the current season's growth including a number of buds.

Most of the illustrations were taken by Mr. R. Watson, of the Provincial Motion Picture Bureau, Toronto, from material supplied by the writer. This very considerable assistance is gratefully acknowledged.

REASONS FOR TOP-WORKING

To Change the Variety

Changing market demands, plantings not true to name, and other causes may make it desirable to alter the variety in an established orchard. This can often be done more cheaply and quickly by grafting than by tearing out and replanting.

Seedlings or "Wild" trees growing in a suitable location may be made to bear good fruit. In the garden several varieties can be grown on one tree.

To Correct Pollination Difficulties

When planted in solid blocks many varieties of fruit will set very light or no crops. Most varieties benefit through having other, suitable varieties available to supply pollen. Proper planting plans provide for pollination but orchards in which this is lacking can be corrected by grafting-in suitable varieties. Every fourth row of the pollinating variety is sufficient. A less desirable method is to graft a branch in every second or fourth tree. This results in difficulties at harvest time and does not give results equal to grafting over an entire tree. Each orchard has problems of its own and the grower is advised to consult a reliable authority if pollination trouble is suspected.

Hardiness and Disease Resistance

Some varieties of apples are subject to forms of winter injury at the collar (base of the trunk) or at the crotch. Such varieties should be grafted on stock which is hardy in trunk and main branches. Tolman Sweet, Hibernal or hardy, strong growing crab-apples are favorite stocks for the purpose.

Pears are all more or less susceptible to fire-blight, which can ruin an orchard in a single season. Trunk infections of this disease are especially dangerous in that the entire tree may be killed through a comparatively slight attack. Commercial varieties are being tried out, topworked on Pyrus calleryana or resistant varieties such as Kieffer and Old Home. For a discussion of pear stocks and blight refer to the Ontario Bulletin No. 354.

REASONS FOR REPAIR GRAFTING

When any considerable width of bark and cambium are removed the transfer of food between the parts above and below the injury is cut off. When a complete circle around the trunk is killed the tree is doomed unless connection is established across the injury.

Mice, collar rot, or other winter injury and to a lesser extent fire blight are the agents chiefly responsible. Large wounds should be bridge grafted even though they may only partly girdle the trunk or branch. (See Figure 1)

SATISFACTORY STOCKS

The present multiplicity of varieties in many of our apple orchards does not permit definite recommendations as to what variety will succeed best on a particular stock. Growers have such a large and varied list of varieties to graft over that it would not be feasible or possible to get information for any considerable number. When fewer varieties are to be taken into account the question can be handled reasonably.

Judging from the contradictory nature of the evidence available, some factors other than variety adaptability when used as stock or scion must be influencing results. Observation leads one to suspect that the most

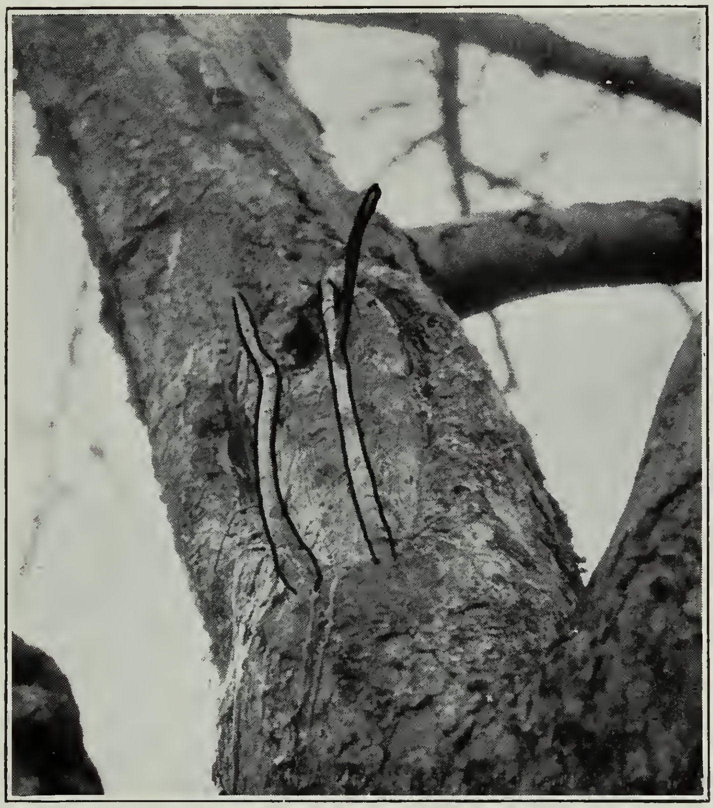

Fig. 1—Bridge Grafting over a large wound.

influencial factor is health and vigor of the stock. That is, we are comparing results obtained on weakened trees with grafts on the same variety in a vigorous, healthy condition.

The situation will only allow for the general recommendations given hereafter.

For apples any variety is presumed suitable for top-working that is vigorous, hardy and healthy. Short lived varieties or those which are tender or weakened by any cause, such as overbearing, are not desirable. They should be taken out and young trees of the required variety planted. Pears and sweet cherries are in much the same category as apples, although pollination is the chief reason for top-working sweet cherries.

Plum growers in Ontario are interested chiefly in grafting over undesirable Domestica (European) varieties to better varieties of the same species or substituting Domesticas for Japanese varieties. Experience here and elsewhere shows that Japanese plums do not make successful stocks for European sorts, although the reverse is sometimes successful. As between European stocks for European varieties the same general statements as given for apples will apply. Damson plums are small, slow growing and do not appear promising as intergrafts for either European or Japanese. In addition planting distances for the latter two are much greater than necessary for Damsons.

TIME TO GRAFT

Budding or Bud Grafting is usually done in late July and August, when the bark of the stock slips easily and the buds of the desired scion variety are well developed in the axils of leaves on the new wood.

Cleft or Whip Grafting time is just as growth starts. On large jobs the work must naturally and can be started earlier. In nursery practise for propagating, whip grafting is carried on indoors during the Winter.

Bridge and other forms of grafting in which the bark is peeled from the wood are most easily handled when the bark slips; that is a little later than cleft grafting. Bridge grafting can be successfully done at least until blooming time, if the scions are dormant.

These forms of grafting can all be done when the stock is growing but the scion **must** be dormant.

Fig. 2—Scion Wood. 1, 3 and 5 right size; 2 and 4 are rather large; 6 and 7 too small. Compare with pencil. 8, Annual ring at base of one-year-old growth.

SELECTIONS OF SCIONS

In budding the scion is a bud from wood which grew that same year. The bud stick should be vigorous, healthy, and not soft or sappy. The buds, in the axil of the leaves, must be well developed, firm and healthy. Buds at the top and bottom of the growth are sometimes poorly developed and if so should be discarded. Peaches and certain varieties of other fruits may have fruit buds on the new growth. These larger, plumper, rounder buds are discarded, only the leaf buds being of use.

Scions for other types of grafting consist of dormant (non-growing), well matured, healthy one year old wood. The usual scion is six to eight inches in length with three to four good buds. Buds must be healthy and fully developed. To get only such buds it is often better to discard the tip and base of the scion. The most satisfactory size of wood is that of an ordinary lead pencil. Sizes of scions and the annual rings by which the age of the wood is ascertained are shown in Figure 2.

Good scion wood is cheap and usually easy to get, yet many failures in grafting can be traced to poor scions. Small wood has not sufficient vitality to withstand adverse conditions and may already be weakened or injured. Very large wood may be soft and sappy and as well have poorly developed buds. Both extremes are more difficult to cut and fit properly.

Sucker growth, if not immature, is as good for scions as terminal growth and is easier to get in the right size. Such wood will produce trees equal in all respects to the tree from which it is taken. It is understood that any growth from below the point of grafting or budding will reproduce the seedling and not the variety worked thereon. In no case should wood be taken from trees unless they are known to be true to name; if at all possible avoid trees which have not borne fruit, or that bear poorly coloured crops.

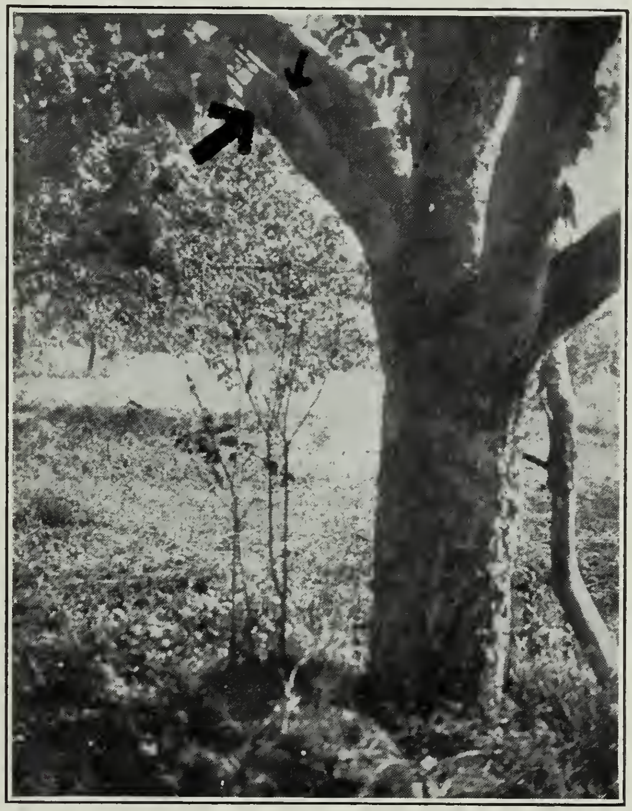

Fig. 3—Entirely too much shade for this graft.

HANDLING SCIONS

The handling of bud sticks will be considered under "Budding".

Dormant wood for grafting can be taken from the time the leaves fall until just before the buds burst in the Spring. Fall cut scions are kept buried in damp sand or sawdust at a temperature below 40°F. until needed. Otherwise the scions are cut a day or so before required. They should be kept moist until used and carried to the field in a damp bag. Dried out scions will not "take" even if the grafting is well done.

For grafting after the stock is growing the scions can be kept dormant in the damp sawdust in an ice house.

Unless brought from a distance there is little object in gathering the wood until needed. It will, however, sometimes be more easily procured before pruning.

In shipping scions wrap in several thicknesses of wet newspaper. For long distance shipment dip the ends of the bundle of scions in melted parraffine, wrap in wet moss, newspaper and finally waxed or oiled paper. It is not necessary to cover the entire scion with wax. Scions have been sent successfully, when packed in this way, from Guelph to China, Russia, Portugal and other distant points. Tin tubes provide a perfect outer covering. The U.S. Dept. of Agriculture in Circular 323 recommend wrapping scions in wax paper, wet burlap, and covering with other layers of wax or oil paper, then dry burlap.

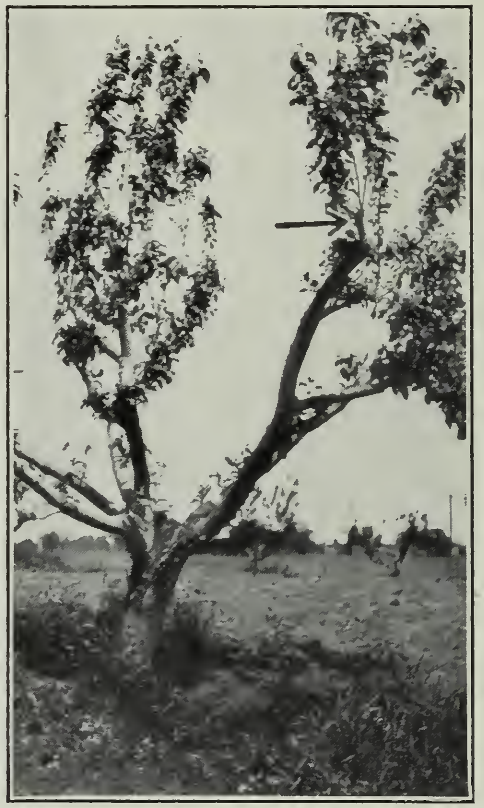

Fig. 4—Grafting much too high. This tree is liable to sunscald as all suckers have been removed. Wood smaller than necessary has been used and the fruiting surface will be six feet higher than need be. See Fig. 5.

(Courtesy E. Renouf)

TOP WORKING

Small trees are budded or whip grafted; large trees cleft grafted.

Trees up to 12 or 15 years of age are ideal in size and condition for top grafting. It is seldom advisable to try grafting trees over 20 years old. The older the tree the more difficult it becomes to get small enough limbs on the lower part of the tree. Then, too, the older trees are often weakened by overbearing or have brittle, black-hearted limbs. It is quite useless to try grafting any but healthy, vigorous trees for a weak tree has not the necessary vitality to heal wounds or adequately feed the scions. Topworking will not in any way invigorate a weak tree.

Medium sized trees can be worked over in one year, except for the removal of branches which are left as "feeders". Large trees, such as a normal 15 year old tree, will require from two to three years. An additional one or two years of attention after grafting is necessary on any tree, to make a finished and permanent job.

Fig. 5—Tree grafted low and half finished. Some suckers are left which will be cut back one-half or two-thirds. This tree will be easily picked and is high enough to work around if desired. See Fig. 4.

SELECTION OF BRANCHES

The same principles apply in choosing branches to graft as in forming the framework of a young tree, except that in the former case one has to make the best of the available material. Choose branches which will make a strong, low headed framework with well spaced branches, and avoiding crotches.

Heavily shaded limbs should not be grafted unless the branches which cause the shading are to be soon removed. The tops of large trees should be grafted first and the lower limbs the second year. (See Figure 3). The practice of grafting a large number of small (1-in.) branches high up in the tree rather than fewer larger and lower branches, is undesirable, although the scions take easily and it is a better financial proposition for the piece worker. The closer to the trunk and the lower grafts can be set without using limbs over three and a half inches in diameter, the lower will be the fruiting wood. Scions grow straight up and will be high enough before bearing without unnecessarily adding to this height. Figures 4 and 5 further explain these points.

Grafting just above a smaller side branch is good practise. This side or "feeder" branch gives shade to the main branch and helps to establish the scions.

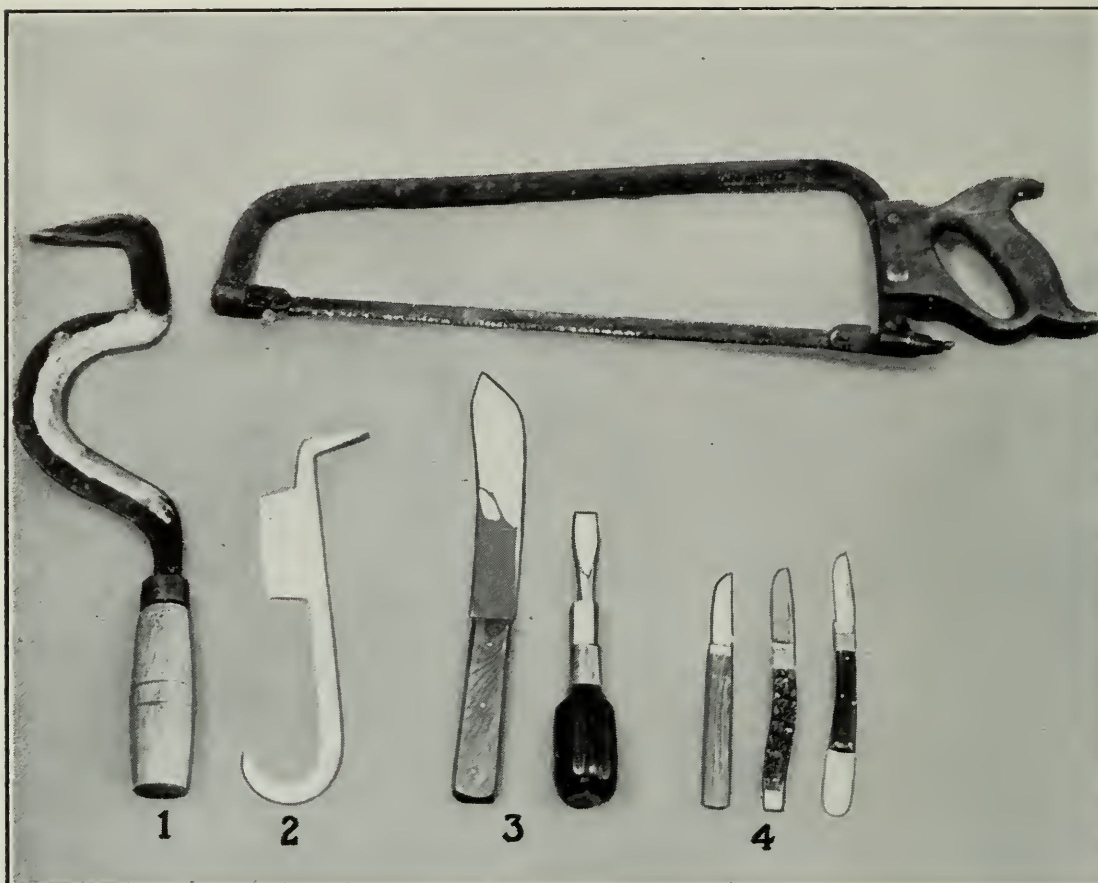

Fig. 6—Grafting and Budding Tools. Top-swivel bladed saw. (1) Home made grafting tool. (2) Factory made tool—too light for practical orchard use but does good work. (3) Good substitutes for grafting tool. (4) Types of budding knives.

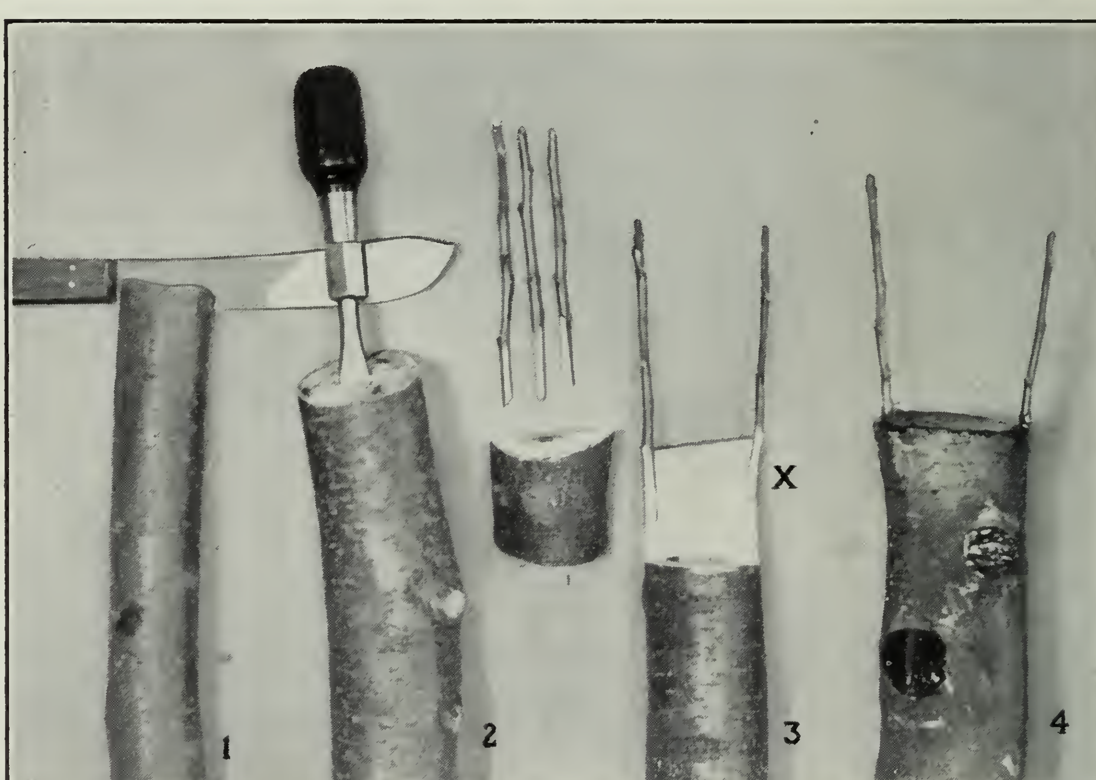

Fig. 7—Cleft Grafting Operations. (3) Cut out to show scions in place. Scion X set too far out.

CLEFT GRAFTING

The various operations and completed graft are shown in Figure 7.

Equipment

1. Knife—Thin bladed, very sharp. If the knife has a thick blade or is dull, it is not possible to cut scions properly.

2. Grafting Tools—A strong butcher knife and a heavy, steel shafted screw driver give excellent service. A regular grafting tool can be made by any blacksmith or purchased. This equipment is illustrated in Figure 6. The grafting tool with a concave cutting edge will not push the bark away from the wood as will a straight edge. If the blade is too thick it will bounce off the stub or split instead of cut. A split stub is much more difficult to fit accurately with the scion. The wedge end, for holding the cut open, is long and thin rather than short and broad. The former is more easily forced into the cut and does not fly out under strain.

3. Saw—A sharp pointed, adjustable-bladed type saves time and temper when working at closes quarters or sharp angles. Dull, or over-set teeth will tear the bark and necessitates smoothing the edges of the stub with a knife.

4. A Mallet, hammer or piece of a fair sized branch for driving the grafting tool, etc.

5. Wax, waxing pot and brush. These are discussed under Grafting Waxes.

Fig. 8—Poor contact by wrongly cut scions. (1) Waved. (2) Thick edge set on inside, leaving outer edge without cambium contact. (3) Too sharply angled wedge.

Cutting Scions

In cutting scions the arms are held rigid, pulling the knife along the scion in one continous movement. The thumb of the knife-holding hand is under the scion. Neither wrists or fingers are used to move the knife. Rocking, whittling or sawing motions result in waved, irregular cuts and an unsatisfactory scion.

The scion for cleft grafting is cut wedge or really, double wedge shaped. Starting below and to the side of a bud, about $1\frac{1}{2}$ inches from the base make a clean cut on both sides of the scion. One side of this wedge should be thicker than the other for the reason shown in Figure 8. Poor fit of scion due to the more common mistakes in cutting are shown in Figure 8. Two views of the completed scion are given in Figure 7. It is advisable to have a bud at the outer, upper point of the wedge as shown in the previous illustration.

Preparing the Stock

The branch to be grafted is cut off clean leaving a stub at least 8″ long free from knots and wounds. If cut at a slight angle it will shed water more easily. Any rough edges are trimmed with a knife.

A cut across the centre about two inches deep is made with the grafting tool or butcher knife. This is held open with screw driver or wedge end

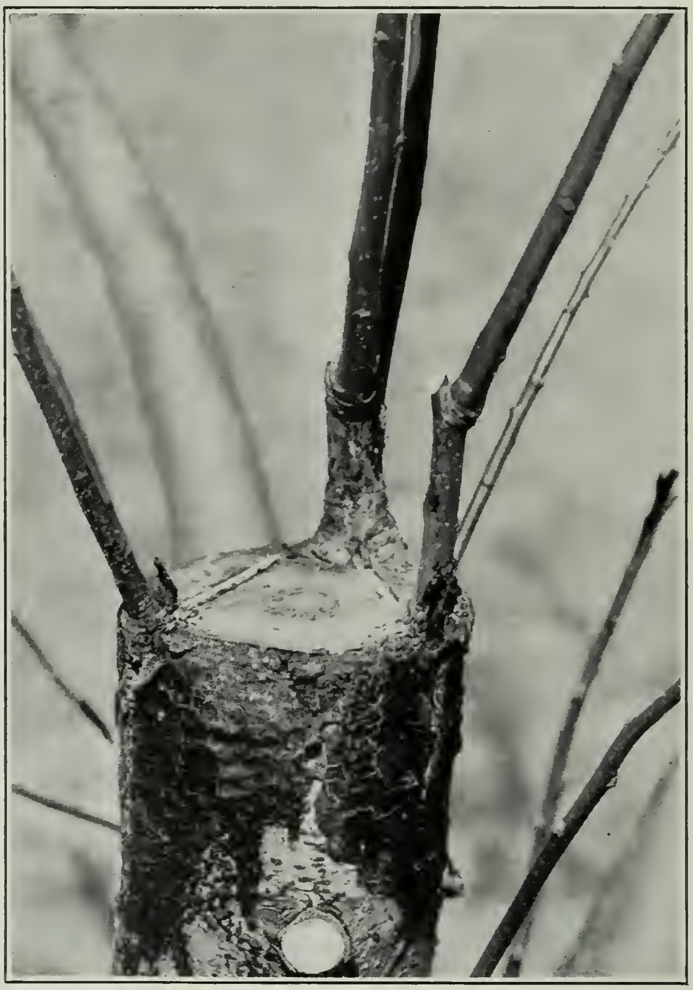

Fig. 9—One way of cleft grafting a large limb. Considerable care is needed in setting scions. Two parallel cuts and four scions can also be used.

of the grafting tool for the "setting" of the scion. A variation in the method of cutting the stock, shown in Figure 9, is adapted to branches over three inches in diameter. There are several variations of this method in use. It is better practice, as a rule, to graft smaller wood.

Fitting Scions

Properly cut scions solve many of the difficulties in setting. The object is to get cambium contact between stocks and scion (See definition of cambium page 2), along as much of the length of the scion bevel as possible.

The bark of the stock is thicker than that of the scion and consequently the outer edge of the scion is never level with that of the stock. In other words the cambium is farther from the surface of the stock than of the scion.

Insert the scion parallel with the stock pushing it down until the top of the cut is level, or nearly so, with the top of the stock. Be sure the cambium layers match. Tilting the top of the scion outward may make a surer contact on at least one point if the scion is cut true, otherwise it will not. There will not be as long a contact of cambium layers as with a properly placed, straight scion. For this and other reasons it is better to take more time and place the scion straight. One scion is fitted on each side of the cleft in the stock.

The wedge is then removed allowing the sides of the stock to spring together and hold the scions in place. Too much spring and danger of

Fig. 10—Bark Grafting. (1) Channel Graft. Note bark, laid back. (2) Ordinary Bark Graft. Less desirable than (1). Scions showing how they are cut, including the shoulder.

crushing the scions is relieved by placing a wooden wedge in the centre of the stock. Branches which are too small to give sufficient spring must be tied. The bark or whip grafts are even better methods for stocks of this size, one inch and less in diameter.

All cut surfaces are waxed, (see under Grafting Wax) including tips of scion, if cut, and down to the extreme end of the cleft in the stock. Brush wax is preferable to hand wax. It is not necessary to fill the cleft with wax. The main object in waxing is to exclude air and organisms causing decay. Air holes are too often left at the point where the scion leaves the stock.

VENEER CROWN-GRAFTING

This is sometimes called the "Channel" graft. It is one of the best of the Bark or Rind types of grafting. The various steps in the process are illustrated in Figure 10. Scions are placed two inches apart. The completed job is waxed as in the Cleft graft.

It has been usual to recommend the bark graft for limbs too large for cleft grafting but it is our experience that such limbs are too large for successful grafting. Channel grafts give a high "take" of scions and excellent growth. However they tend to break away from the stock with a

Fig. 11—Sunscald on exposed main limbs. X dieback where scion failed to grow.

high wind or under a load of fruit, if the strain comes before the top of the stock is well healed. It is essential that all the scions be left on the stock until the top is completely healed over. Unnecessary scions may be twisted around those to be retained, to strengthen them. When it is necessary to use branches too small for cleft grafting or larger than can be conveniently whip grafted the bark or channel graft is ideal. The scions are tied and not tacked on such wood.

AFTER CARE OF TOP-WORKED TREES

Considerable attention is needed for a year or two after grafting if the operation is to result in a healthy, long lived, bearing tree. Rot, broken or weak grafts, imperfect healing or sunscald too often take their toll of grafted trees.

It is mistaken kindness to remove all the suckers from a grafted branch until the scions are large or low enough to shade the trunk and main branches. Heavy sucker growth is an indication of a disturbed food balance in the tree, and can be expected under any conditions of heavy pruning. To consider suckers as sapping the vitality of the tree is, strictly speaking incorrect. Poor growth of scions may be, and is sometimes caused by sucker competition but more often the real cause is poor union of stock and scion. Suckers that interfere with the scion must be removed but enough should be left to shade the tree until scion growth can do so. If this is not done sunscald or Winter killing of the bark on the South and South West sides of the trunk and main branches may result, causing the loss of part or all of the tree. Suckers can easily be kept in bounds by pruning. Figure 11 shows a typical case of such injury. Figure 5 illustrates suckers left on. These did not hinder scion growth.

It is seldom advisable to allow both scions to develop. Sufficient side branches will be formed by one to supply the needed branching. Two from the same stub will crowd, killing out desirable branches on adjacent sides, and forming a weak, easily-broken crotch.

Fig. 12—One scion dwarfed to allow proper development of the one remaining. Upper arrow points to scion development resulting from this treatment. Lower arrow shows scion dwarfed by pruning and to be removed later.

There is sometimes difficulty in healing over the stub in a satisfactory manner. When both scions live, the least desirable can be dwarfed by cutting it back heavily. When the top of the stock is grown over the small scion is removed. Figure 12 shows the relative sizes of the two scions treated in this way.

The side of the stub on which a scion has failed to take will not heal. The most satisfactory way to deal with the situation is shown in Figure 13. Starting close to the living scion with a swivel bladed saw, a sloping cut is made, removing one side of the stub. The bottom of the cut is three inches below the top of the stock. Some prefer this method to that of nursing along one scion until it can be removed.

Water or sap collects under the old wax, giving ideal conditions for decay, or the wax breaks away leaving the wound exposed. Cleaning off the old wax and allowing the wound to dry before putting on a fresh coat is advisable. A great many grafts can be re-waxed, with the brush wax, in a very short time. Better healing actually takes place if the centre of the wound is covered with some wood preservative, as asphalt compounds, and the outer edge, of growing tissue, left unprotected. Just what material is best for this centre protection is a matter for really careful experiment.

PRUNING GRAFTED TREES

The accepted pruning recommendations for young trees are applicable to grafted trees. Heavy pruning has many weaknesses and, in this case, no virtues. Fruiting is delayed, growth is dwarfed, and the cost is greater when heavy pruning is compared to light pruning, and the difference is even greater with no pruning. The scions should be pruned as little as possible previous to bearing, although growth will undoubtedly be upright and vigorous. The tree cannot be made to spread by cutting to certain buds or branches, but will continue, after the check, on its upward way. Too great vigor will correct itself providing there are no abnormal

Fig. 13—Side of stock cut off. Note healing all around wound. Most useful where one scion fails.

conditions of food supply. There is nothing that will spread branches and open out a young tree in as satisfactory a way as a crop of fruit. (See Figure 14.) When this spreading comes after pruning, the tree is too open, leaving spaces which would have been perfectly filled by the branches removed. The most important thing is a crop of fruit and not especially a beautifully shaped tree. Limbs which grow through the centre of the tree or equal size parallel limbs will, of course, need to be removed or reduced. Varieties that do not branch freely may be caused to do so by cutting off part of the new growth of the leaders, although this is seldom necessary with grafted trees.

Figures 15 and 16 illustrate maximum pruning on four-year-old grafts.

Fig. 14—Upright tree spread by moderate crop. Previous to bearing all branches were close to position of centre upright branch. Not nearly as much pruning needed now as before spreading took place.

Fig. 15—Tree 4 years after grafting. Unpruned. See Fig. 16.

WHIP GRAFTING

When small trees are to be worked over, using branches about ½-inch in diameter, the whip or tongue graft is the ideal method. Scion wood is the same as used in other forms of grafting. Details of this graft are illustrated in Figure 17. This same method is used in propagation, one or two-year-old seedling trees or roots of these being the stock.

A sloping cut, one to one and one-half inches in length, is made at the base of the scion and at the point on the stock where the scion is to be attached. Available information indicates the advisability of making the cut on the scion so that the top bud will be in line with the point of cambium contact. More growth and a better "take" should result from

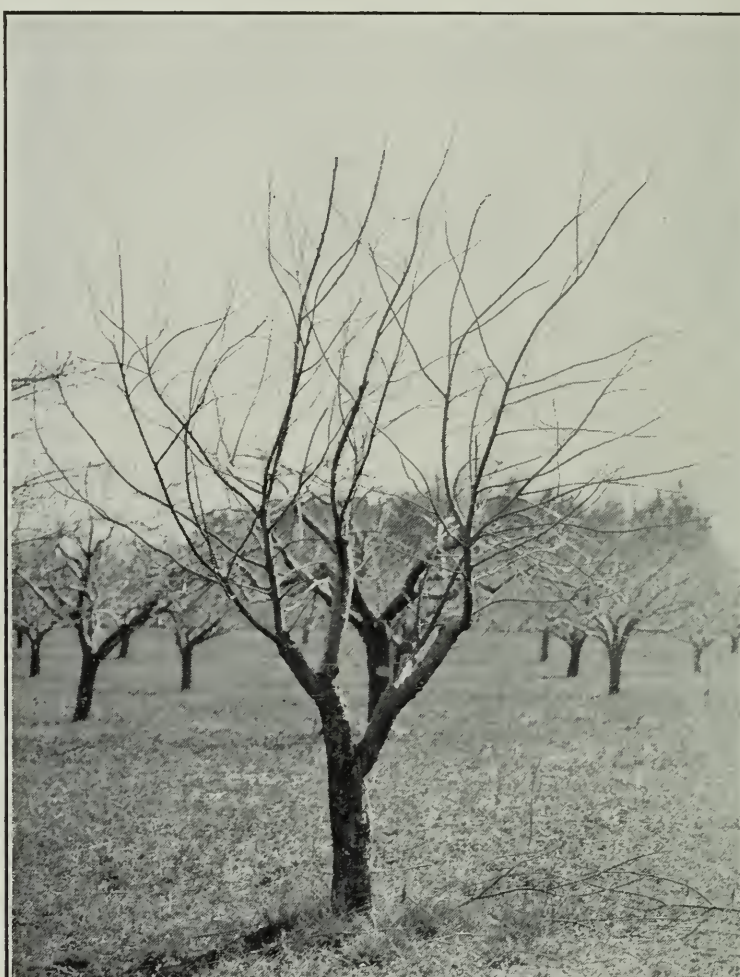

Fig. 16—Tree in Fig. 15 pruned. Pruning might have been lighter.

this extra attention. Two-thirds of the distance from the base of the cut a slit is made in both. Splitting should be avoided by cutting down and in, toward the centre, across the grain of the wood.

Stock and scion are fitted together making sure the cambium layers match on at least one side. Equal sized stock and scion are best, for the cut surfaces will meet on both sides.

Tight-jointed, evenly matched grafts will need only waxing. If it seems necessary the parts may be bound tightly with soft cord before waxing or waxed bandages used. These must be loosened or removed during the summer as growth progresses, to prevent girdling and consequent death or injury to the graft.

BUDDING

Shield budding is an alternative method to whip grafting and useful on the same size of tree. It has the additional advantage, however, of being adapted to the peach and cherry, both of which are difficult to work over in any other way. Figure 18 gives the details of budding. This same method is used in the propagation of an endless number of woody plants. The illustration shows it in use for this purpose and on seedling stock.

The peach is a short-lived, early bearing tree, and replanting is probably better than top working.

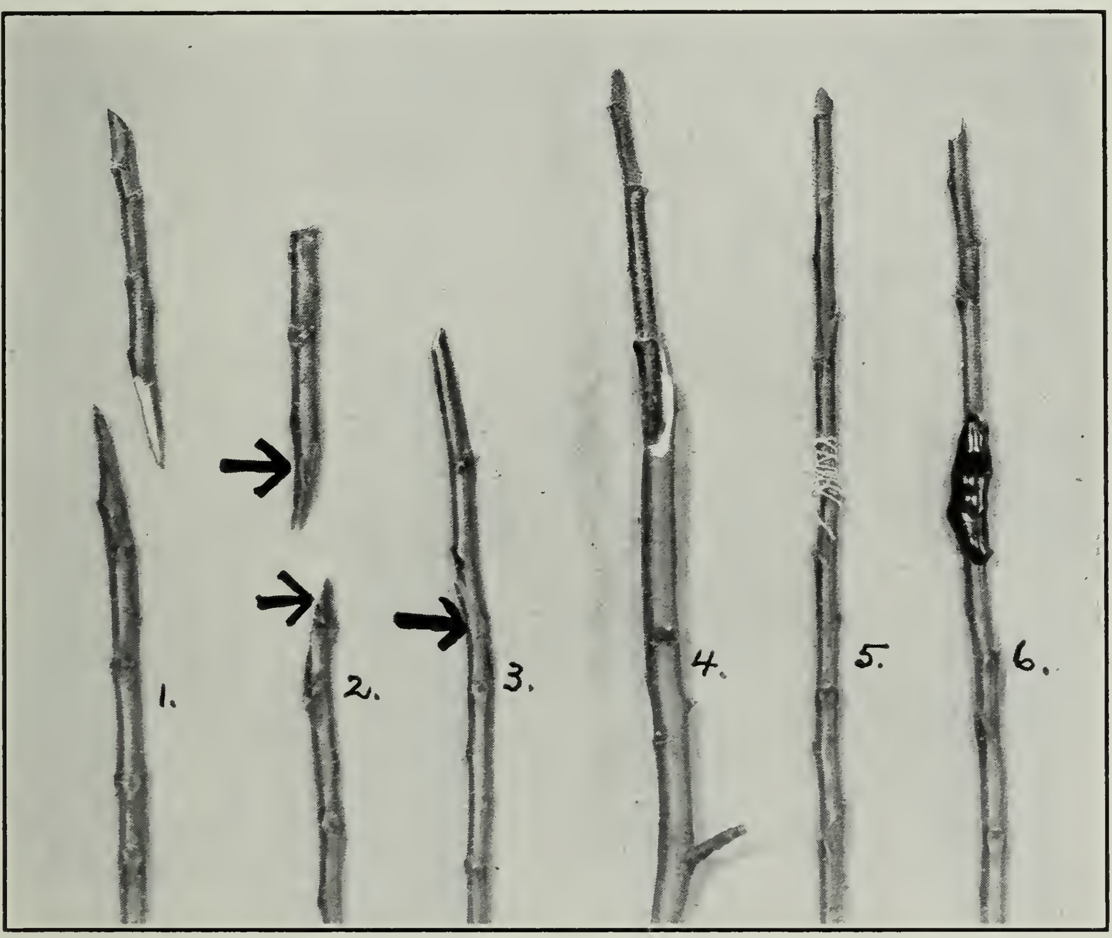

Fig. 17—Various stages in Whip Grafting. (4) Shows place of scion on a larger stock. (2) Stock and scion with second cut. (5) Graft wrapped with waxed cord.

The cherry, especially the sweet varieties, will frequently repay top working for the purpose of introducing pollenizers or to change the variety. Further information on top-working cherries is given from Ontario Bulletin No. 316, "The Cherry in Ontario":—

"It should be clearly understood that the sweet cherry is not easy to top-work, but by the use of methods developed fair results may be secured. Cherries may be converted by budding and grafting, but budding seems to give somewhat better results. This statement is based mainly on results obtained by growers in the Niagara District, and partly on experimental work done at this Station and elsewhere.

"In top-working cherry trees, the method of procedure varies somewhat with the size and condition of the tree. Young trees with branches of ⅓ to 2 inches in diameter, may be topworked by grafting or budding directly on the branches as they are, but older trees with larger branches should first be forced into vigorous condition of new growth. This can be done by a combination of severe pruning, soil cultivation, and the use of nitrogenous fertilizers. In heading back for this purpose cut off from one-third to one-half of the top growth and, if at all possible, cut just beyond and close to a good lateral. Large cuts should be coated over with liquid grafting wax or white paint, to prevent decay.

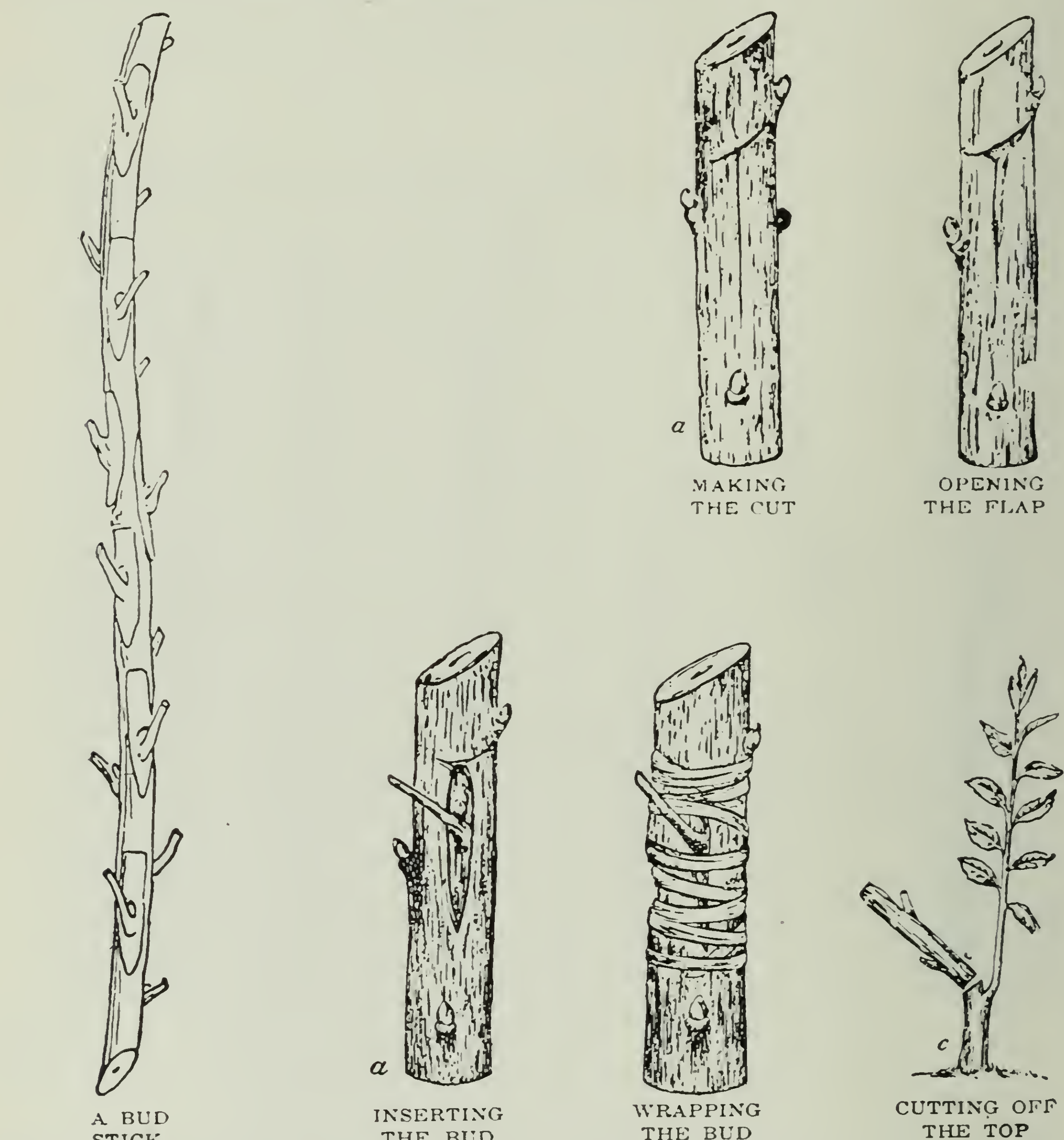

Fig. 18—Budding as used for propagation. The same method is used in Top Working.

"Cultivation of the soil will further stimulate growth by destroying grass or weeds and conserving moisture. In addition to this, an application of nitrate of soda at the rate of 5 to 8 lbs. per tree, according to its size, would likely result in a still more vigorous growth.

"After a vigorous new growth has been obtained the new branches may be budded or grafted by various methods as desired.

"The Shield method is used with success. It has been found that waxed cotton torn into strips of $\frac{1}{4}$ to $\frac{1}{3}$-inch in width makes the best wrapping material. The waxed cotton is applied by starting below the incision and wrapping around the branch slightly lapping the edge of the material at each turn, and continuing upward to a point above the incision. The end of the waxed strip should be slipped under the last turn or held tightly in place with a small tack. After the wrapping has been applied the bud and any other exposed tissue next to the bud should be coated with liquid parafin wax. As a matter of precaution it is advisable to insert three or four times as many buds as are necessary for the formation of a good frame work, so as to allow for casualties.

"In topworking cherries by grafting the usual methods are followed. Regardless of the method used, special care should be taken to tie the scions in position, and also to coat the scions at the lowest point of contact to the tip, with liquid parafin wax. The use of parawax is suggested as a means of preventing desiccation, a factor that is almost fatal in cherry grafts. Some authorities recommend the placing of paper bags over the scions as a preventative of desiccation, but the parawax is less costly and easier to apply."

Equipment

Budding Knife—These come in numerous styles, the main requirements being a thin, very sharp blade with a rounded point. Three types are illustrated in Figure 6, one a rigid, wooden handled knife, the others similar to a pocket knife. Any of the three will give good service, the rigid style, naturally, being much cheaper than the other two.

Raffia—The inner bark of a palm tree, which may be purchased in skeins from any dealer in florists' supplies. This material is cut in pieces a foot or more in length, thoroughly soaked in water and kept moist while in use. Dry raffia is hard and slips readily, so cannot be used to advantage in that condition.

Several other tying materials are being used in an experimental way, the most prominent of which are adhesive tape, similar to that used by surgeons, and rubber strips. The former is not altogether satisfactory in that it is difficult to remove quickly and peels the bark off with it. The latter material seems very promising. It is easy to apply, reasonably cheap, gives satisfactory results, and does not need removing, as its binding power is gone before girdling can take place. For a small job soft twine is satisfactory.

Bud Sticks—Wood of the current season's growth, taken from the desired variety. The leaves are cut off **as soon as the wood is removed from the tree,** leaving a piece of leaf stem to assist in handling the bud. Allowing the leaves to remain on, or the bud sticks to become dry, results in dried out, weakened buds. The bud sticks must be kept damp until the budding is finished, the common method being to keep them rolled in a wet bag.

Strop or Sharpening Stone—The knife needs to be razor sharp. Carrying a stone or a piece of leather fastened on a box, in which the bud sticks and raffia are carried, provides the means of sharpening at all times. A dull knife means slow, rough work.

Cutting Buds

Hold the bud stick across and close to the body, the thumb of the knife hand underneath, to steady it. Start ¼-inch to ½-inch below the bud and cut under and about ½-inch above it. With practice the bud can be removed with one cut, otherwise a cross cut above the bud is necessary to free it. Do not scoop the bud out or remove any more wood or bark than is necessary, to avoid injuring the bud. Hold it by the piece of leaf stem left for the purpose.

Shield Budding Method (Fig. 18.)

The same factors apply in selecting branches for budding as with grafting, although young trees allow of a better selection than older trees.

A "T"-shaped incision is made in the bark, not the wood. Make one cut across the stock a little above where the bud is to go, then, starting about 1-inch below the first cut, draw the knife upward. When the two cuts meet twist the knife both ways and the ends of bark will open, providing the bark is slipping properly.

Press the bud down under the bark, well below the cross cut. If the piece of the bark above the bud protrudes beyond the "T", cut it off to allow the bud to lie flat against the wood of the stock.

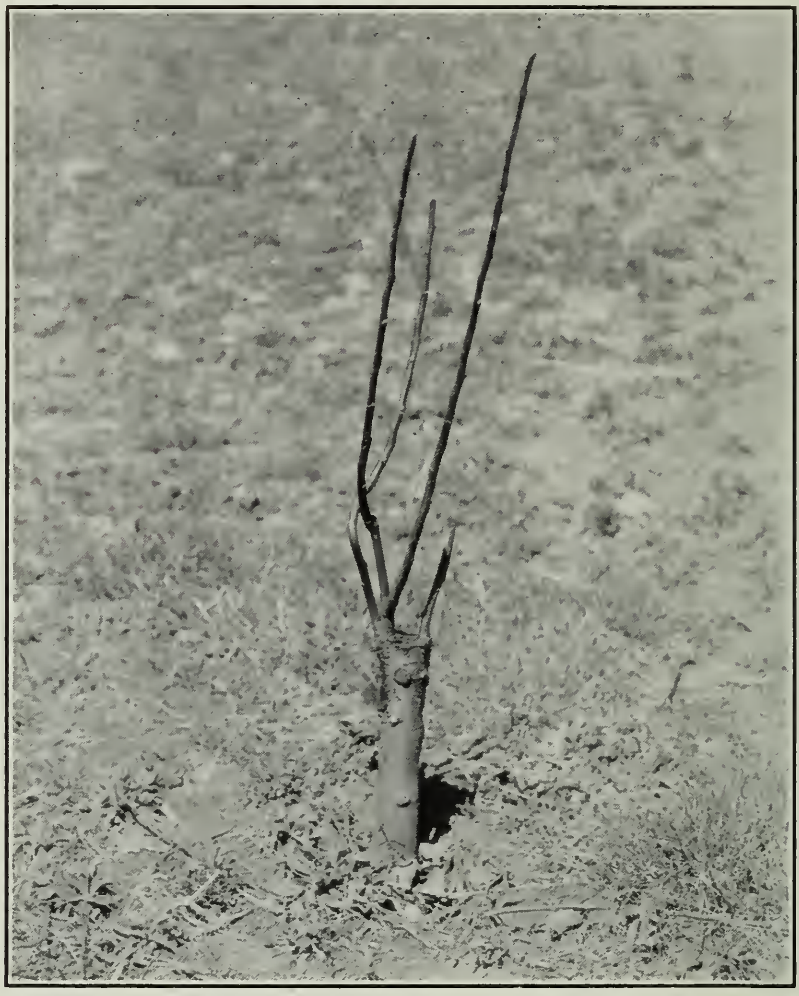

Fig. 19—One method of Top Working a young tree or treating a small tree which has been girdled. Note that right hand scion has been pruned to dwarf. It is left until top of stock is healed.

Commencing at the bottom of the "T" cut, cross wrap, to hold the end of the raffia, and with both hands pass the raffia around and up the stock, finishing above but **not** covering the bud. The top end may be tied or slipped under the last turn and pulled tight. There are many ways of wrapping, but the main objects are speed, to keep the bud in close contact with the stock and to exclude air. Beginners usually wrap too loosely.

After Budding

The raffia is cut in about three weeks by drawing a knife up the side opposite the bud. Girdling will result if the tying material is not removed. The Spring following budding, the stock is cut away just above the bud. Suckers must be rubbed off several times during the season, when they are an inch or so long.

REPAIR GRAFTING

Much of the necessity for repair grafting can be avoided by wire screens or other protection from mice, more careful handling of tillage implements, and bracing of trees so that large limbs are not torn or broken off. The fact remains that such preventative measures are rarely taken in time or are not thoroughly carried out.

Many growers think of bridge grafting only in relation to mouse girdling, or crown (collar) rot. There would be fewer dead or dying trees if more attention was paid to areas killed by fire blight, trunk wounds, or wounds caused by the removal of large branches. The time occupied by this grafting may be considerable, but it is insignificant when compared to the value of the tree saved or rejuvenated. Rubbing dirt on wounds only reduces any chance there may be of natural healing. Where only the bark is damaged the remaining cambium may repair the damage, if it is left alone.

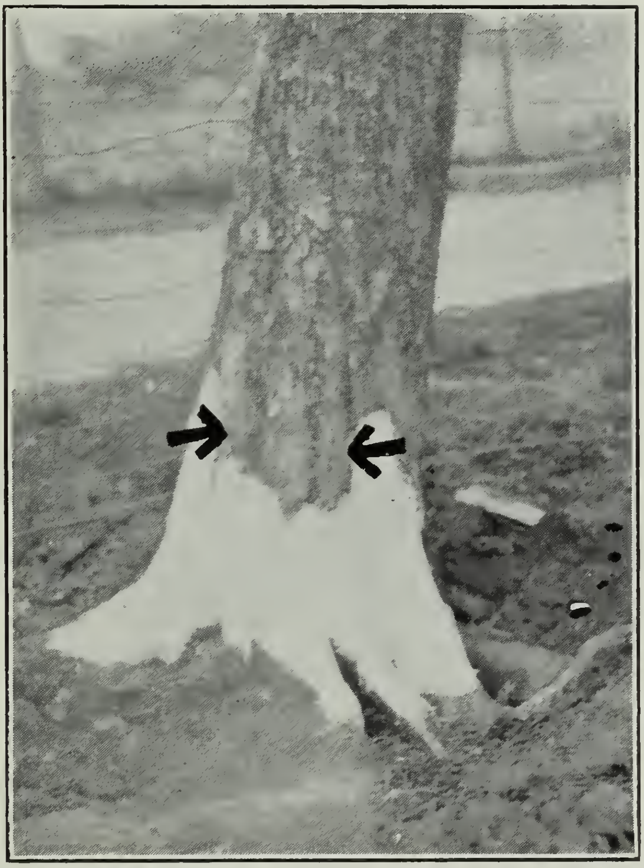

Fig. 20—Apple Tree ready for bridge grafting. Part indicated by arrows will be cut back level with the rest of the wound.

(Courtesy E. Renouf)

A careful survey of the orchard should be made each Spring, followed by preparation for the necessary repair grafting. The range of time over which this grafting may be done has been previously explained.

Girdled trees up to three or four years of age are better handled by cleft grafting below the injury than by bridge grafting. (See Figure 19.)

The equipment required for bridge grafting is a sharp knife, liquid wax, container and brush, hammer, small nails (basket nails) and a 3/16-inch to ¼-inch screw driver.

Preparation of Stock

One of the chief causes of failure in bridge grafting is the lack of vitality of the cambium of the stock. The bark where the scion is to be inserted should not be dry and granular in appearance but fine textured and moist. The area between bark and wood should be clear, and bright in colour. Although scions may take in weak cambium they will die or break out in a short time.

The injured area is cleared of dirt and the edges cut back to sound, healthy tissue. Any exposed wood is thoroughly coated with asphaltum or other paint to prevent decay. This can be done much better before grafting than when the scions are in place. Liquid grafting wax is good but

Fig. 21—Methods of Bridge Grafting and Scions. Ordinary and varied Bark Method. (1) Channel. (2) and (3) Bark. (1) is preferable. Note gradual slope of the cut on scions X.

on a large job is more expensive. Small trees, on which the wood will crack, are painted as soon as the injury is noticed. Figure 20 shows a tree ready for grafting.

Preparing and Fitting Scions

Scion wood is the same as used for cleft grafting. Suckers provide the greatest length of straight clear wood, and so are preferable. The variety from which they are taken is of no importance as long as it is hardy.

Allowance must be made in the length of scion so that when both ends are attached a slight "bow" is formed. This makes for better contact and lessens danger of the scions breaking out, especially when small trees sway with the wind.

The number of scions required depends on the area to be bridged. They are usually put 2 inches apart.

Figure 21 shows scions and several methods of making the graft as described hereafter. The channel method is preferable.

Make a bevel cut from 1-inch to 1½-inch long on the same side, at each end, of the scion. Cut a channel in the bark of the stock, both above and below the wound, that will fit the scion as exactly as possible and at least as long as the cut on the scion. Lift up the flap of bark with the screw driver or knife and lay in the scion. Fasten the scion down, with or

Fig. 22—One year after Bridge Grafting. Note length of right hand scion. White cloth used to bring out details of scion in picture.

without the bark on top, using one or two brads or small nails. If the bark is not slipping perfectly, care is required to remove any of the bark adhering to the wood, which will prevent the cambium layers of stock and scion from meeting. Scraping should be very carefully done or the cambium as well as bark will be removed. In cases where the bark does not slip easily it is advisable, if possible, to postpone the work until it does.

Any cut surfaces are waxed, preferably with liquid grafting wax. The point most often neglected is underneath the scion, where it first meets the stock.

Figures 22 and 23 show bridge grafting on a mature tree, where the lower end of the scion is grafted to the roots.

Use of Suckers and Nursery Trees

The tops of sufficiently long suckers coming from the base of the tree may be grafted in and prove ideal for the purpose.

One-year-old whips or slightly larger trees provide a means of saving mature trees when a considerable area of the roots are killed. With such cases it is difficult or impossible to find healthy tissue in which to attach the lower end of the scion. The one or two-year-old tree or trees (nursery stock) are planted close to the injured tree and the top branch or branches are grafted in as with the suckers and ordinary bridge grafting. Figure 24 illustrates suckers used in bridging.

After Care

Growth coming from the scion is best left one or two years, because the scion will grow much faster and function better than if this is removed. Any failures can be replaced the year following.

Fig. 23—Bridge Grafting into roots. Note position of scion.

GRAFTING WAXES

There are two main formulae used for making grafting wax in Ontario. These meet at present the needs of the commercial worker and until some now unknown compound is devised, will continue to do so. The quantities of the ingredients may be varied slightly without materially affecting the quality of the product. All grafting waxes are inflammable when melted and should be handled with care. Do not hurry the making with excessive heat.

Hand Wax

This wax is worked and softened by the heat of the hands when used. It was for years the only wax used, but is now losing in popularity because the cost per pound is more, a larger quantity is used per graft, and the time required to use it is greater than with brush wax. For the purpose intended it is perfectly satisfactory.

The standard formulae is: resin, 4 lbs.; beeswax, 2 lbs.; tallow, 1 lb. Additional resin makes a harder wax. For use in cold weather or to make a softer wax, increase the tallow or substitute part of it with linseed oil.

Melt the resin and add the beeswax; when both are melted, put in the tallow and allow the mixture to simmer for a few minutes, stirring well. Pour into cold water and when it has cooled enough to handle, grease the hands with lard or tallow and work the wax like taffy until it is a light yellow colour. Wrap in one-pound balls in wax paper until needed. The time required in making is shortened if the resin is crushed and the beeswax and tallow cut in small pieces before heating.

When a graft is ready to wax, grease the hands and work the wax until it is plastic and easily spread with the hands. If the weather is cold, keep the wax in a pail of warm water.

Fig. 24—Suckers used in Bridge Grafting. (Inarching.)

Brush or Liquid Wax

The brush or liquid wax formulae consists of 5 lbs. resin, 1 lb. beeswax, ½ pt. linseed oil, and ¼ to ½ lb. lampblack or powdered charcoal. The first two materials are melted together, adding the oil last. This mixture is more inflammable than the hand wax but perfectly safe if reasonable precautions are used. When all the ingredients are melted add the lampblack, stir thoroughly, and allow to simmer for a few minutes. Pour an inch or so deep in shallow pans and allow it to harden. A few blows will loosen it from the pans, and the wax can be broken into lumps for future use. If the wax is brittle, breaking away in clean flakes when chipped with a knife, it is too hard and should be re-melted and oil added.

This material is used hot with a brush, one to one and one-half inches in width. A cheap brush is just as good as an expensive one and will last as long. Boiling wax will kill the tissues and some care must be exercised to avoid too hot applications.

Wax Pots and Heaters

The devising of heating and carrying apparatus allows for much ingenuity on the part of the operator. A one or two quart pail is a good container for the wax. Either are easily handled under all conditions and hold enough wax to last for a considerable time, while the bulk of wax prevents too quick cooling. A small flat two-burner kerosene stove in a cut-down barrel or suitable box makes a very satisfactory and cheap heating unit. We have found this stove in a box high enough to cover the stove and to the top of the wax pail an ideal outfit. Although somewhat cumbersome, it works well under orchard conditions. If two pails are kept on hand one is heating while the other is in use, giving a constant supply of hot wax. A small box built for the purpose is less awkward than trying to adopt some available fruit package. A nail in the brush handle to allow hanging on the side of the pail and keep it off the bottom, will prolong its life.

Fig. 25—Wax Heaters. Left—cheap, efficient equipment to be carried in a box. Right—Merribrooke Melter.

The patent types of heaters, such as are used for parawax, contain too little wax for practical purposes and cool very quickly on a cold day. Figure 24 illustrates both heaters.

Parawax

Parawax or compounds with this material as a base have not proven equal to the two types of wax previously mentioned. Ordinary parawax cracks and breaks off in cool weather. On warm days they are all inclined to run, leaving the grafts with insufficient protection. In order to get a sufficiently heavy coating many light applications are necessary, which takes too much time. These waxes melt quickly, however, and are easy to use.

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Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

GUELPH, CANADA

THE EUROPEAN CORN BORER

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The province of Ontario like many other parts of North America has suffered severely from the introduction of insect pests from Europe and Asia, as for example, the codling moth, the San José scale and the cabbage maggot, but probably never has any insect been introduced more capable of doing harm than the European corn borer (*Pyrausta nubilalis* Hübn.).

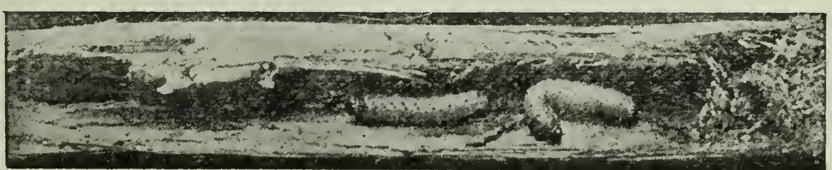


Fig. 1.—Full grown borers and their work in a corn stalk, slightly reduced; the borers, if natural size, would be about one inch long. (G. J. Spencer).

Brief Description

The borer (Fig. 1) is a whitish caterpillar with a brownish or often a pinkish tinge. It is about one inch long when full-grown, has a brown head and many small brown spots over its body. The young borers, even when very small, resemble closely the full-grown but are often, when about one-half inch or a little more in length, a good deal darker.

Stages in the Life Cycle

Like most insects the corn borer in the course of its life-cycle passes through four stages—the adult or moth, the egg, the larva or borer, and the pupa. The moths lay the eggs from which the larvae come; the mature larvae transform into pupae; and the pupae into the moths, thus completing the cycle.

Origin

There is no definite knowledge of how the insect was introduced into Ontario or even into the United States, but there is a good reason to believe that it was brought into both countries in broom corn imported from Europe. A shipment in 1909 or 1910 from Mid-Europe to a broom factory at St. Thomas was probably the means by which it first reached this province.

Present Distribution

The borer was first discovered in Ontario in the year 1920. By that date it had not only become very numerous in the territory between St. Thomas and Lake Erie but also had spread out thinly all over Elgin county and a considerable part of all adjoining counties. There were also isolated infested localities in Welland and Huron counties. Since then the insect has continued to spread at a rapid rate—sometimes more than 50 miles a year—and is now (autumn, 1930) in practically every part of Ontario where corn is grown, though most of the province is still comparatively lightly infested.

Outside of Ontario the borer has spread throughout most of Quebec and a large part of New Brunswick and Nova Scotia.

In the United States the spread has been about as rapid as in Canada and the borer is now present throughout every state along the great lakes and the St. Lawrence river, and from there east to the Atlantic ocean. It is also in every state along the Atlantic down to New Jersey. Most of the great central corn belt area is still free but the borer has entered Indiana and in a few years will doubtless be distributed generally throughout the whole of the corn belt; in fact, there seems no doubt, judging from its distribution in Europe and Asia, that it will be found ultimately in every part of North America where corn can be grown. There is little doubt, however, that it will not be equally troublesome in all parts of the continent.

Host Plants

In Ontario the only plants, so far as known, on which the insect lays its eggs freely, and the larvae mature, are corn of all kinds and sorghum. Sorghum, however, is not nearly so heavily infested as corn, apparently because on account of its hard surface a very small percentage of the young borers are able to work their way through this and find safe quarters.

Eggs are laid also to some extent upon hemp, oats, barley, gladioli, dahlias, zinnias, thorn apples, sugar beets and beans. Hemp is grown to a very slight extent in Ontario. It is occasionally somewhat heavily infested but not nearly to the same extent as corn. In the case of oats and barley the plants ripen before the borers mature and so the latter perish with the exception of a few which may happen in their wandering about to enter stout weeds around the borders of the field. On gladioli, dahlias and the other plants mentioned the number of borers which reach maturity is so small as to be almost insignificant.

In Europe, the common mugwort (*Artemisia vulgaris* L.), a weed closely related to ragweed, is said by a French entomologist to be a favorite host, but experiments, both in Canada and the United States have shown that this weed in these two countries has very little attraction for the moths and eggs are rarely laid on it.

The indications are therefore, that so long as there is corn nearby the insect will not breed to any extent on any other plants except sorghum and possibly hemp. What would happen if there were no corn is not known but the probability is that, if corn growing were abandoned in any individual county, the moths would almost all fly to neighbouring counties where corn was still to be found and oviposit upon it.

Weeds and the Borer

Many persons on reading what has just been said will reply, "This cannot be correct, because we have found the borers in many kinds of weeds and so they must breed in weeds too." It is true that the corn borer, especially in heavily infested areas, may be found readily in ragweed, pigweed, barnyard grass and almost any stout weed either among the corn or not farther away than a few feet. *Weeds in other crops or growing along roadsides or in waste lands are either entirely uninfested, or so nearly so that no attention need be paid to them.* Hence it is the presence of the corn that causes the weeds in or close to it to become infested. Even then the eggs are rarely laid upon the weeds themselves; for nearly all the borers found in weeds came originally from the corn. A large number of the borers, especially when full grown, desert the corn plants upon which they have been feeding and after wandering around a while enter either another corn plant or almost any stout weed they meet, and often remain in it over winter. This, then, is the chief way in which the weeds in the corn field become infested, though when a weed is close to a corn plant the moths will occasionally lay eggs upon it.

Fig. 2.—Borers and their work in stubble, about two-thirds natural size. Some of this work is at times below the ground. (G. J. Spencer).

Other Kinds of Borers in Weeds

A great deal of the mistaken belief that the corn borer breeds freely in weeds, no matter where these may be, is due to the failure to realize that there are several other borers besides the corn borrer and that some of these breed freely in weeds. For instance, there is one species which breeds in goldenglow, another in columbine, another in iris, another in wild carrot and parsnips and another in smartweed. Then there are still other borers, some of which attack a dozen or more kinds of weeds or other plants; for example, one called the stalkborer attacks almost any kind of stout plant, whether a weed or not. Most of these borers can be distinguished readily from the corn borer if the two are compared side by side; others are so like it that only a specialist can distinguish between them. It is natural, therefore, for anyone not accustomed to observe insects carefully to suppose when he finds a borer in a weed, that it is a corn borer.

The Corn Earworm vs. the Corn Borer

The corn ear-worn (Fig. 3) is an old enemy of corn, which many persons confuse with the European corn borer. Most years it is not numerous enough to attract attention, but occasionally it becomes very abundant and then causes much injury to the ears, especially towards the end of the season. It can be distinguished from the corn borer in the following ways:—(1) It limits its attack almost exclusively to the upper portion of the ears where it feeds upon the kernels, and unlike the corn borer rarely bores into the cob or stem. (2) It is a much larger caterpillar, being when full grown almost two inches long, while the corn borer is only one inch. (3) The colour is different from the corn borer: most ear-worms are strongly marked with brown or black; a few are greenish or even pinkish, but scarcely any have the whitish or brownish-white nearly uniform colour of the corn borer. (4) The corn borer has many small brown spots over the back which are easily seen by a hand lens; the ear-worm has not.

Fig. 3.—Corn earworm and its work, natural size. Compare with Fig. 1.

Nature and Extent of the Injury

The corn borer attacks almost every part of the corn plant,—leaf, tassel, ear, stalk and even the thick part of the root below the ground.

The Leaves are slightly injured by the young borers, which soon after hatching, eat small holes in them, but the chief injury to them is brought about by the larvae tunnelling in the midribs, especially where these join the stem. This often causes the leaves to break over, dry out, die, and in some cases fall to the ground.

The Tassels are a favorite breeding place for the young larvae and are often, soon after expanding, so weakened by the tunnels made in them that they fall over or break off (See Figs. 4 and 6.).

The Ears, especially in sweet corn, are very commonly attacked, the borers entering them from either end or through the husks. Once inside they feed upon the kernels and eat out small or large areas, thus making sweet corn unfit for table use and lessening the yield of husking corn. (See Fig. 5.). Often rain and disease organisms enter through the borer holes and produce rots or moulds, which may destroy even more of the grain than the borers. But the worst injury to the ears is not caused by the kernels being eaten nor by disease but by the borers attacking the ear-shank or the main stem and thus in many cases cutting off all or nearly all of the supply of food with the result that the ears fail to fill, and so become stunted and shrivelled and of little or no value. Moreover, the feeding of the borers in the shank often causes the ears to fall over and even to break off and drop to the ground.

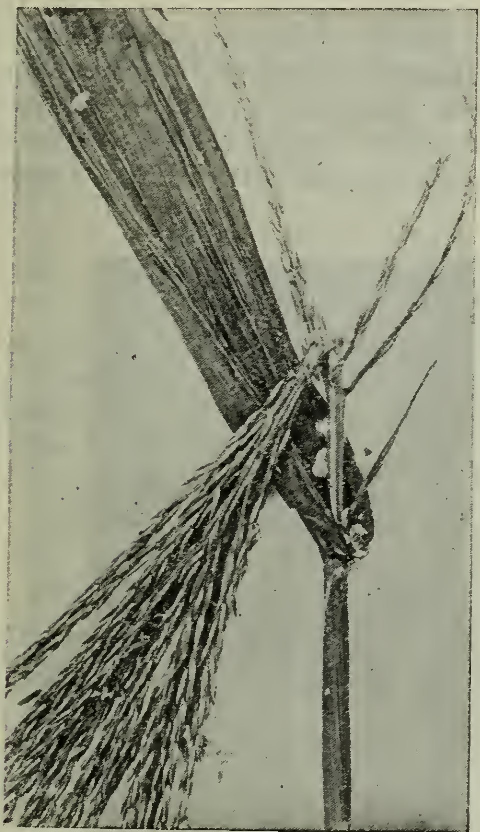


Fig. 4.—Tassel broken over by young larvae. Observe the whitish castings at the break and also in the axil of the leaf.

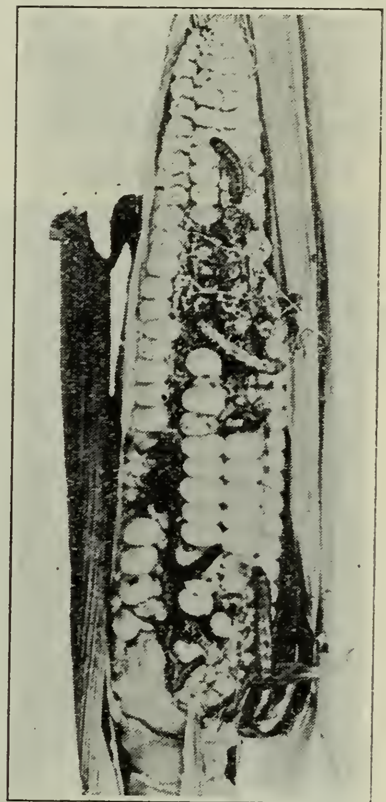


Fig. 5.—Work of borers in corn ear, much reduced. (G. J. Spencer).

The Stalks are nearly always the part where most borers are found. If the infestation is heavy, so many may enter a single stalk that all the interior will be devoured or so riddled with burrows and filthy with castings and with rot as to be utterly worthless as food for cattle. (See Figs. 1 and 2). Infested stalks are weakened at the point of attack and many of them break over with the wind; in fact, if they are heavily infested, they may break in several places.

Injury Not Always Conspicuous

Many persons on learning that borers can be found readily in any part of their corn field are surprised that the corn does not seem to have been much damaged. The fact is that in the case of ensilage corn very little damage, as a rule, will be observed until over 50 per cent. of the plants are attacked, but once that figure has been passed the damage increases rapidly until the whole crop may be totally ruined. Sweet corn, however, may become unprofitable even when less than 50 per cent. of the plants are attacked, because usually a larger percentage of borers work in the ears of sweet corn and, if even 5 per cent. of these are infested, people will not buy the corn. The work of examining the ears and removing those that are infested takes too much time in most cases to make it profitable.

Description of a Severely Infested Corn Field

By the middle of September all, or nearly all, the borers are full-grown and have finished feeding. By this date a severely infested field, such as was common in Essex and Kent in the fall of 1926 just before the Corn Borer Act came into force, is a sickening sight. Such fields often have an average of from 20 to 50 borers per plant. The result is that almost every tassel has broken off and fallen to the ground; most of the ears have broken down and hang close to the stalk, while those still upright are dwarfed and worthless in appearance; nearly all the leaves have collapsed at the stalks and hang limply along their sides; the stalks themselves are riddled with borer holes, filthy with masses of the insects' castings, and stand up like small, brown, dead poles of nearly uniform height; in fact the sight of such a corn field reminds the writers of a once beautiful spruce forest which has been swept over by fire and left a mere skeleton of its former self.

Fig. 6.—Corn field severely broken down and ruined by the borers. (H. G. Crawford).

Rate of Increase of the Borers in Essex and Kent Counties

No part of the Province has suffered so severely as the two great husking corn counties—Essex and Kent. In 1921 there were only a few borers scattered here and there along the southern part of these two counties. In 1922 they were present in every township in both counties, but the majority of the fields were still free. In 1923 they could be found in almost every field, but as yet there was no noticeable damage. In 1924 a few fields had as high as 80% stalk infestation. In 1925 in a large area about the centre of the two counties several score of fields of corn were totally ruined, and the borers had also increased greatly all over the rest of the counties. In 1926, the year before the Corn Borer Act, the average stalk infestation for Essex was 83% and for Kent 78.7% and in an area equivalent to 60 miles long by 20 miles wide, practically every corn field was totally ruined, some fields having over 50 borers on an average per stalk. Perhaps nothing shows more clearly how serious the injury that year was than the fact that the next spring the acreage planted to corn in Essex dropped to one-quarter of what it had been when the borer entered the county; namely, from 81,256 acres to 20,214 acres. In Kent too there was a similar drop. Everyone except a few optimists now felt that the corn industry in these two counties was probably doomed and that it was not wise to plant more than just a few acres per farm on the chance that something might turn up to destroy the borers.

Cause of the More Rapid Increase in Essex and Kent Than in the Rest of the Province

Up to the fall of 1926 when clean-up of corn remnants was made compulsory, the rate of increase in the infested counties varied greatly. Counties which grew corn solely for fodder had a much slower rate of increase than counties which grew corn almost solely for husking. The explanation of the difference in the rate of increase was largely as follows: In counties where corn was grown for fodder the regular practice was, with rare exceptions, to cut the corn low—usually about 6 inches high—and either ensile it or feed it whole. Then the stubble was ploughed under before the next crop was sown. These two operations destroyed the great majority of the borers and so retarded greatly the rate of increase. On the other hand in the counties where corn was grown for husking a common practice was to leave the stalks on the surface of the field over winter without doing any fall or spring ploughing and in the spring merely to disc and cultivate the field thoroughly and sow it to grain. This practice afforded ideal conditions for the borers to survive, for very few of them were killed either by winter or by the cultivation of the soil.

LIFE HISTORY

Method of Wintering

The corn borer passes the winter as a mature larva in any part of the corn plant where it has fed or hidden after ceasing to feed, and also in coarse weeds in or alongside the corn field. Hence if the corn is all left in the fields, as sometimes it is, the borers will all be there too. If, however, it is cut and the stalks are hauled away, any borers in these will also be taken with them and will remain in them unless killed by being put into the silo, fed to cattle, shredded, burned, or buried deeply in manure. The remainder of the borers will be left in the field in the stubble—sometimes as low as the tap root goes—and in the other corn remnants and weeds. (See Figs. 1 and 2).

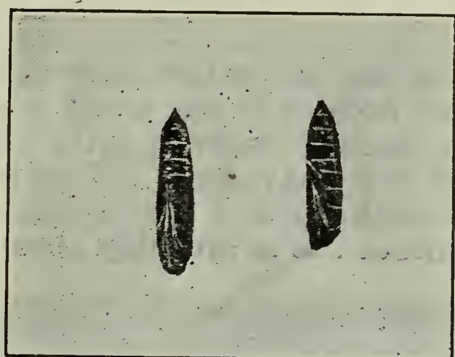


Fig. 7.—Pupae, natural size.

Pupae

Late in May or in early June the borers, wherever they happen to be, begin to change into pupae. The pupae are brown, about two-thirds of an inch long and cigar or shuttle-shaped. (See Fig. 7). Some larvae pupate much later than others but practically all will have done so in a normal season by about the end of June. The pupal stage lasts about two weeks and then the moths begin to emerge.

Adults

The earliest moths in Essex and Kent usually begin to appear about the middle of June and in the other counties one to two weeks later. Moths continue to emerge for a month or more but under normal conditions they have all or almost all appeared by the end of July. A cold, backward season, of course, tends to delay both pupation and the emergence of moths.

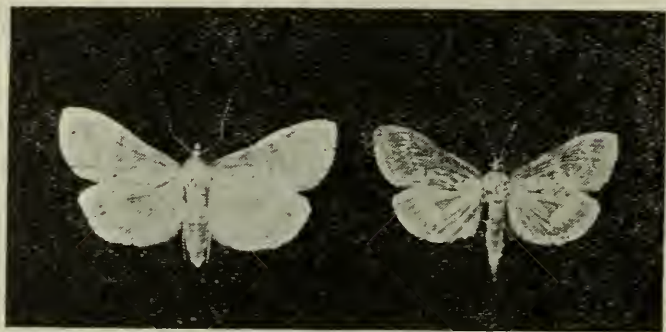


Fig. 8.—Corn borer moths—female on left, male on right, natural size. (J. Marshall).

The moths are of the size and shape shown in Fig. 8, the females being a little larger and lighter colored than the males. Very few people ever see the moths, as they do not fly by day. Even if they did see them, they could not be sure they were corn borer moths, as there are several other common species of about the same size and color. The females vary in color but are generally cream-colored or a very light yellow with brownish markings on the wings. The males are darker, being a light brown with creamy markings on the wings.

During the daytime the moths hide among the corn plants or other dense vegetation nearby and late in the evening and at night come out to feed, mate and lay eggs. The only food they seem to require is water, and this they get from rain or dew. They can fly for long distances and have been known to travel in this way at least twenty miles, though probably most of them do not go more than one or two miles and some not that far. They have a wonderful instinct to spread out and not concentrate in one place; hence, when a locality is even lightly attacked, the infestation will usually be nearly uniform in all the fields, if the corn in these has been planted about the same time.

It is not known how long the moths live under natural conditions. The length of time is influenced greatly by the weather and depends to a great extent upon whether they can get water to drink; for without it they die in about three days. Both sexes have been kept alive in cages for a month or more but observations on the rate of egg-laying in the field would indicate that the average length of life is probably about ten days.

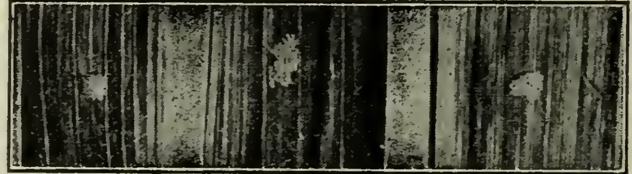


Fig. 9.—Three clusters of eggs, each on a piece of corn leaf, about natural size.

Eggs

Egg-laying begins in from 2 to 9 days after the moths have emerged. The eggs are white but before hatching turn nearly black. They are circular, flat and are laid in small clusters of from 3 to 100 or more. (See Fig. 9). The average number in a cluster is about 16. The total number of eggs laid by a female is not known but probably averages about 350. In cages the average is about 500. Nearly all the eggs are placed on the underside of the corn leaves near the midrib, where they are protected from the direct rays of the sun. They are nearly all fertile and hatch in 3 to 9 days, the average being 5 days. The time required depends chiefly upon the temperature.

Larvae

The larvae on hatching are very small, only about one-sixteenth of an inch long. They usually feed at first upon the leaves, eating small holes here and there in them, and then work their way down to the main plant and there do the injury described above. In an ordinary season many of those which hatched early will be mature before or by the end of August, and the rest early in September, but if the season is cool and backward, some will not be full-grown until the end of September. They mature earliest in the warmest parts of the province, as in Essex and Kent.

Number of Generations a Year

In Ontario we may say that there is only one generation a year for, even though a small second generation does sometimes occur in a long warm season this is so small—much less than one per cent.—that it may safely be considered negligible. Along the Atlantic coast of the United States there is most years a large percentage of a second generation and this plays a very important part. In the two-generation areas the moths act somewhat differently from what they do in Ontario and other single-generation places, in that they lay eggs upon a much greater variety of plants. This is true especially of the second generation moths, but also to a considerable extent of those of the first generation. The result is that in two-generation areas control measures are more complicated than they are in Ontario.

Natural Control

The most striking way in which nature helps us in control is by the destruction of a large number of the very young larvae before they are able to work their way into the corn plant and find shelter. Every year from 70 to 90 per cent. or more of these perish. All the causes of their destruction are not known, but some are destroyed apparently by excessive evaporation of their body moisture, due to hot, dry weather, while others are knocked off the plants by high winds or washed off by rains and perish either because of the heat of the ground or their inability to find a plant which they may enter and feed upon. In the very hot, dry season of 1930 as high as 95 per cent. of the larvae in several of the drier counties perished, apparently because of the drought and heat combined.

In addition to the great mortality of the young larvae just mentioned a considerable number of those left are later destroyed either in the larval or other stages by ants, ground beetles, ladybird beetles, birds, especially woodpeckers and crows—and by unfavourable winter conditions. Winter, however, does not kill more on an average than 4 or 5 per cent. Very dry weather lessens the length of the life of the moths and cold weather prevents them from laying eggs; so that these two factors also help to hold the insect in check.

Importation and Rearing of Parasites

Since the corn borer is an imported insect and since its native enemies in Europe and Asia have not been imported with it, many people think that the simplest and most satisfactory way of combating it would be to introduce these parasites into Ontario, breed them in large numbers and then free them in the infested areas. A good deal of this work has been done by the United States Bureau of Entomology, and by the Dominion Entomological Branch. A number of parasites have become established but up to the present these have had very little effect in keeping the insect in check.

New parasites are being introduced each year and the probability is that after a number of years parasitism will begin to be a considerable factor. We should not, however, expect that parasites alone will control the borers, for they have not done so either in Europe or Asia.

Importing Borer Diseases

A number of diseases which attack the insect in Europe have been introduced into the United States in the hope that cultures might be made of these and used to distribute the organism among the borers in the field. The work is still in progress and it is too early yet to draw any conclusions as to its value, except to remind the reader that, so far as we know, diseases have not in Europe or elsewhere played any important part.

CONTROL MEASURES

By far the simplest, most practical, and economical method yet discovered of controlling the corn borer is to kill the larvae either in fall or spring while they are still in the corn plants or their remnants, including the stubble, or in the weeds which have grown up among the corn in the field. This can be done by ensiling or feeding or burning all the corn stalks or pieces of stalks or cobs and by ploughing under completely all the stubble or other corn remnants or coarse weeds among the corn and not dragging any of these up again when cultivating the soil or sowing the next crop, or, if they are dragged up, by picking off and burning those that have come to the surface. All such measures must of course be completed before there is time for the borers to have changed into pupae and these in turn into moths, which would lay eggs on the new corn plants.

There is one condition when ploughing is not absolutely essential for control; namely, when the corn has been cut level with the ground and all the stalks, corn refuse and weeds removed and ensiled or otherwise treated to destroy the borers in them. If this is done thoroughly almost all the borers in the field will be killed and ploughing therefore not be necessary. There is, however, one exception to this; namely those fields which were very heavily infested. In these a large number of borers often will be down below the ground and so be left there when the plants are removed. Such fields should always be ploughed in the interest both of the grower himself and of the community.

We shall now discuss in detail the different steps in the above method of control which is usually called the clean-up method. It must, of course, be kept in mind that this method will be a success only if every corn grower does his part. This is why it was found necessary to pass the Corn Borer Act and put it into force in all heavily infested counties. This Act makes it compulsory for every person, no matter how small a plot of corn he or she may have, to destroy all remnants of it before May 20th each year.

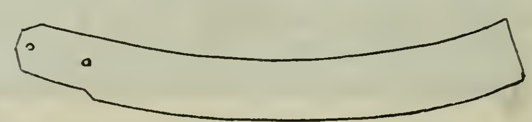


Fig. 10.—New low-cutting stationary knife for corn binder. Length of blade 28 inches, width 3¼ inches.

(1) Cutting the Corn. Corn should always be cut as low as possible, for the lower it is cut the fewer the borers left in the stubble and the easier the ploughing under completely of the stubble and debris.

If the field is small, cut it by hand with a short-handled, heavy hoe, never with a sickle or knife. With the hoe it is easy to cut level with the ground; with the sickle or knife it is very difficult to do so. Many growers in Kent and Essex are now using the hoe to cut all their corn and find it pays them to do so.

If the field is large, or moderately large, and the farmer has a corn binder, he should equip it with one of the stationary knives. These cost about $20.00 or some makes even less. The knife runs along the ground and cuts the corn level with the surface. As it is cut it is hoisted up by the chains in the usual way and bound into sheaves. The writers have tested this knife device and believe it will work well on most fields, though perhaps not in stony ground or in very weedy corn. The ordinary so-called reciprocating knife is, however, always left on the binder and so if in any field the new device does not work satisfactorily, it can be removed easily and the cutting continued with the ordinary knife. Both the Massey-Harris and the International Harvester Companies are now manufacturing the stationary knife for their respective binders. It is well worth trying and, if it works as satisfactorily as we hope, it will enable a man to comply with the Corn Borer Act without any more labor than he used in dealing with his crop before the corn borer existed in Ontario. Moreover, it will enable him, unless the corn was heavily infested, to omit ploughing the field.

If the corn is cut by a binder with the ordinary reciprocating knife the binder should be set low so that the stubble will be as short as possible.

(2) **Disposing of the Plants after Cutting.** There are several ways of disposing of the plants after cutting:

(a) *They can be ensiled,* for no borer, even if it escapes the knives, can live in the silo; the heat soon kills it.

(b) *They can be shredded.* A good shredder will kill all the borers which pass through it; many of them are not killed immediately but die soon after from the crushing received.

(c) *They can be run through a cutting box and fed to cattle.* The cutting box kills the majority, but the rest escape injury. Therefore any corn thus treated and left over until spring should always be hauled out to a field and ploughed under before the end of May; or it may be thrown upon the manure heap. In that case the surface of the manure will have to be treated as mentioned below.

(d) *They can be fed whole to live stock.* The borers in the parts consumed by the stock perish but those in the parts not consumed will live. Hence all corn remnants left when the stalks are fed whole to cattle must be destroyed. The best way is not to throw them out into the manure but to put them each day in a pile by themselves and later haul them away and burn them or plough them under. If they are thrown into the manure and become scattered over the barnyard the top foot, or at least eight inches of the manure and also all pieces of stalks in the rest of the barnyard, should be hauled out in spring after all feeding of corn has ceased and should then be ploughed under completely or piled neatly, covered with at least four inches of earth and left until needed as fertilizer. The reason for removing only the top of the manure pile is because all the borers deeper than that will have perished or migrated into it.

(e) *All corn stalks left over in spring in stooks in the field or along fences, or in feeding paddocks, barns, sheds or any other place, can be gathered and burned.*

(3) **Disposal of Uncut Corn Which is Not Required for Fodder and from Which the Ears have been Removed.** A common method of dealing with such standing corn is to break it off on a frosty day in winter or early spring when there is no snow, by hauling an iron rail or heavy planker or a heavy piece of timber over the field; or to cut it off with a hoe in winter or spring, or run a mower over it in spring. The United States Agricultural Engineers have devised a simple sled type of cornstalk

shaver with a large knife projecting from each side. (See Fig. 12). This is pulled by a single horse and will cut off the stalks level with the ground, either in fall or spring. Last year they devised a method of equipping an ordinary two-horse corn cultivator with three large knives. This enables a man to cut three rows of corn stalks at a time level with the ground. Any person desirous of making either of these devices should write to the Provincial Entomologist, O.A.C., Guelph, and he will secure for him the necessary specifications. Of all the above devices for breaking off or cutting standing corn the hoe, shaver and corn cultivator do far the best job because they cut level with or even below the surface.

As soon as the corn has been broken off or cut it should, while still dry, be raked up into windrows and burned, and then re-raked and burned. A side-delivery rake is often better for the purpose than the ordinary trip rake. Burning is not at all difficult if done when the material is dry.

After the stalks have been removed the field should be ploughed.

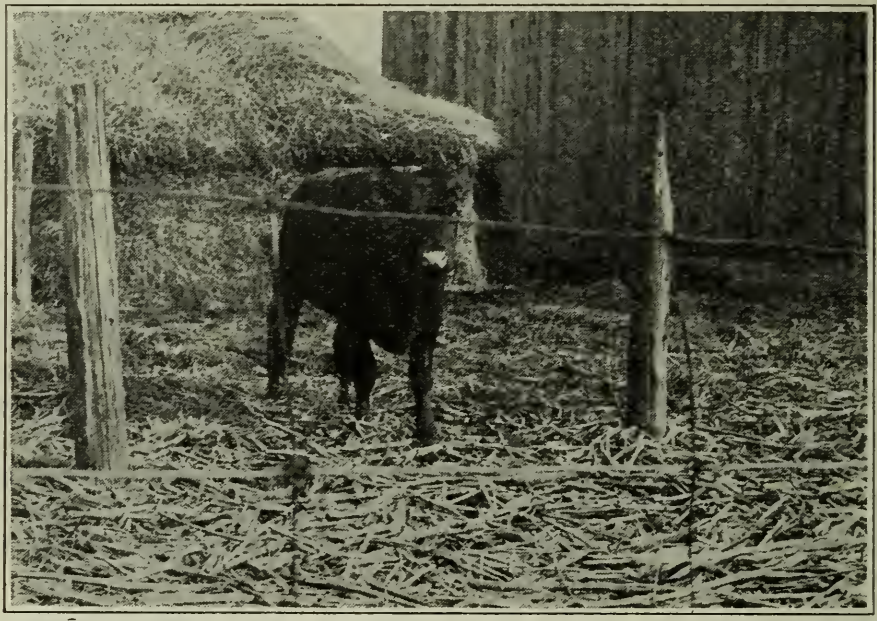


Fig. 11.—A dirty barnyard, harboring many borers. These stalks and corn remnants must be gathered and burned. (G. J. Spencer).

(4) **Disposal of Ears and Cobs.** All ears should, if at all possible, be shelled in winter or spring, or if this cannot be done, should be kept in a crib covered with wire screening of 20 meshes to the inch so that the moths emerging cannot escape, or if the owner prefers they may be taken out of the crib and stored in a perfectly dry place, as in a grain bin, or attic. The cobs themselves are likely to contain borers and should therefore all be burned before May 20th.

Fig. 12.—A light 2-row corn stalk shaver with knife on each side. The photograph largely conceals the knife on the left, which is the same size and shape as the one on the right. (After Irons, U.S.D.A.).

Fig. 13.—Corn cobs left lying around the barn or corn crib. These contain borers and must be gathered and burned or ploughed under completely. (G. J. Spencer).

(5) Cleaning up Barnyards and Surplus Corn in Barns. As already mentioned above under 2 (d), all corn remnants lying around in barnyards should be gathered and burned and if the manure contains pieces of stalks or cobs the top foot of it should be hauled out and ploughed under or piled neatly and covered with earth. All corn stalks left over in the barn should likewise be hauled out and burned or ploughed under.

(6) Disposal of Stubble and Other Debris in the Corn Field. We have already said that if the corn is cut level with the ground and then all removed, leaving the field clean, ploughing is not necessary, except where the field has been heavily infested. If, however, the stubble is not level with the ground but is even an inch above it, or if there are corn remnants left on the surface, too many borers will be left and so all such fields in the counties under the Act must be ploughed.

How Ploughing Kills the Borer

Under natural conditions the borers remain all fall, winter and spring inside corn stalks or pieces of stalks or cobs or in stout weeds growing among the corn, and all are above ground except those which have worked their way down into the tap root below the surface. Therefore when a corn field is ploughed and the borers buried they are put under unnatural conditions. The result is that most of them become restless and work their way to the surface after a time. This is true whether the ploughing is done in fall or in spring. When they reach the surface they at once search for a piece of corn stalk or something into which they can enter and find shelter. If the surface is clean they find nothing suitable and perish either from exposure to the sunlight and weather or from the attack of birds, beetles, ants or other enemies. Moreover any that remain underground and transform into moths do little or no harm because the moths nearly all perish in attempting to reach the surface. Hence ploughing is a great factor in the control of corn borer.

Many farmers would like to know whether we or others have proof of the above statement. To these we may say that we have ourselves buried thousands of borers in corn stalks and caged the burial plots so that any moths that might emerge would be captured. In all cases the results showed that fully 99% of the borers had perished and only a very rare moth emerged. In the United States the Bureau of Entomology has spent many thousands of dollars testing the effect of ploughing under uncut infested corn plants. Some of the cages they used covered an acre of ground. Their results were the same as ours and showed that if the corn, even heavily infested standing corn, were ploughed under cleanly and not dragged up again, over 99% of the borers perished.

Preparation of the Field for Ploughing

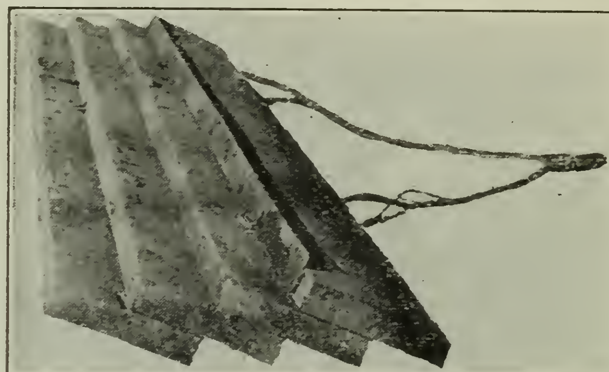


Fig. 14.—Planker, 10 feet long, which may be made of 2-inch planks 8 to 10 inches wide. Note that the planker is upside down to show the strip of iron projecting from the rear of the first plank. The planker is an excellent device for crushing stubble on clay or hard ground. (J. Marshall).

There are two methods of preparing corn fields to make burial of the stubble by the plough easy and thorough,—first, by cutting the stubble very short—the shorter the better—and second, by crushing it. The crushing may be done with a heavy roller or heavy planker (See Fig. 14) or a disc. If the corn has been planted in hills the disc gives the best result, because it tears the hills apart. A single discing is not sufficient to put the field into good condition. Two discings are necessary.

If the farmer has only a light roller it can easily be weighted by bags of sand. The rolling and the planking should both be done in the same direction as the plough will run so that the stubble will lean that way.

More farmers each year are practising one or other of the above methods because they find it pays.

The Kind of Plough to Use

In ploughing corn fields it is a great mistake to use a narrow bottom plough. These ploughs are very common throughout most of the province, but they turn too narrow a furrow slice to bury completely even moderately short stubble and in consequence they increase the amount of hand picking. A wide bottom plough should always be preferred, because a wide furrow gives more room for the stubble to be thrown into it and a wide slice buries the stubble better. Moreover wide bottom ploughs destroy weeds better and plough a field in about two-thirds the time required by the narrow plough. Tractor ploughs are usually equipped with wide bottoms and are also satisfactory.

Proper Equipment of the Plough

In nearly all cases both walking and tractor ploughs should be equipped with a skimmer, or jointer as some call it, and a No. 9 wire about 9 ft. long. Both of these devices help to roll the stubble and weeds right into the bottom of the furrow and thus make it easier for the mouldboard to throw the earth completely over them. The wire is simply a substitute for a chain and is attached in much the same way. The best place to attach it on any particular plough should be found by trial. It is lighter and easier to use than a chain. The free end of it runs along in the furrow and the furrow slice holds the wire taut. For best results the wire should be at least eight feet long.

Care in Ploughing

The writers have seen many a field of six inch stubble ploughed in such a way that most of the tops of the stubble could be seen sticking up. This was because the ploughman did not use good judgment in his work, and failed to see that to cover the stubble he should have run the furrow next to the stubble row just as close to it as possible, for this would have enabled him on the next round to throw the stubble flat into the furrow and thus cover it. Instead of that he paid no attention to where the furrow came in relation to the stubble, and in many cases it was six inches or more away, with the result that the stubble tops fell against the side of the previous furrow slice and were thus left exposed. Hence this matter of planning to have the last furrow before the stubble row run close to it should always be kept in mind.

Time to Plough

Either fall or spring ploughing is satisfactory. Most farmers prefer to do it in the fall because this leaves them free for other work in spring and because they believe that the exposure of the soil to winter helps in the control of weeds and in some cases results in better crops. Fall ploughing, however, is sometimes followed by heaving of the stubble, whereas there is no heaving after spring ploughing. The farmer, therefore, should choose for himself when he will plough, but it is important not to do it when the soil is too hard or too wet to make a good job. If he has heavy clay land and the weather is dry it will usually be wise to wait until rain comes or until spring.

Depth to Plough

Deep ploughing is not necessary, six inches is usually the best depth for walking ploughs and about seven inches for tractors. Ploughing shallower than five inches almost always results in too many stubble being dragged up later in cultivating and sowing.

Fig. 15.—Clean ploughing of corn stubble. The stubble in this field was stout and 6 inches high. It was broken by running the planker both ways over it and then was ploughed 6 inches deep in November with an ordinary wide-furrow walking plough with straight coulter and skimmer. (J. Marshall).

Cultivation After Ploughing

As the farmers aim should always be to avoid the necessity for hand picking, he should not use toothed implements in working the soil or sowing the seed, but should, so far as possible, use a disc for the cultivation and a disc drill for sowing, as these implements leave the stubble for the most part where the plough puts it. If stubble has heaved to some extent it is usually worth while to roll the field before working it because the rolling drives the stubble down and firms it, so that it does not drag up easily.

Are There Any Immune Varieties of Corn?

All experiments indicate that while some varieties of corn are less susceptible than others to injury by the borer, yet none are free from attack. In Michigan a praiseworthy attempt is being made to produce a highly resistant variety by crossing a South American corn called Maize Amargo with good commercial varieties. It will take years yet, however, to determine whether this work will be a success. So while we should welcome the discovery of a much more resistant variety than any we now possess, provided it is a good yielder, it seems wise at the present simply to choose the most satisfactory variety that is available for the district and stress the solution of the problem by reducing the number of the borers themselves rather than by relying upon the resistance of the corn to them. This does not mean that no special attention should be given to the choice of a variety. In the ensilage areas the variety which gives the best yield of ensilage and that has a sturdy stalk and so will stand up well, should be chosen. In the husking corn areas a sturdy stalk which will not break down easily, if entered by a borer, is the best, largely because it makes clean-up measures easier. In addition it should be a high yielder and should have at least a moderately short maturing season, so that, even if planted a week or ten days later than normal, it will ripen before the fall frosts come. There are at least three such varieties to be found at present in Essex and Kent.

While on this subject it seems worth while digressing to call the attention of growers to the fact that in 1930 in the husking corn areas nearly one-third of the corn failed to yield well solely because it was planted too thick, and that thick planting caused as much loss or more than the borer.

Late Planting

Experience has shown that early planted corn is almost always most heavily infested. The reason for this is chiefly that the moths prefer to lay their eggs on the tallest corn and as the early corn is the tallest in July, the time when most of the eggs are laid, it is chosen by the moths to lay upon. We do not rely upon late planting as a means of controlling the borer, but rather upon a thorough clean-up. Nevertheless we believe that in Essex and Kent it is not wise for the farmer for at least two or three years yet to plant all his corn early, lest favorable weather should bring about a temporary increase of the borer some year and serious loss be incurred. Therefore our advice is to plant half the corn in these two counties at the normal date selected as the best before the advent of the borer, that is about May 19th to 21st, and plant the remainder ten days later, but not later than May 31st, for fear of autumn frosts. Of course only a comparatively short season corn should be planted at the latter date. Such varieties as Burr-Leaming and Wisconsin No. 7 seem to have too long a maturing season and so would be almost sure to fail to ripen. In ensilage areas late planting has no place because the season is too short and because there is less danger in them of serious damage from the borer.

The Corn Borer Act

The terrible losses in Essex and Kent showed the farmers clearly that, if the corn industry was to be saved it was absolutely necessary that every grower in the heavily infested area should be compelled to practice control measures on his own property by cleaning up all corn remnants in spring before the moths could emerge and lay eggs on the new crop. It was this conviction that led to the passing of the Corn Borer Act.

The first year the Act was applied only to the eight worst infested counties in the province. Next year it was extended to sixteen more counties. Up to the time of writing (1930) no more counties have been added. Any county, however, which thinks it should be under it can do so through its county council, as stated in section 2 of the Act. This section also gives the provincial entomologist the power to add new counties when he thinks it wise to do so. The principle which guides him is not to put any county under the Act until the borers have increased sufficiently in it so that they would do considerable damage unless control measures were made compulsory.

A copy of the Act has been included below so that readers of the bulletin may see what is required under its regulations.

Results of the Corn Borer Act

The Corn Borer Act has now been in force for four years in eight counties; namely, Essex, Kent, Lambton, Middlesex, Elgin, Norfolk, Oxford, and Prince Edward, and for three years in sixteen others. The area now under it includes all that part of the province south of a line running from a few miles north of Goderich east to about the middle of Hastings county. This includes the great majority of the corn growing counties.

Owing to the pressure of other duties it has been impossible to inspect all the counties under the Act each fall to see the results of the spring's clean-up. Nevertheless we have been able to obtain yearly records for six of the counties which have been longest under it. These form a solid block and are the counties which were most heavily infested at the time the Act came into force.

Table Showing the Percentage of Infested Stalks Just Before and Since the Corn Borer Act Came into Force

County	1926	1927	1928	1929	1930
Essex	83.0*	64.7	41.7	35.9	16.7
Kent	78.7*	48.8	35.0	21.4	22.2
Lambton	34.0*	56.9	21.4	14.2	7.4
Middlesex	28.5*	36.2	18.3	9.9	9.0
Elgin	40.0	37.1	24.0	20.9	9.0
Norfolk	16.1	10.1	19.7	6.1	5.1

Note: The year 1926 was the last year previous to the Act's coming into force. The figures in it marked with an asterisk are federal, the remainder are provincial.

A study of the table shows that while in some counties the borer increased temporarily, yet at the end of four years there was a great reduction. The reduction is greater than the figures indicate. The fact is there is not more than about one-tenth the number of borers to-day in most of these counties that there was in 1926.

The farmers, even in Essex and Kent, where most of the corn was ruined in 1926, feel that the borer has been beaten and that they may now safely plant as much corn as they wish to.

In the other counties under the Act there has also been, so far as we can judge, a satisfactory decrease, though in 1930 there was a considerable increase in Prince Edward and probably also in southern Hastings. This, however, was due to specially favorable weather conditions that year for the borers in these localities. There is therefore good reason to believe that by strictly enforcing the Act we shall gradually be able to reduce the insect to such an extent that it will do little or no damage.

CORN BORER ACT AND ITS REGULATIONS

THE ACT

R.S.O. Chap. 312, 1927

1. In this Act,—

(a) "Corn borrer" shall mean the insect known as the European corn borer;

(b) "Regulations" shall mean regulations made under the authority of this Act.

2. The council of a county, city or separated town may, and upon notice in writing from the Provincial Entomologist, shall by by-law provide,

(a) for the appointment of an inspector for the purpose of eradicating the corn borer;

(b) for fixing the remuneration and expenses to be allowed to any inspector so appointed.

3. The Provincial Entomologist of the Department of Agriculture shall furnish assistance and co-operation to any inspector appointed under this Act and shall instruct the inspector in the methods to be adopted for controlling and eradicating the corn borer and the inspector shall adopt only such methods as are approved of by the Provincial Entomologist.

4. Every inspector appointed under this Act shall have authority to enter upon any premises where he has reason to believe that the corn borer exists and shall give such advice and instruction to the owner or occupant of such premises as to the methods to be adopted to control and eradicate the corn borer as the inspector may deem necessary and as may have been approved by the Provincial Entomologist.

5. Where such premises are unoccupied or the owner or occupant neglects or refuses to carry out the instructions of the inspector, the inspector may, by himself, or with such assistance as he may deem necessary, carry out such measures as may have been approved by the Provincial Entomologist for the control and eradication of the corn borer on such premises and he shall certify any expense so incurred to the clerk of the municipality and the amount shall thereupon be entered on the collector's roll and be collected in the same manner as other taxes.

6. The municipal corporation shall pay to the municipal inspector such compensation as may be agreed upon or as may be fair and reasonable and his reasonable travelling and other expenses in the performance of his duties under this Act and upon furnishing to the Department on or before the 15th day of December in each year a statement of the amounts so paid, certified by the Provincial Entomologist, the corporation shall be entitled to receive from the Department one-half of any amount so paid during the twelve months next preceding the said date.

7. Every person who,—

(a) refuses or neglects to carry out the instructions of the inspector; or

(b) obstructs the inspector in the performance of his duty

shall on summary conviction incur a penalty of not less than \$10 nor more than \$50 for each offence and such penalty shall be in addition to any other costs and expenses to which the offender may be liable under this Act.

8. The Minister of Agriculture, with the approval of the Lieutenant-Governor in Council may make such regulations as may be necessary for the better carrying out of the provisions of this Act.

REGULATIONS OF MINISTER OF AGRICULTURE

1. It shall be the duty of every person growing corn in the counties in which the Corn Borer Act has been made effective to adopt such methods in the growing of corn and in handling the land and the remnants of the crop as will most effectively control the corn borer; and all persons growing corn shall be responsible for giving effect to the provisions of the Act and Regulations whether owners of the land or not.

2. All corn stalks, pieces of stalks and cobs of each year's corn crop, whether in the field, barn or elsewhere, shall, if not fed, or ensiled, or shredded or mixed with manure, be destroyed by burning or by ploughing under completely, or by a combination of burning and ploughing.

3. Wherever corn stalks, or pieces of stalks, or cobs are mixed with the manure the top eight inches of the entire surface of the manure shall be removed and burned, or ploughed under completely, or piled in a heap and the heap at once thoroughly covered to a depth of four inches with earth or well-rotted manure, free from corn stalks, or any coarse plants or parts of plants capable of affording a hiding place for the borers. This covering shall remain intact until at least July 1st.

4. All shelled corn and corn-on-the-cob shall be stored in a perfectly dry place after May 20th. Hence all such corn if in a crib or other exposed storage shall be transferred by the above date to a barn or granary.

5. Corn shall be cut level with the ground and all remnants gathered and burned: or, if cut higher, the stubble shall be ploughed under completely and if any of it is dragged up later when cultivating or sowing it shall be gathered and burned within ten days.

6. No person or persons shall plant wheat or any fall or spring crop in a field in which the immediately preceding crop was corn until all the remnants of the corn crop on the field have been disposed of in accordance with the above regulations.

7. These regulations shall apply to land not being used for immediate cropping as well as to land being so used, and all control measures shall be completed not later than May 20th, of the year succeeding the corn crop.

8. Whenever the inspector on examination, finds that any of the above Regulations has not been complied with, he shall at once take such action as may be necessary for the destruction of the borer.

9. Any prosecutions for violation of the Act or regulations shall be made under The Ontario Summary Convictions Act.

BULLETIN 359] [APRIL, 1931

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

Insects Attacking Vegetables

LAWSON CAESAR, Provincial Entomologist

INTRODUCTION

Any person who has to combat insect pests can do so intelligently only if he keeps in mind the following things:—

1. Most insects, as, all beetles, moths, and two-winged flies, pass through four stages—egg, larva, pupa, and adult. For instance, in the case of the house fly there are the little white eggs, laid usually in fresh horse manure. These hatch into tiny, white maggots which feed on the juices of the manure until full grown; at which time they are about half an inch in length. Then these change into pupae, which are like large, plump grains of wheat but are brown or reddish brown in colour. These in turn change into adults or winged flies, thus completing the life cycle.

During the pupal stage insects do not feed but remain inactive while the internal changes, which transform them into adults, are taking place.

2. Other insects, as grasshoppers, plant or leaf bugs, leaf hoppers, scales, and aphids, instead of passing through the above four stages in their life cycle pass through only three—egg, nympth or larva, and adult. Hence in these insects there is no pupal stage. In their case the larvae are usually called nymphs. Most nymphs resemble closely the adults except that they have no wings.

Aphids during the summer are an exception to the above rule in that they lay no eggs but give birth to living young. In late autumn, however, they do lay eggs and this is the stage in which they winter in the open.

3. For our purpose all insects may be divided into two great classes:—

(*a*) Those having biting mouth-parts.

(*b*) Those having piercing and sucking mouth-parts.

These two classes may be distinguished from each other easily by observing how thev feed or the effect of their feeding. The biting insect always eats pieces out of the plant, leaving holes or jagged margins. The sucking insect never does this but merely punctures the surface of the plant with its fine, sharp, needle-like beak and then sucks the juices up from the interior. The injury to the plant in this case comes from the loss of its juice or sap and sometimes also from a poison injected into the tissues by the insect when feeding.

4. Biting insects may in most cases be combated by spraying or dusting the plants on which they feed with a poison, such as arsenate of lead, arsenate of lime, or Paris green. These poisons are often called *stomach poisons*, because the insect in feeding takes them into its stomach and is thereby poisoned.

5. Sucking insects cannot be killed by stomach poisons, because they feed only on the juices drawn from beneath the surface of the plant, and so cannot get the poisons into their bodies. They may be combated by *contact poisons;* that is, by hitting them with a spray or dust that kills them by contact or by fumes given off. Such poisons are nicotine sulphate 40 per cent, lubricating oil emulsion, soap sprays, nicotine dust, pyrethrum sprays and corrosive sublimate. Remember that to kill a sucking insect the poison must hit it.

6. All larvae and nymphs are more easily killed when young and small than when full grown or nearly so; hence it is usually wise to spray injurious insects as soon as possible after the eggs have hatched.

7. Thoroughness of application is very important; for, if a plant is only half covered with the spray, sufficient insects will often escape destruction to continue breeding and cause much loss.

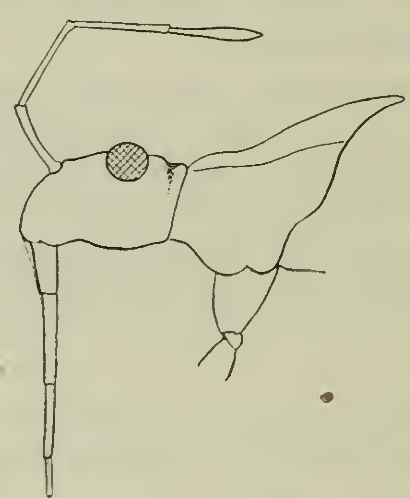


Fig. 1.—Head of sucking insect, showing long, slender beak and fine, needle-like lance, which pierces through the surface of the leaf or plant. (R. Ozburn.)

8. Since many pests winter over as eggs, larvae, pupae or adults on plants left in the field or under rubbish or in weedy or grassy places, it is often a great help to make a practice in the fall of cleaning off all the rubbish and ploughing under or burning all the crop remnants, and in the spring burning over early all weedy and grassy places before the insects become active.

Stomach Poisons

Arsenate of Lead.—This is white in colour and is sold almost exclusively in the powder form. It is generally used at the strength of one and a-half pounds to forty gallons of water or of Bordeaux mixture. Against some insects, however, as potato bugs, it is necessary to double or nearly double the strength. *Arsenate of lead is the only safe arsenical poison to use with water alone on delicate foliage.* It remains well in suspension and adheres excellently to the surface of the leaf. Its main defects are that it is a slow killer and somewhat expensive.

Arsenate of Lime (Calcium arsenate).—This also is a white powder and looks exactly like arsenate of lead but is much stronger, one pound being equivalent to one and a-half pounds of the arsenate of lead. It remains in suspension and adheres to the plants almost as well as the other poison and in addition costs only a little more than half as much per pound. Its chief defect is a tendency to burn the foliage of tender plants, if used with water alone. With Bordeaux mixture, however, it is safe. Potato foliage is hardy; so this is the cheapest poison to use on these plants either as a spray or as a dust.

Paris Green.—This is a green powder commonly used at the strength of one-half pound to forty gallons of water or of Bordeaux mixture. On potatoes the strength is usually doubled. Its chief merit is that it kills quickly. The main defects are that it does not remain in suspension at all well and therefore washes off usually with the first heavy rain, that it is inclined to burn when used with water, though safe with Bordeaux mixture, and that it is expensive.

Fluosilicates.—There are several kinds of fluosilicates of which barium fluosilicate, calcium fluosilicate and sodium fluosilicate, seem to be the most promising. Of these the first is apparently the safest. All three are sold in the form of a fine white powder. They are sometimes used as sprays at a strength of 1 lb. to 40 gals. of water, but as they have a tendency to burn foliage it is wiser to use them as dusts, mixed with equal parts, or even larger proportions, of hydrated lime. The dust does much less burning than the spray; in fact it is claimed that pure barium fluosilicate dust will not injure ordinary foliage. These insecticides have not yet been tested sufficiently well to recommend them and they are not yet readily obtained commercially. They are included here, however, because they have considerable merit, can be manufactured cheaply and will probably be used to a considerable extent in the future.

Derris.—This is a light, brown powder made from the roots of certain shrubs grown in the far east, especially in the Malay peninsula. It is supposed to be both a contact and stomach poison and when used as a dust is usually diluted with air-slaked lime or hydrated lime or gypsum in the proportions of about one part by bulk to twenty or even forty parts of the diluent. As a spray it may be used at the strength of 1 lb. to 40 gals. of water and is quite harmless to foliage. It is a good insecticide against a considerable number of insects but not against all. Unfortunately it is even more difficult to secure than the fluosilicates, though it will likely be put on the market in the comparatively near future.

Contact Poisons

Nicotine Sulphate 40 per cent.—This is a concentrated extract of tobacco containing 40 per cent. of nicotine. It is commonly used at the strength of about one pint to 100 gallons of water. The addition of five pounds of soap adds to its killing power, chiefly by causing it to spread more uniformly over the surface of the insect. It can be and often is mixed with hydrated lime and used as a dust. As a dust the most common strength is five pounds of the nicotine sulphate to 95 pounds of hydrated lime. This gives the dust a strength of two per cent. of nicotine.

Nicotine sulphate is an excellent insecticide against aphids, leaf hoppers, and some other small insects, especially if applied as a dust on a calm, hot day. It should never be applied on a windy day because the wind blows the fumes away from the insects. Its chief drawback is the rather high cost.

Lubricating Oil Emulsion.—This is used by vegetable growers, chiefly against the onion maggot. The methods of making it up and using it are described in the account of this maggot given under Onion Insects. For fuller information on lubricating oil emulsions write to the Department of Entomology, O.A.C., Guelph.

Soap Sprays.—A soap mixture made from one pound of laundry soap, or better, fish oil or whale oil or linseed oil soap, in five or six gallons of rain water will kill most small sucking insects, such as aphids. The soap, if hard, is first dissolved in boiling water. Soap washes are very likely to injure the foliage, especially tender foliage. They should therefore be used only on very hardy foliage, such as that of cabbage, or, if used on other plants, as garden peas, be washed off with water about an hour after applying.

Pyrethrum Sprays.—These are commercial preparations in which the poisonous substance is obtained from the flowers of the pyrethrum plant. Several insecticide companies have the last two or three years been putting on the market pyrethrum mixtures under special trade names. They are usually in liquid form, and must be greatly diluted with water before using. Each manufacturer states on the container, or the sheet sent with it, the directions for use. Pyrethrum is a powerful contact poison, and tests indicate that several of these commercial pyrethrum products have real merit and are worthy of trial for insects which are not readily controlled by our common insecticides. The main objection to pyrethrum sprays is that they are considerably more costly than the ordinary arsenicals or even than nicotine sulphate. One of their valuable qualities is that they are harmless to vegetation and almost non-poisonous to man.

Corrosive Sublimate.—This is a heavy substance purchased usually in the form of a powder. It is a deadly poison to man and livestock and is used chiefly to control the cabbage maggot. The strength required and the method of applying it are given under that insect.

Bordeaux Mixture.—As Bordeaux mixture is used to control flea beetles and leaf hoppers of potatoes as well as to prevent late blight of potatoes, celery blight and certain other diseases, a formula and method of preparing it are given:

Bluestone (copper sulphate)	4 lbs.
Fresh stone lime 4 lbs., or hydrated lime	6 lbs.
Water	40 gals.

For convenience this formula is called the 4, 6, 40 formula, it being taken for granted that in most cases hydrated lime will be used instead of stone lime, as it is much more convenient, can more easily be secured and stored and requires no slaking. Hydrated lime, however, if left exposed to the air becomes worthless. Hence it should be kept in tightly fastened paper bags in a dry place.

To prepare Bordeaux Mixture.—Dissolve the bluestone; then nearly fill the tank with water; add the proper amount of dissolved bluestone; start the engine to agitate the liquid; add the hydrated lime or slaked stone lime, and agitate the mixture for about five minutes. If a hand outfit is used agitate by pumping the liquid back upon itself for about five minutes.

Note.—The easiest way to dissolve bluestone in the crystal or lump form is to place 40 pounds of it in a bag and suspend this in a barrel containing 40 gallons of water in such a way that the bottom of the bag sinks only three or four inches below the surface of the water. Leave over night and in the morning all will be dissolved. One gallon of the liquid will now contain one pound bluestone.

Small quantities can be dissolved rapidly in boiling water by stirring. Powdered bluestone dissolves very readily and is usually placed in the desired amount upon a burlap screen on the hopper or inlet of the tank and dissolved by the water being poured over it as the tank is filled.

Caution.—Bluestone will corrode iron or tin, so wooden or copper vessels should be used for handling or storing it. Remember too that it is poisonous to livestock, as are most of the insecticides.

Bordeaux Dust.—Bordeaux dust with or without a poison is often used by growers to combat potato blight or other vegetable diseases. Against insects it is not nearly so satisfactory as the liquid Bordeaux. A common formula is:

Very finely powdered dehydrated copper sulphate	12 lbs.
Hydrated lime	80 lbs.
Arsenate of lime	8 lbs.

Often it is advisable to increase the copper sulphate to fifteen or even twenty pounds and the arsenate of lime to ten pounds. In such cases the hydrated lime should be decreased proportionately to make the total of 100 pounds. Of course if there are no insects to combat the poison may be omitted and an equal number of pounds of hydrated lime added in its place to keep the right strength of the copper sulphate.

Unless the grower has a good mixing machine he should buy these dusts ready mixed.

Dusting and Spraying Machines

Only a brief account of these will be given as the grower can secure catalogues from the various companies making them.

Of the larger outfits the writer prefers those that are driven by gasoline engines as more durable and satisfactory. The nozzles on all of these should be so arranged as to spray both sides of the leaves, and the horses should be driven slowly enough to allow the spray to cover each plant thoroughly. Power sprayers for orchards can be equipped for use on vegetables.

For plots of one to five acres a barrel sprayer should prove satisfactory, the knapsack sprayer in most cases being too slow to be suitable. Where the

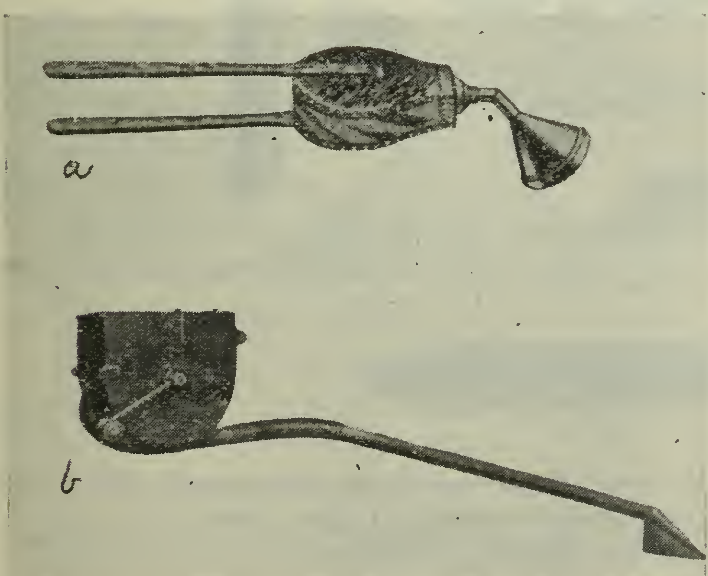


Fig. 2.—(*a*) Small, cheap, hand-bellows duster; (*b*) larger duster of rotary type, carried by straps over the shoulders.

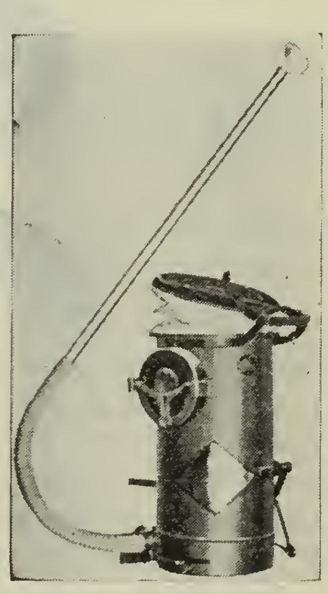


Fig. 3.—Large type of bellows duster, carried by straps over the shoulders.

garden is less than an acre in size a knapsack, or in some cases a compressed air sprayer, will suffice. It is perhaps wise to point out that barrel sprayers do not cost much more than a good knapsack and will last several times as long as most of these.

A good hand duster is a very convenient implement for a vegetable grower or gardener to possess. The best makes cost about $20.00 to $25.00. Three types of hand dusters are illustrated. The first is a very cheap one costing not more than $2.00 but is, of course, adapted only to a very small garden. The other two are each large enough to take care of at least two acres. Power dusters for large acreages are also for sale.

Acknowledgements

In discussing the different insects the writer has based most of what he has written upon his own experience but for several insects is much indebted to publications by other entomologists in Canada and the United States. Gratitude is due also to Dr. L. O. Howard, Dr. W. E. Britton, Dr. C. J. Drake, and Mr. Arthur Gibson for permission to use illustrations from their publications.

INSECTS WHICH ARE NOT LIMITED TO ANY ONE KIND OF PLANT BUT ATTACK MANY KINDS

Cutworms and Army Worms

Army worms are true cutworms and therefore may properly be considered here as such. The reason they have received the name "army worm" is that they have developed to a greater degree than other cutworms the habit of marching, often in great numbers, from one field crop to another when in need of food.

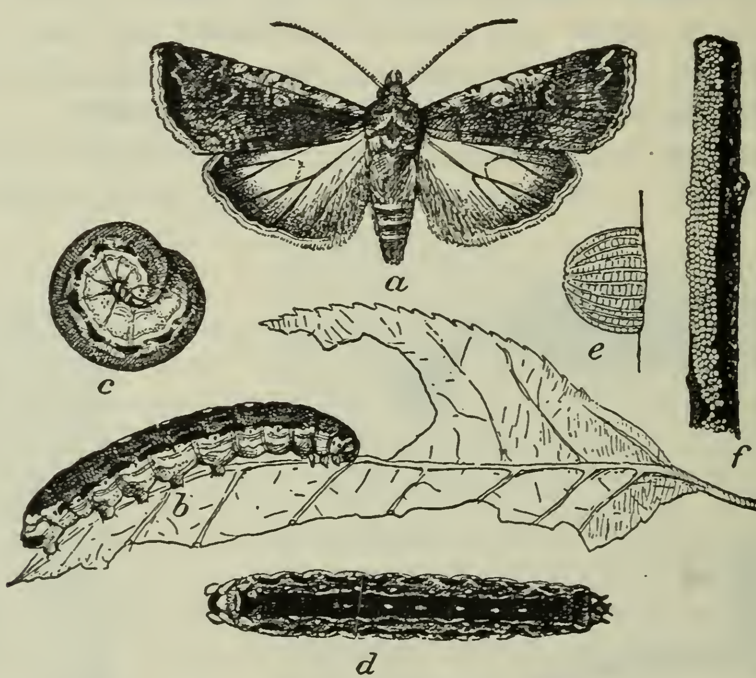


Fig. 4.—Variegated cutworm—(*a*) moth; (*b, c, d*) cutworms themselves in various postures; (*e*) egg greatly enlarged; (*f*) egg masses on a stem (after Howard, U.S.D.A.)

Cutworms are stout, hairless caterpillars about one and a-quarter to almost two inches long when full grown. Figure 4 shows their natural size and also their habit of curling up when at rest. The colour varies with the species, some being nearly white, others dark greasy gray, others brown and others black. Some are a uniform colour all over except that the under side is usually lighter than the upper; others have characteristic bands, stripes or lines along the back or side; and still others have black or other coloured markings on the back. All have three pairs of true legs and nearly always five pairs of false legs.

The adults are stout-bodied, dull-coloured moths with a wing expanse of one and one-quarter to one and one-half inches. The colour here too varies with the species but almost all are some shade of grey, brown or black, or a combination of these. The moths hide by day and fly at night.

There are many species of cutworms but usually not more than two or three of these are injurious the same year, and some, for instance the army worm (*Cirphis unipuncta*), usually only once in ten or twenty years. Our most common and most destructive species are probably the red-backed (*Euxoa ochrogaster*), the variegated (*Lycophotia margaritosa*), the spotted (*Agrotis c-nigrum*), the glassy (*Sidemia devastator*), and the greasy (*Agrotis ypsilon*).

Injury.—Although most species have two broods a year, the first in May and June and the second in July and August and early September, the greatest damage, as a rule, takes place in May and early June. The army worm is an exception to this as it does nearly all its damage in July. The variegated and the spotted cutworms are also sometimes quite destructive in July and August.

Cutworms work chiefly at night, hiding by day just under the surface of the soil or under the shelter of leaves or rubbish. Most of them, as the name indicates, cut the plants off at the ground or slightly beneath it. In this way even a comparatively small number can do great damage to cabbage, tobacco, tomatoes, corn or any other crop where the plants are in hills or set far apart. The glassy cutworm and one or two other species, instead of cutting the plants at the ground, feed entirely, or almost entirely, beneath the surface and kill the plants by attacking the roots. Some species have the habit of climbing the stalks of plants, even of fruit trees, and of feeding upon the foliage. These are often called climbing cutworms.

There is scarcely any kind of cultivated crop which is not subject to cutworm attack. Many weeds and uncultivated plants are also attacked.

When the worms are abundant and nearly full-grown they sometimes destroy whole fields of wheat, oats, corn, tobacco, or other crops; in fact, there is scarcely any other insect in the Province except grasshoppers which can do so much damage in so short a time.

The injury is almost always more likely to take place when the crop has been planted on a field which was in grass, clover, or weeds the previous fall.

The adults feed upon the nectar of flowers and do no injury to plants.

Life History.—Nearly all our destructive species winter either as partly grown larvae or as eggs in the soil, and in both cases the larvae attack the plants in May and June. Those of most species become full grown before the end of June and then pupate in the soil. By the end of the month or early in July the moths appear and lay their eggs usually on weeds or grass, though some, for example, the red-backed cutworm moth, lay them in the ground. The favourite place for egg-laying is where there is dense foliage such as long grass or weeds. The second brood of larvae becomes full-grown usually about the end of July or early in August. The moths from the pupae of these lay eggs during

August and September. The larvae from these eggs become partly grown by winter and remain over winter in the soil. The eggs of the red-backed species, however, do not hatch until the next spring.

Control.—1. It has been stated that the moths prefer to lay in long grass or weedy places or where there is dense vegetation; hence if a crop is to be put on such soil it should be ploughed as early as practicable in August and cultivated occasionally to keep down weeds the rest of the season, so that eggs will not be laid there, or if they have been laid before the ploughing, they and any larvae that may have hatched will be destroyed by starvation.

2. When cutworms have begun to attack plants the best method of control is to use a poison bran bait. There are many formulae for such a bait. A cheap and apparently as good a one as any is:

Bran	25 lbs.
Paris green, or very fine white arsenic	1 lb.
Cheap molasses	½ gal.
Water, enough to moisten the moisture, about	2½ gals.

Note.—In many cases, but probably not in all, the molasses may be omitted without lessening the value of the bait.

Mix the bran and one of the poisons thoroughly, then gradually pour the water on the poisoned bran and mix until all is wet and will fall like sawdust through the fingers. The mixing may be done in any large vessel or on a cement floor.

Half a teaspoonful or even less of the above mentioned bait dropped near each plant but not touching it will be sufficient.

If whole fields or large areas are attacked, scatter the bait at the rate of about 15 pounds (dry weight) per acre over the ground soon after sunset. This time of the day is best because the cutworms begin to feed then and like the bait fresh. Usually one application is sufficient, but sometimes a second is necessary.

3. If it is known or suspected that cutworms are in the soil prepare the ground in spring for planting, and a day or two before setting out the plants or sowing the seed scatter the bait broadcast over the ground late in the evening so that the worms will feed upon it and be killed, and the plants thus saved.

Caution.—Remember not to let livestock, including poultry, have access to the bait either when stored or after being scattered in the field; also wash out well all vessels used in making it.

4. If the cutworms are of the underground feeding kind which attack the roots it will be necessary to drill the bait into the ground two or three inches deep. In this case it should be mixed dry and shorts or middlings substituted for bran, as this makes it go through the drill better.

5. Seed-beds may be protected the same way as open spaces by scattering the bait over them thinly.

Wherever there is a great outbreak of cutworms or army worms and they have begun to march forward, the poison bran bait scattered for a few yards all along in front of them will usually destroy them, though occasionally they will pass over it. In that case a furrow, or better two parallel furrows a yard or two apart, should be run ahead of them and the sides pulverized by dragging a log about ten inches in diameter and six feet long up and down the furrow. Cutworms can go up the firm side of a furrow but cannot climb over fine loose earth near the top, as this falls back under their weight. Poison baits should always be scattered along in these furrows. The furrows themselves should be at least six inches deep and should be ploughed carefully.

Usually any outbreak can be controlled completely by the combination of the dust furrow and of the poison bait, but it is seldom that the furrow will be needed.

Grasshoppers

It is only where vegetables are grown in the vicinity of old pastures, old meadows, waste lands and roadsides that grasshoppers are likely to do any damage to them. This is because it is only in such places that our injurious species breed.

There are many kinds of grasshoppers, some large and some small, but the only ones troublesome in this province are:—the red-legged grasshopper (*Melanoplus femur-rubrum* De Geer), the lesser migratory grasshopper (*Melanoplus atlanis* Riley), and the roadside or clear-winged grasshopper (*Camnula pellucida* Scud.). These are all small, 1 to 1¼ inches long, and all have the same general habits.

Life History.—All three species have a similar life history: The winter is passed in the egg stage. The eggs hatch in May. The nymphs or young grasshoppers feed upon grasses, grains, or other green plants, and change into winged adults in June and July. The adults feed the rest of the season on the same kind of plants as the nymphs but wander more widely. Soon after this stage has been reached, the females begin laying eggs and continue to do so at intervals until killed by the frost in autumn. The eggs are deposited in meadows, pastures, waste lands and roadsides, and are enclosed in little pod-like structures made just below the surface of the ground by the females with their abdomens. These pods are lined and covered by a mucilaginous substance which holds them in place and protects them from the weather.

Control.—1. If the breeding places mentioned above can be ploughed late in fall or early in spring, this will bury the eggs and prevent the young after hatching from reaching the surface.

2. If such lands are put into a short rotation of crops there will be no need to fear damage from grasshoppers.

3. Outbreaks can be controlled readily by the use of the following poison bait:—

Bran	12 lbs.
Sawdust	an equal bulk to that of bran.
White arsenic or Paris green	1 lb.
Salt	1 lb.
Water	about 2½ gals.

Fig. 5.—Grasshopper.

Mix thoroughly together while dry the bran, sawdust, and poison in a large receptacle or on a clean cement floor. Dissolve the salt in the water and then pour the liquid on the above mixture and stir until every part is wet and will fall freely through the fingers.

If sodium arsenite liquid can be secured, it is preferable to Paris green or white arsenic as it kills more quickly, and by being poured into the water and stirred, it gives a more uniform poisoning of the whole bait. Moreover, as it is a liquid, there is no danger of the operator being poisoned or injured by arsenic dust when making up the bait. One pint of sodium arsenite liquid is about the equivalent of 1 pound of Paris green or white arsenic.

Apply the bait between 6.00 a.m. and 4.00 p.m. on a bright, warm day, not on a cold, wet or dark day. The above amount is sufficient for at least two acres of infested land. An easy way to apply it is to draw the required amount to the field on a stoneboat or wagon, then using a large pail scatter it by hand like seed grain very thinly over the infested fields or roadsides or wherever the grasshoppers are present. It is possible to sit in a rig and scatter the bait as one drives along. One application is sufficient as a rule, but sometimes a second a few days after the first is desirable. The bait will kill nymphs as well as adults and should be applied as soon as the insects are seen to be numerous enough to justify treatment.

Caution.—Do not allow cattle, poultry or livestock of any kind to have access to the bait. There is usually no danger to cattle or other livestock, except poultry, once it has been scattered over the field, if this has been done thinly.

White Grub

White grubs are the large, white, curved larvae which live in the soil and destroy the roots of many kinds of plants and bore into tubers of potatoes. The grubs have brown heads and three pairs of legs and their body is always bent into nearly a circle. When full-grown they are about 1½ inches long and 1/3-inch thick. They are the larvae of large, stout, brown beetles known as June beetles. These are the beetles we hear and see flying through the air on warm, calm nights late in May and in June. They are often attracted by lights into our homes.

There are about a dozen injurious species of these insects in the Province, all belonging to the genus Phyllophaga, but as they all have similar life histories and habits we shall consider them as one.

Injury.—Both beetles and grubs are injurious. The former feed at night upon the leaves of many kinds of trees, as oak, elm, ash, poplar, willow and cherry, and when very abundant may completely defoliate them. The grubs feed underground on the roots of grasses, cereals, corn, strawberries, young seedling trees including conifers, and many other plants. They also, as said above, bore into the tubers of potatoes and at times into beets and other fleshy

Fig. 6.—White grub and adults—June bettles. (J. Marshall.)

roots. It is not uncommon to have whole fields of potatoes or of corn, grass or other plants severely damaged or even ruined by them. Grass in lawns is also often damaged or destroyed. Clover is almost immune, so too are soy beans, and to a large extent alfalfa and sweet clover.

Life History.—White grubs have a much longer life history than most insects and this is one reason why it is harder to free the ground from them. The beetles begin to emerge from the soil in May, usually late May, and fly around, especially on warm nights, during the remainder of that month and all through June. Some are found even in July. They feed, as said, on the foliage of trees, some species preferring one kind of tree, others another. During the day the beetles hide in grass or other cover on the ground. A short time after emerging egg-laying begins. The eggs are white and are placed singly in the soil in small balls of earth at a depth of from 1 to 8 inches and always where the ground is covered with vegetation. The favourite places are old pastures, meadows, and roadsides. Eggs are not laid in bare fields and only seldom in good stands of red or sweet clover or of alfalfa. They hatch in 2 to 3 weeks.

The first year the grubs are small and feed chiefly upon decaying vegetable matter in the soil, and usually do little damage. Early in October they begin to prepare for winter by working down below the plow line. The usual winter depth is between 1 and 3½ feet. Next spring, in May as soon as the ground has thawed out and is in good shape for plowing, they come up again to within about 3 inches of the surface. This year they feed chiefly upon the roots of growing plants or the tubers of potatoes; hence, as they are larger now, they often, if abundant, do much damage. In early October they again work their way down in the soil, and the following May come up and resume once more their feeding, but only for a short time; for in June they become full grown, then cease to feed and begin to prepare an earthen case in which to pupate.

Pupation takes place in July and August usually within 5 inches of the surface. This stage lasts about 1 month; then the pupa becomes an adult. The new adults do not emerge until the following spring, but remain over winter just where they were inside the pupal cases. An exception has been found to this practice in Manitoba, where at least one species of the new adults leaves the pupal case and goes deep down like the grubs themselves over the winter. As mentioned above all overwintering beetles emerge in spring. Thus the complete life cycle requires in the south-western half of this province three whole years, as follows:—eggs 2 to 3 weeks; larvae 2 full years from June of the 1st year to June of the 3rd year; pupae, 1 month; and adults in the ground before emerging, 10 months or more.

In some of the colder parts of Ontario and in our western provinces, owing to the shorter summers, four years are required instead of three, and in that case the insect spends three years in the grub stage instead of two.

Control Measures.—Hogs if allowed to run in an infested field will root in the ground and destroy most of the grubs if the soil is not too hard or if it is plowed first. The hogs of course should not be ringed.

Poultry will sometimes follow the plow and devour the grubs as they are turned up.

Numerous beetles can be trapped at night by a lantern placed in a tub of water.

Spraying the trees on which the adults are feeding with arsenate of lead, 2 pounds to 40 gallons of water, will kill large numbers of the beetles.

All the above are helpful but the main method of control is to get rid of the chief breeding places, which are old pastures, timothy or wild grass meadows and waste lands. This is best accomplished by a rotation of crops which will not leave any field seeded down for more than two years, or better still, for more than one year. It must always be remembered that no very susceptible crop such as corn, potatoes, or strawberries should be planted on land broken up from sod, if white grubs are seen to be present, until at least the third year or better the fourth after breaking up the sod. A good practice to follow in such cases is to plow the sod in September to expose the grubs before they go down into the soil and to kill many of the new beetles, then next spring disc deeply and sow oats or barley with red or sweet clover, using a little more oat or barley seed per acre than usual. Next year take off a crop of clover and as soon as possible plow the field, work it up and sow wheat that fall. Then by the time the wheat is off the next year, the grubs will usually have disappeared and any crop may be sown. If, however, when preparing the field for wheat many grubs are seen it will be wise to sow clover on the wheat the next spring and by the time the clover is ready to cut or plow the following year the grubs will have disappeared and any crop may then be planted with safety.

In Manitoba plowing and working the soil in June and July is said to kill the eggs and at the same time fit in well with their method of farming, but such a practice could not well be followed here.

Infested lawns may often be saved by frequent watering throughout the summer and by using a dressing of nitrate of soda.

In gardens, if only a few plants are being attacked, the grubs may be found by digging and destroyed.

Wireworms

Wireworms, as the name suggests, are hard, slender, round or nearly round worms. There are several species, the colour and size varying with the species. One, known as the wheat wireworm (*Agriotes mancus* Say.), though it attacks other kinds of plants besides wheat, is glossy, pale yellow or straw colour, and when full grown is about 1 inch long. Another common species, the corn wireworm (*Melanotus communis* Gyll.), which also attacks many kinds of plants, is light reddish-brown and about 1¼ inches long. All the other common wireworms in this province resemble closely one or other of the above two.

Fig. 7—Millipedes, natural size. Note the large number of slender legs all along the body and the habit of curling up when at rest.

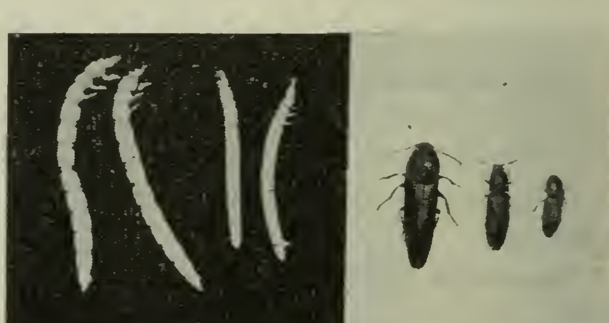


Fig. 8.—Two common species of wireworms and three species of adults, all natural size.

The adults are called click beetles, because, if placed on their backs, they spring up into the air with a clicking sound. They vary in size, some being about 1/3-inch in length, others nearly 1 inch. The general shape is shown in figure 8.

Millipedes are often mistaken for wireworms, especially in the fall of the year, but may be distinguished easily by the fact that they have numerous legs along the under side of the body, whereas the wireworms have only 3 pairs of legs.

Food Plants.—Wireworms attack a wide range of plants, including almost all cereals and grasses and most vegetables. Legumes, including red clover, sweet clover, alfalfa and peas are seldom attacked. The same is true also to a considerable extent of buckwheat and flax.

Injury.—The beetles feed upon the blossoms of many kinds of plants and also upon sweet substances wherever they can find them, but in Ontario do almost no harm. Hence it is the wireworms themselves which do the damage. These, as mentioned above, attack numerous plants but most complaints have been received of injury to potatoes, tobacco, tomatoes and corn. Potatoes are injured by the larvae boring into the tubers and making tunnels in them. They may even continue to work when the potatoes are stored for winter, if the temperature is high enough. Tomatoes and tobacco may be injured either by the roots being eaten off or by the wireworms boring up through the stems and killing the plants. Corn seed in the soil is often fed upon to such an extent that no plants are produced, but even when the plants have appeared they may be killed by the roots being devoured. In addition to the above four plants it is not uncommon for such crops as oats, barley and wheat to be destroyed or seriously injured, if the wireworms are numerous. This seems to take place to a greater degree in a cold backward spring when the plants are making little or no headway while the wireworms are quite active. In brief, we may say that wireworms are among the most destructive of all insect pests of the farm.

Most species do little or no damage in this province wherever a short rotation of crops and good farming methods are practised. This is because they breed almost entirely in land that has been in sod for several years. The first year after breaking up such a sod the wireworms often do little harm to the new crop, with the exception of potatoes, which may be seriously injured at times. This is because the worms find all the food they desire the first year in the decaying sod itself. The second year, however, there is no decaying sod left to feed upon and so they attack the new crop, if susceptible, and do serious damage. Damage may continue to be done for two or three years longer, but usually not to so great an extent as in the second year.

While most species of wireworms breed in old sod land we have at least one species which breeds in well cultivated lands and which is at times troublesome, especially in private gardens and land devoted to vegetable growing. Fortunately this species is not nearly so common as the sod-breeding type.

Life History.—The life history of wireworms is very similar to that of the white grubs. The adults come out of their winter quarters usually in April, and can be found throughout May and most of June. Eggs are laid in the soil, chiefly in grass lands. We have not full data on the eggs but those of several species at least are round, glossy, white and hatch in two to four weeks. The larvae the first year do little harm as they feed mostly upon the decaying sod itself. In October they go below the plow line, though possibly some may remain above it at times. The next spring when the ground is ready to plow and plant, they come up, and this year, because of their larger size, and often too because of the disappearance of decaying vegetation, feed upon the seeds or the roots of the living plants and do great damage. In October they again go down into the earth. Next spring they come up and resume feeding for a few weeks. In June they cease feeding and make an earthern case in which to pupate. Pupation occurs in either July or August and this stage lasts about one month. The pupa then changes into the adult which remains in the earthern case, like the June beetle, until the next spring. It may be mentioned here in passing that breaking the pupal case by plowing in July or August will kill most of the pupae and many of the new adults.

The above is the life history of the common so-called wheat wireworm, but the corn wireworm and some other species seem to have a longer life history, and to remain as larvae not for two years only, but for three or four years. Therefore, after breaking up an old infested sod, it will require longer to free the soil from these than from the wheat wireworm.

Control.—1. As already stated, the chief method by which farms and gardens are kept free from wireworms is by practising a short rotation of crops. This removes the main breeding places; namely, the old pastures and meadows. When breaking up such a field a good practice to follow is either to plough it early, work it up and sow wheat the same fall or, if this cannot be done, plough it later in the fall, and next spring sow oats or barley. In either case put in red or sweet clover in the spring. Next year take off the clover, plough early and put in wheat, adding a clover again the following spring; or oats or barley with a clover may again be used. After this crop of clover has been harvested or ploughed under usually any crop may follow.

Peas, buckwheat and flax being, like clover, very little attacked by wireworms may also be used in the rotation until the soil is free from the worms. Alfalfa, too, is seldom injured but does not work well into a rotation.

Corn and potatoes being very susceptible should never be planted in any soil which is known to contain wireworms.

2. It has been observed that wireworms are usually worse in poorly drained soil; hence tile draining will often help greatly. Liming of wet soils, which are usually acid, will probably also be of value, at least in assisting plant growth.

3. The more rapidly the plants grow, especially in spring, the less likely they are to be killed by wireworms; hence before planting the field prepare the soil well and, if poor, add commercial fertilizer and lime where needed.

4. Baits may sometimes be used on a small scale, especially in gardens and greenhouses, to capture the wireworms. Potatoes may be placed about 3 inches deep in the soil and 10 feet apart. Stick a short wire painted white into each potato to mark its position. Examine the potatoes once a week and destroy the wireworms present. Replace the potatoes and repeat. This may be done for three weeks in succession and will result in getting rid of many of the wireworms. It should be begun in spring as soon as the ground is warm and the wireworms have come up, as can be determined with a shovel.

Baits of moistened bran and flour kneaded into balls or of wheat or corn may be substituted for potatoes. In that case they will not be removed, but the worms will merely be picked out of them and fresh material, if necessary, added each time.

5. Seed baits followed by poisoning with calcium cyanide are now being used in some cases by market gardeners where the crop to be planted is high-priced.

In applying such baits and cyanide Thomas* states that the following points should be observed:—

1. Remove crop remnants and weeds, and plow and harrow and loosen soil to a depth of 4 inches before baiting.

2. Use baits in the spring, when the wireworms are becoming active. (Test this by a shovel; dig 4 or 5 inches deep and see if any wireworms are to be found.)

3. *The best baits are wheat, oats, or corn, drilled thickly in rows about 2.5 feet apart and about 2 inches deep.*

4. Allow about two weeks between baiting and treating the rows with cyanide, time enough for most of the wireworms to reach the baits. Too dry or too cold soil may retard their movements.

5. Apply the cyanide when the soil is easily worked, but not wet, as the cyanide gas does not readily permeate wet soils.

6 Apply the cyanide uniformly with a seed drill, slightly below the level of the bait.

7. Use about 6 pounds of the granular calcium cyanide per 1,000 feet of row; this will amount to about 100 pounds per acre when the rows are 2.5 feet apart.

8. Do not plant the regular crop for at least a week or 10 days after this treatment, or the cyanide gas may injure the plants.

The calcium cyanide gives off a poisonous gas which penetrates through the soil and kills the wireworms. Calcium cyanide costs about 20c per pound in 100 pounds lots. Hence enough for an acre would cost about $20.00.

Caution.—Calcium cyanide taken internally is a deadly poison. The gas is also poisonous; hence store in a dry, safe place and label **POISON.** When handling stand to the windward side so as not to inhale much of the gas.

6. If wireworms are still present in spite of a short rotation of crops, as is sometimes the case, the cause may be that weeds were allowed to grow in early spring or fresh barnyard manure was applied just before planting and its odour attracted the beetles to lay their eggs. The freer from weeds the garden or field is the better and, if the use of barnyard manure seems to be the trouble, it should be applied in fall and ploughed under before winter, or else commercial fertilizer substituted for it.

It may be, however, that neither weeds, nor barnyard manure is the cause of the presence of the wireworms, but that the real cause is that the species of wireworm which breeds in cultivated land and not in sod is present. If this be the case baits or cyanide are the only methods we can recommend at present, though it might be possible in the case of tomatoes, cabbage or a few other plants to sow a few seeds of corn alongside each plant, and leave these for the wireworms to feed upon, thus giving the tomato or other plants a chance to get a good start and be able to withstand attack when the corn is killed or removed by cultivation. We should perhaps mention, too, that Dr. Headlee, of New Jersey, has found that a pyrethrum soap mixture in water will kill wireworms. This, however, is costly.

*Technical Bulletin No. 259, Pennsylvania State College, School of Agriculture and Experiment Station, State College, Pennsylvania.

Useless or impracticable remedies.—Neither salt nor gas lime will kill wireworms unless applied heavily enough to ruin the crop. Lime has no effect upon them, except that sometimes it may be valuable in promoting better growth. Strychnine, arsenic, corrosive sublimate or any other known poison which might be put on baits will not kill them. Covering the seed with coal tar or gas tar cannot be recommended, as it often prevents germination and usually fails to keep off the worms.

Slugs

There are several species of slugs. Our most common one is gray in colour, tapers gradually towards both ends, has a soft, slimy body, moves slowly and leaves behind it a trail of slime. When full-grown it is about 1½ inches long and 1/3 to ½ inch in diameter.

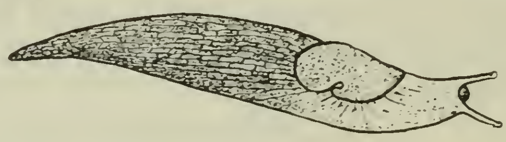


Fig. 9.—Common grey slug (R. Ozburn).

Slugs have sharp biting mouthparts with which they can eat holes out of leaves or by starting at the edge gradually devour the whole leaf itself.

They feed at night or in late evening or early morning. Moisture is a necessity to them; so they shun the daylight and dry air by hiding under leaves or beneath the surface of the ground. They are regularly most abundant and destructive in wet seasons.

Food Plants and Injury.—In a wet spring the foliage of beans and corn is often severely attacked and sometimes much of it eaten. In addition the slugs are fond of feeding upon lettuce, cabbage and cauliflower and eat large areas out of the leaves of these. They feed to some extent on almost any vegetable and in fall are often found boring into tomatoes, beets and carrots. In dry seasons they usually cause very little damage.

Life History.—The winter is passed chiefly in the egg stage in the ground. The eggs are roundish, bluish white, jelly-like and translucent. They are laid either singly or in small clusters. Another form in which the winter is sometimes passed is as adults hidden in the soil, especially in well protected places such as are afforded by dense vegetation. Cold winters kill a large percentage of both eggs and adults. The eggs hatch in spring, about June. The young slugs become full grown about August, and in September and October eggs are laid. There is only one generation a year.

Control.—When slugs are attacking plants the simplest and safest remedy in most cases is to dust hydrated lime around the base of the plants so that the slugs must go through it to climb up the plants. The dusting will have to be repeated after a rain, because the rain soon spoils the effectiveness of lime. Hydrated lime, however, will injure celery; hence to protect it use the Oregon poison bait made by chopping up lettuce or clover leaves into small pieces and dusting these with calcium arsenate at the rate of 16 parts by weight of leaves to 1 part of the poison. Scatter this bait in the evening close to the plants to be protected. Sometimes the bait used for cutworms (page 8) is used. Hawley* found that keeping plants sprayed with Bordeaux mixture largely protected them from attack.

*Memoir 55, Agricultural Experiment Station, Cornell University, Ithaca. New York.

As slugs may come from old sod or other places where they find shelter from the sun, it is often worth while to place a narrow barrier of hydrated lime or salt between such places and the plants to protect them. It is also a good plan in fall as soon as the plants are harvested to scatter hydrated lime over the bare ground or to moisten the soil with corrosive sublimate at the strength of 1 oz. to 6 gals. of water.

Caution.—Corrosive sublimate is a deadly poison and all vessels should be washed out after using and the material itself labelled **Poison** and kept out of reach of children.

Tarnished Plant Bug
Lygus pratensis Linnaeus

The tarnished plant bug is a very common brownish insect about one-quarter of an inch in length and of the form shown in the accompanying figure. The nymphs are green or yellowish-green, and in their earlier stages look a good deal like aphids but are much more active and when disturbed quickly seek shelter. Both adults and nymphs have very fine, sharp, piercing mouth parts with which they penetrate the tissues of their host plants and extract the juices. When feeding they are said to inject a poison into the wound and thereby increase the injury.

Fig. 10.—Tarnished plant bug adult, enlarged about four times.

Food Plants.—A full list of the food plants has never been made but the insect is known to feed upon so many different cultivated and wild plants that it may be said to be almost omnivorous. Some of its favourites are mullein, pig-weed, golden rod, aster, dahlia, chrysanthemum, celery, beet, strawberry and young peach trees.

Injury.—The greatest damage is usually done to cultivated flowers which bloom in late summer and autumn, especially asters, dahlias and chrysanthemums. So common is the insect on asters that it is often called the "aster bug." The adults do most of the damage. They puncture the unopened buds, especially the flower buds, and suck the juices, at the same time inserting a poison. The result is that many of the buds are killed outright and the bloom on many others is distorted and rendered worthless. The plants themselves also often become stunted and bushy as a result of punctures in their tissues. Celery is also much injured. The adults in July and early August gather from weeds and other plants in the vicinity and puncture the celery stems here and there, causing them to turn brown at the affected places. In addition both adults and nymphs attack the heart of the plant and by their feeding cause similar killing and browning of tissues there. The result is that soft rot frequently gets entrance into the injured heart tissues and the whole inner and most valuable portion of the plant becomes a slimy rotten mass. In 1929 several very promising celery plots were almost totally destroyed in this way, thus causing a loss of several thousand dollars.

Fig. 11.—Soft rot in celery heart, following upon injury by the tarnished plant bug. All the black area is rotten. The rot often extends much farther down.

On strawberries the immature fruits are fed upon by the adults, with the result that they are either killed or produce one-sided or "buttoned" fruit. When beet leaves are attacked they become crinkled and dwarfed. Young peach tree buds and tender terminal growth are often punctured and killed. Trees thus attacked are forced to produce lateral branches and thereby become bushy and hard to shape properly.

Life History.—The winter is passed in the adult stage under leaves, long grass and other kinds of rubbish, the favorite and chief wintering place, according to Mr. R. Painter, of the Entomological Branch, Ottawa, being in woods or thickets or along hedges, where the fallen leaves afford excellent protection. Early in April the adults come forth from winter quarters and feed at first upon the buds of fruit trees, and shrubs, and the green crowns or leaves of biennial and perennial plants, and then upon the early annual plants. Later, when more succulent or more favored plants appear, they leave the less attractive plants and fly to these. Egg-laying begins early in May and continues until near the end of June. The eggs are flask-shaped and are inserted into the petioles and midribs of leaves, or into buds or flower heads, or soft fleshy terminal growths of numerous host plants. They hatch in about 18 days.

The nymphs are greenish or yellowish-green, and usually have four black spots on the thorax. They have the same general feeding habits as the adults. The nymphal stage lasts about 38 days, and the total life-cycle from egg to adult is almost two months. Adults begin to appear early in July and continue appearing on into August. They soon mate and commence egg-laying for a second brood of nymphs, which begins to appear late in July and continues to do so throughout August and early September. This brood of nymphs becomes mature during late August, September and October and the adults from them go into winter quarters in October and November. There are only two generations a year.

Control.—No really effective method of control has yet been discovered, though many have been tried. Greenhouses may be protected by screening the ventilators and doors to keep out the adults. Some benefit is obtained by burning over, late in fall or in March, all grass and waste places and also all rubbish and leaves around hedges to destroy the adults in their winter quarters or to drive them to distant places for hibernation. Many persons use a 3 or 4 per cent. nicotine dust or a double strength of nicotine sulphate spray to protect flowers and celery. This kills nymphs, if they are hit, but does not kill many of the adults and it is doubtful if it pays. The addition of Penetrol to the nicotine sulphate is worth trying as it increases the killing power. It is just possible that some of the new pyrethrum sprays which are coming on the market may be helpful, if not too costly. Any spray should be applied early in the morning when there is no wind and when the adults are still too sluggish to be frightened and fly away. Fortunately natural factors most years help greatly to keep the insect within bounds.

INSECTS ATTACKING ASPARAGUS

Asparagus Beetle

Crioceris asparagi Linn.

The asparagus beetle is a brilliantly coloured insect about ¼ inch long. The general colour is bluish-black. The thorax is red and the wing covers dark-blue marked with lemon-yellow and bordered with red.

The beetle is fairly common almost all over the province, but apparently does not occur in so large numbers as a few years ago, probably because of the attacks of a parasite.

The larvae are dark brown, grey or olive-grey in colour with black heads and legs. When full-grown, they are about 1/3 inch long.

Injury.—In the spring until the eggs hatch, the beetles do damage by feeding upon the new shoots and eating holes in them. As soon as the eggs have hatched the larvae take a share in the same kind of injury and from then until the end of the season both beetles and larvae may be found together feeding on the plants. If the insects are abundant they cause havoc by eating off all the young and tender parts, leaving only the main branches and the stems. Even the stems are often gnawed by the beetles and the green bark removed. Where the plot is severely attacked in the above manner the result is that the plants are greatly weakened, are unable to store up food in their roots to any great extent and next year produce a very small crop.

Life History.—The winter is passed in the adult stage, the beetles hiding in sheltered places, usually near the asparagus plantation, such as in holes or crevices in logs or stumps, under loose bark on trees or beneath clusters of leaves and rubbish of various kinds. In spring about the time the asparagus plants

Fig. 12—Asparagus beetle—(*a, a*) adults; (*b*) eggs; (*c, c, c*) larvae about full grown; (*d*) pupal case, all natural size.

begin to send up shoots through the soil the beetles commence to leave their winter quarters and proceed to attack the young shoots. Egg-laying begins in a few days and continues for several weeks. The eggs are dark brown, about three times as long as wide and are attached at one end to the shoots in spring and later on in the season to the leaves and branches. There is usually a row of several eggs together. The incubation period varies from about 5 to 10 days. The larvae grow rapidly and are full size in 7 to 16 days. They then drop to the ground, work their way a short distance below the surface and pupate in a little finely woven cocoon covered with earth. The period spent in the soil before the adults appear varies from 7 to 18 days. Thus the whole time from egg to adult may be passed in less than a month though it averages about a month. Some seasons the new beetles begin to appear by the end of June. There are at least two generations a year throughout the whole province and probably three or at least a large portion of a third in the warmer districts.

Control.—1. The asparagus plots should be well cultivated and well fertilized. This results in the plants growing rapidly, allows cutting to be done frequently enough so that the beetles have little chance to injure the shoots during the marketing season, and prevents any eggs that may have been laid from having a chance to hatch.

2. If poultry are allowed to run in the plot they will devour many of the beetles.

3. If the plants are heavily attacked during the cutting season leave a few yards of plants in 3 or 4 rows here and there uncut so that the beetles may cluster on these. Spray such plants from time to time with 2 lbs. arsenate of lead to 40 gallons of water to which has been added 1/3 lb. of calcium caseinate mixed up first into a thin paste with a little water. The calcium caseinate acts as a spreader. Two pounds of soap are often used instead of the caseinate. Dissolve the soap first in boiling water.

4. New plots which are too young to be cut should be protected by spraying with the above mixture whenever they are attacked.

5. After the cutting season is over all the plants should be sprayed with the above poison if there are enough beetles or larvae to justify it. The spraying should be repeated if necessary. It is seldom that more than two applications will be required any year for a commercial plot.

Twelve-Spotted Asparagus Beetle

Crioceris dodecimpunctata Linn.

Fig. 13.—Twelve-Spotted asparagus beetle—adult enlarged; the line to the right shows natural length.

The twelve-spotted asparagus beetle is very similar in size and shape to the species just described but can be distinguished easily from it by its red colour and the 12 black spots on its wing covers.

The larvae are about the same size and shape as those of the asparagus beetle, but instead of being grey are yellowish white to brownish yellow or orange. They feed inside the asparagus fruit and so are seldom seen.

Injury.—The beetles injure the plants by feeding upon the shoots during the cutting season and later upon the leaves and branches in the same way as the other species, but as a rule they are not so abundant.

The larvae do practically no harm as they feed inside the berries on the pulp. A single larva may attack several berries.

Life History.—The life history of this species is very similar to that of the asparagus beetle. The main difference is that the eggs are apparently not laid until the berries have at least begun to form. The eggs are elongate, dark green, and are attached by the side to the branches of the plant. The lateness of egg-laying results in the new generation of beetles appearing later than that of the other species. In 1926, in Elgin county, emergence of the beetles from the soil was just commencing on August 11th and large numbers were still in the pupal or larval stage. As 1926 was a cold season, probably emergence would begin under normal conditions about August 1st. There are apparently two generations a year. The winter is spent in the same sort of places as the other species chooses.

Control.—The same control applies to this species as to the asparagus beetle.

INSECTS ATTACKING BEANS

Bean Weevil

Mylabris obtectus Say.

The bean weevil is a small, stout, somewhat wedge-shaped, yellowish-brown or olive beetle about ⅛ inch long and 1/10 inch wide at the broadest part of the body, namely, near the posterior end.

Food Plants.—Our common kidney beans are the favourite but lima beans and cow peas are also subject to attack.

Life History and Injury.—In Ontario the weevil seldom attacks growing bean plants but limits itself either exclusively, or almost exclusively, to stored seed. In this the beetles lay their eggs. The larvae on hatching bore into the beans and feed there until maturity. Each larva makes a separate chamber or cell for itself and a single bean may contain a dozen or more such chambers. In these, when full grown, the larvae pupate and the pupae change to adults. When emerging, the adults remove the surface covering and thus leave the larval chambers exposed to view. Breeding goes on throughout the winter, if the storage room is heated, but otherwise stops with the advent of cold weather. In warm buildings the insects may become so numerous as to reduce the beans almost to powder and thus make them a total loss.

Fortunately our winters are cold enough to destroy all stages of the insect whenever the beans are stored in barns or sheds or unheated buildings. This is no doubt the reason why it is only occasionally that stored beans are attacked in this province compared with what takes place in the warmer parts of the United States.

Control.—1. Infested beans should not be planted, partly because there may be living weevils in them and partly because many of them will not germinate.

2. Beans should be stored in dry unheated buildings where the inside temperature in winter will correspond closely to the outside and so will destroy any weevils present.

3. If at any time beans are being injured they should be fumigated at once with carbon bisulphide—a clear yellowish liquid, costing about 35c. to 50c. per pound.

Fumigation must be done in an air-tight or nearly air-tight receptacle such as a 40 or 50 gallon water or oil barrel. Fill the barrel with seed to within a couple of inches of the top, then pour 1/3 pint of carbon bisulphide uniformly over it and at once cover the barrel with two ply of heavy wrapping paper fastened down by a stout cord or barrel hoop around the top of the barrel, or use a close fitting lid or a couple of heavy blankets.

If large quantities of seed must be treated a larger receptacle or several barrels may be used and the amount of carbon bisulphide increased proportionately to the size of the receptacle.

Fumigation should last for 48 hours before removing the covering.

The temperature should never be lower than 60°F. and preferably should be 70° or higher.

If a special chamber is prepared for fumigating large quantities of beans or other seed the amount of carbon bisulphide required will be from 4 to 10 pounds to every 1,000 cubic feet of space, the larger quantity being necessary at 60°F.

Fig. 14.—Bean weevils and their work, natural size.

The amount required decreases with the increase of temperature, so that 4 or 5 pounds will be sufficient for 70° or 75°F., provided of course that the chamber is air tight. If it is not air-tight even larger quantities will be necessary.

The following points should be kept in mind in using carbon bisulphide:—

1. It is useless to fumigate when the temperature is below 60° F. as the insects will not be killed.

2. Good results cannot be expected if the container is not air-tight or almost air-tight.

3. Shorter fumigations than 48 hours are not likely to kill all the insects in all stages.

4. The seed should always be covered as soon as the carbon bisulphide has been poured over it; for, even though the fumes are heavier than air, they will to a large extent escape if there is no cover.

5. Carbon bisulphide does not injure germination nor does it spoil the seed for food.

Caution.—Never bring a lamp or fire, not even a lighted cigarette or pipe, near the fumes of carbon bisulphide as they are explosive and inflammable. The fumes themselves are not poisonous to man but tend to suffocate if inhaled for a long period.

Seed Corn Maggot or Bean Maggot

Hylemyia cilicrura Rond.

The seed corn maggot, or, as it is usually called in Ontario, the bean maggot, because it has done more damage in this province to beans than to corn, is a little white maggot about 1/4 inch long when mature, which attacks and destroys either the bean seed in the soil in spring or the young bean plants as they are coming through or soon after they have come through the soil.

The adults are olive-gray, two-winged flies about 1/5 inch in length. They look much like the cabbage maggot flies except for being a little smaller. The figure of the cabbage maggot adult on page 30 gives some idea of their appearance.

Fig. 15.—Work of seed-corn maggot or bean maggot on young bean plants. (After Gibson & Treherne).

Food Plants.—There is a long list of plants and seeds in which the maggots have been found, but beans, seed corn and seed potatoes are the chief in this province. It should be kept in mind, however, that almost any kind of decaying vegetable matter is likely to attract the flies to lay eggs on it.

Injury.—It is usually only in a cold, wet spring when germination is slow and growth retarded that this insect causes serious damage. In such seasons the maggots destroy beans either by attacking and killing the seed before it can germinate or by working into the stems soon after germination and killing them. The injury is commonly worst where the beans have been sown in fields which were in clover, alfalfa or grass the previous year, the reason probably being that the decaying roots and stems of such plants attract the flies and cause many eggs to be laid in them even before the beans themselves are planted; then when the beans are planted the maggots from the above eggs attack the bean seeds and plants, often apparently in preference to the decaying roots of the previous crop.

Poor drainage is also favourable to maggot injury because the growth and germination in such places are slower.

Seed corn is injured much the same way as beans.

Seed potatoes are occasionally so infested by maggots as to be utterly destroyed.

Life History.—So far as known this insect winters over in the puparial stage, just as the cabbage and onion maggot do, in the soil where the maggots have been feeding. The puparia are about the shape of a grain of wheat and are brown or reddish brown. From them in May, usually several days earlier than the cabbage maggot flies, the adults begin to appear. Eggs are soon laid and are usually placed on or in the soil where there is an odour of decaying vegetable matter or of decaying seeds. Manure recently ploughed under is said to attract the flies.

The eggs hatch in two or three days. The maggot stage requires about 11 days and the puparial stage about two weeks. There are apparently three generations or one full generation and two partial. Of these the first, which occurs in late May and June, causes nearly all the damage.

Control.—Growers should keep in mind that it is only in a wet spring when growth is backward that the maggot is likely to cause any serious injury. Under these conditions the following recommendations should be of value:

1. Good drainage always helps.

2. There is little or no benefit to be gained by treating seed with kerosene, turpentine, tar or any other substance tested up to the present. None of them will protect it.

3. The more quickly the seed germinates, the less liable the beans are to injury; hence, sow only seed of high germinating power; prepare the soil well to warm it and to be in good shape to bring about rapid germination and growth; and sow the seed shallow, never deep, because the upper soil is warmer than the lower and therefore the seed in it will germinate more quickly.

4. Remember that there is more risk in sowing land broken up from sod, especially clover or alfalfa sod, than other land. In such cases, work the field up well early in spring to make a good seed bed and then if the weather is warm sow early; but, if it is wet and cold, postpone sowing until there have been several days of warm weather to heat the soil.

5. If early sown beans have been ruined by the maggot it is usually safe to work the field up again and re-sow, as by this date the majority of the maggots in the field will have ceased feeding.

INSECTS ATTACKING BEETS AND SPINACH

Spinach Leaf Miner

Pegomyia hyoscyami Ponzer.

The spinach leaf miner is also called the beet leaf miner. It is a creamy white maggot very like the cabbage and onion maggots but, instead of attacking the roots as they do, it makes mines in the leaves. The adults are grey, two-winged flies of much the same shape as the cabbage maggot fly but a little smaller. The grey colour and yellow legs will help to distinguish them from other flies, which might be found around the same plants.

Food Plants.—Spinach, chard, beets of all kinds, including sugar beets and mangolds, are the common cultivated plants fed upon. In addition pigweed and lamb's quarters are quite heavily attacked. A few other weeds are also attacked but to a much less extent. The miner in dock leaves is a different species.

Injury.—The injury is caused by the larvae making mines in the leaves, especially in June. The mined portion of the leaf dies and turns brown or white. As several larvae usually work in each mine and as there may be half a dozen mines in a single leaf when there is a severe outbreak, many plants may be killed. It is not an uncommon sight during such an outbreak to see whole fields of beets or mangolds with fully half of their leaves either dead or severely mined. Yet in spite of this a very large percentage of the plants, as a rule, outgrow the injury and give fair yields, though doubtless not so large as they would have given if there had been no miners. When spinach is severely attacked the crop is usually ruined, because no one wants to buy infested spinach leaves and the time necessary to select only the intact ones is too great to make it profitable to harvest the crop. Fortunately most years the insects are not abundant enough to cause much damage or anxiety. It is only about once in four or five years or even longer that they are very numerous.

Fig. 16.—Work of spinach leaf miner in beet leaves (A. Wilkes).

Life History.—The winter is passed in the soil, just as in the case of the cabbage maggot, in the pupal (puparial) stage. From this in spring the flies commence to emerge towards the end of May and begin laying eggs about the first of June. These are white and are placed on their side in small clusters, averaging about 4 eggs each, on the under surface of the leaves. They hatch in four or five days. The young larvae bore directly into the leaves and soon make a conspicuous mine. As there are often many clusters of eggs to a leaf there may be many mines and, as these frequently coalesce, the whole leaf may in this way be killed. When dissatisfied with a mine, a larva commonly leaves it, migrates to another leaf and mines it. Often it leaves this second one and goes to a third or even to a fourth. The larval stage lasts about two weeks, then the larvae leave the mines and pupate in the ground. From the pupae adults begin to emerge in approximately two weeks. There are apparently three generations a year, though the last two are only partial generations. The first generation is the one that causes nearly all the damage, natural control factors being sufficiently strong to prevent much injury from the second or third generation.

Control.—No really satisfactory control measures have yet been discovered. Spraying with nicotine or other substances fails to do any good, because the spray cannot penetrate through the epidermis of the leaf and reach the larvae within. As the flies are known to be fond of sweet substances and as they apparently do not begin laying eggs for about a week after they emerge it is possible that the beets and mangolds might be protected during the danger period in spring by spraying them with 1½ pounds arsenate of lead to 40 gallons of water to which has been added 1 gallon of cheap molasses. The spraying would only be effective when the weather was dry. It should be applied about 4.00 p.m. on a bright, warm, calm day. The first application should, of course, be made just as soon as the eggs can be found on the under side of the leaves. The eggs are very similar in appearance to the cabbage maggot eggs shown in figure 20, and can be seen easily with the naked eye. A second application made in about four or five days should kill most of the flies which emerged in the meantime and these two should give the plants a chance to make sufficient headway to escape any serious damage.

As the flies move around freely it would probably be sufficient to spray every third row. A barrel sprayer could be put on a cart and equipped with two short stationary leads of hose, and a single disc nozzle on each, set about six inches above the plant. This would make it possible for one man to drive, pump and do all the work. Very little spray would be required and also very little time.

Caution.—It would not be safe to spray spinach with a poison, hence only mangolds and beets could be treated.

Another method which would help considerably in reducing the number of flies is to destroy all pigweed and lamb's quarters as soon as mines begin to appear in considerable numbers in them. Up to this time they would, of course, serve as traps and entice many flies to oviposit upon them instead of upon the cultivated food plants

INSECTS ATTACKING CARROTS, CELERY AND PARSNIPS

Carrot Rust Fly

Psila rosae Fabricius

The carrot rust fly larva is the little white or cream-coloured maggot which often ruins carrots and to a lesser extent parsnips by burrowing into them, destroying the tissues and leaving rusty stains wherever it works. The larva is about 1/3 of an inch long when full grown, is very slender and has no legs and no visible head, though there is a pair of small black hooks at the smaller end which serve as jaws.

The adults are slender, two-winged, glossy, greenish-black flies about ¼ of an inch long with yellow or yellowish-brown heads and legs.

Food Plants.—Carrots are the favourites but parsnips are also attacked and to a lesser extent celery and parsley.

Injury.—All the injury is done by the maggots and takes place at two periods in the season—in spring, in June and July and in fall, in late August, September

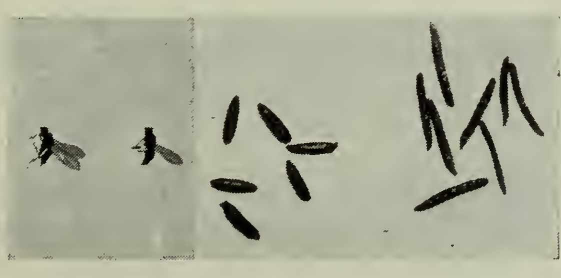


Fig. 17—Carrot rust fly—adults on the left, pupae in the centre, larvae on the right, all natural size. The larvae are not black as in the figure but cream-coloured or white.

and October. The fall injury is nearly always much the more serious. In June the early brood of maggots attacks the young plants, burrows into the tap root, and, if abundant, either kills the plants or checks their growth greatly. The attack is in full headway about the time the carrots are ready to thin. In fall the late brood attacks the carrot and parsnip tap-roots, which are of course well developed by this time. Narrow rusty-coloured furrows are made here and there over the surface, and tunnels through the interior. The tunnelling is usually most common towards the tip of the root, and this portion often becomes dark and rotten.

The injury to celery and parsley is brought about chiefly by the maggots attacking the roots. Usually the plants are vigorous enough to withstand the attack by sending out new roots. Where, however, several main roots are destroyed the plants often become stunted. The grower may not be aware that this is due to the maggots, especially as they seldom bore up into the saleable portions.

It is probable that in normal seasons the carrot rust fly prefers sheltered places, for most of the complaints of injury have come from towns and villages. Nevertheless, during heavy outbreaks even exposed fields may be heavily infested.

Life History.—The winter is passed chiefly in the ground near where the food plants were, in the puparial stage, the puparium being brown, about ¼ inch long and 1/16 of an inch thick, and rounded at each end. Many of the maggots are still immature when the plants are harvested. These continue to feed and grow in storage and finally pupate there. The adults begin to emerge in the fields in May and emergence continues well into June. Egg-laying begins in about four days after emergence.

Fig. 18.—Work of carrot rust fly on carrots. Note the scars on the surface. About half natural size.

The eggs are very small, white and elongate and are laid chiefly in or upon the soil close to the food plants. They hatch in about a week and the maggots require nearly a month to become full grown. At the end of this period they pupate in the soil. The new brood of flies emerges in August and early September and lays eggs for the second brood of maggots. These when mature pupate in the soil, as said above, and winter there. There are probably only two broods a year, though in New York there is a partial third generation which occurs in October and November.

Control.—It is doubtful whether in commercial plots it will pay to use any control other than to rotate carrots or parsnips with other crops and to plant them where they will be exposed to the wind, because it is only rarely that the insect is troublesome to any appreciable extent in such plots. If, however, the grower is afraid that he is going to suffer severe loss, the writer would suggest that at the end of August he pull up a few carrots here and there throughout the plot and, if he finds a number of these are being attacked, harvest the crop at once before more eggs hatch and more larvae attack the roots. The carrots or parsnips should then, if only lightly attacked, be sold or stored in a cool place in soil taken from some spot where there could be no danger of its containing eggs or larvae.

Such substances as derris, naphthalene, corrosive sublimate and mercurous chloride have in experiments in a number of places given fair results, but the cost would usually be too high to justify their use, especially as it is difficult for the grower to know whether the insect would do any damage in any particular year even if no control measures were taken. Moreover, most of the substances cause injury either to the foliage or roots of the plants and so lessen the yield.

Parsnip Webworm

Depressaria heracliana DeGeer

The parsnip webworm is the caterpillar that attacks the blossom heads of parsnips and carrots when allowed to grow for seed. It webs the blossom parts together and by feeding upon them prevents the formation of seed. Like most other insects it is much more abundant some years than others. The caterpillar when full grown is about ¾ inch long, yellowish green in colour with a black head and many conspicuous black spots over its body. The adult is a brown moth of the size and shape shown in the illustration.

Life History.—The winter is passed in the adult stage in sheltered places, often in attics or barns. About June the moths lay their eggs on parsnips and carrots grown for seed and also on wild carrots. The larvae on hatching work their way to the unopened blossom heads, eat into them, web the unexpanded blossom parts together and feed upon them. The result is that the blossoms

Fig. 19.—Parsnip webworm—(*a*) adult with wings closed, natural position; (*b*) same with wings expanded; (*c*) larva full-grown; all natural size.

cannot open properly and of course cannot produce seed. After feeding for nearly a month on the blossoms and neighboring leaves and becoming nearly full grown the larvae crawl down the plants, eat a hole into the hollow stem, feed there a few days and then spin a cocoon and pupate within the stem. Many persons finding the larvae in such places mistake them for the European corn borer, but the black head and black dots on the body easily distinguish them from the corn insect. In August the pupae change into moths. These fly around for awhile and then go into winter quarters; so there is only one generation a year.

Control.—Heavy dusting of infested heads with Paris green 1 part mixed with about 20 parts of land plaster or hydrated lime sometimes destroys a considerable portion of the worms but at other times only a few. The difficulty is to get the poison forced into the webbed portion in such a way that the larvae will eat any of it.

2. Cutting off and destroying all infested heads as soon as seen is the most common method practised. This should be supplemented by the destruction so far as practicable of all wild carrots in the neighborhood. Even cutting these down as soon as they begin to bloom should help greatly to lessen the number of moths for the next year.

INSECTS ATTACKING CABBAGE, CAULIFLOWER, TURNIPS, RADISHES AND CLOSELY RELATED PLANTS

Cabbage Maggot

Hylemyia brassicae Bouche

The cabbage maggot is probably the most destructive insect which attacks cabbage, cauliflower and radishes. It is a small white maggot about ¼ inch long when full-grown. The body is blunt at one end and tapers gradually towards the other. There are no legs and no visible head, but a pair of black hooks at the smaller end of the body takes the place of jaws and tears apart the plant tissues, thus freeing the juices on which the maggot lives.

The adults are two-winged flies about the size of a housefly. The females are greyish brown or olive brown; the males are darker, being of a steel grey colour.

Injury.—The maggots attack the roots of cabbage, cauliflower, radishes and several other closely related plants. In the case of the former two, the injury is done, not only by the maggots devouring the small roots, but also by their feeding in the main tap-root itself and destroying it. The result is that the plants soon

Fig. 20.—Cabbage maggot—female adult and eggs, the latter slightly enlarged.

wilt and die. The early crop suffers much more injury than the late. Radishes are even worse attacked than other plants. The maggots work their way into them, make brown tunnels wherever they go and often cause much of the interior to rot. Wormy radishes are of course unfit for table use. Seed beds of cabbage and cauliflower, especially for late planting, are also often damaged severely.

Life History.—The winter is passed in the pupal (puparial) stage in the ground near the roots of the affected plants. The pupae are reddish brown and resemble in shape and size plump grains of wheat. In spring about the time European plums are coming into full bloom the flies emerge and in 3 or 4 days begin laying their little, white, elongate eggs in the soil close to the stems of the plants. These hatch on an average in 5 days. The maggots feed as described above and become mature in 2 or 3 weeks. They then pupate in the soil and in another period of 2 to 3 weeks, the new brood of flies begins to emerge. There are three generations a year, but only the first generation is a full one, as many of the pupae (puparia) of the other two remain unchanged in the soil until the next spring.

Control.—Much the best method of control is to treat the soil around the base of the plants with corrosive-sublimate solution of the strength of 1 ounce in 8 to 10 gallons of water. Dissolve the corrosive sublimate by mixing it first with a stick in a little water so that it will be thoroughly wet and all lumps broken; then add more water and stir thoroughly until it is all in solution. It requires about half a gallon of water to dissolve an ounce readily. When all is in solution dilute to the proper strength. The liquid should always be applied to the plants shortly before or as soon as the eggs have begun to hatch; for it controls by killing the eggs and the young maggots before the latter have entered the roots. Therefore, if cabbage or cauliflower have been set out very early do not apply it until European plums are in full bloom, as very few eggs will have been laid until this time. If the plants are not set out until that date or later apply the solution the third or fourth day after planting and repeat in a week. Two applications are usually sufficient but many growers prefer to give three,

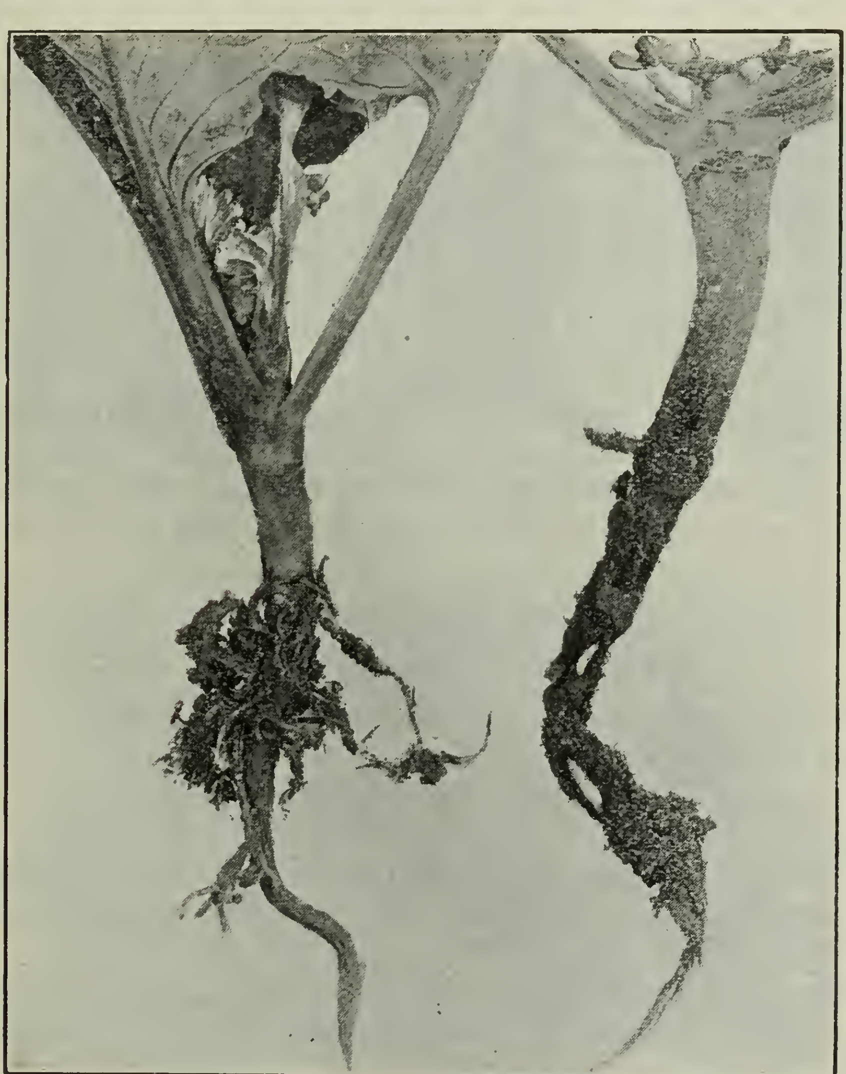


Fig. 21.—Work of cabbage maggot on cabbage roots.

the third being a week after the second. The poison should be poured directly on the soil right against the stem, using about 1/3 to ½ of a cupful to each plant. On small plots this may be done easily by carrying the mixture in a wooden pail and applying it with a cup or dipper. A handy dipper can be made from an empty tomato can by tacking a lath about 14 inches long to the bent-back lid and then squeezing the top to form a spout. On large fields a barrel may be placed on a cart or wagon and filled with the solution, and two lines of soft rubber hose fastened to this. Then two men, one to each hose, can apply the liquid by walking along behind the outfit, pinching the hose between plants to prevent the escape of the liquid and releasing the pressure at each plant. They should always take care to see that the soil is thoroughly wet for about an inch around each of the plants.

In the case of radishes, too, the corrosive sublimate solution should not be applied until European plums are in full bloom if the radishes have been planted and are through the ground before that date. If the radishes have not come through the ground until after the plums are in full bloom apply the poison on the third or fourth day after they appear above the ground. If, however, the weather is cold it will be wise to wait a day or two until it warms up, as the flies are not active in cold weather. Repeat the application in five or six days. A watering can with the knob or rose removed is a handy way to apply the liquid. Pour it along the rows right upon the plants, and wet the soil for half an inch or more deep. The radishes, of course, should be planted in rows to make treatment easy.

Never treat radishes when they are nearly ready to use. It will do no good and may poison those who eat them; but there is no danger of poisoning if treated at the time mentioned above.

In treating cabbage and cauliflower seeds beds saturate the soil thoroughly by means of an ordinary watering can. Wash the can out thoroughly after using to prevent its being corroded, as corrosive sublimate will injure any kind of metal vessel though it does not injure wood. It is a good plan to paint the can inside before using.

Caution.—Remember that corrosive sublimate is a deadly poison; hence be sure that none of it is left in any vessel where children or livestock may have access to it. Keep the substance itself labelled **Poison.** The antidote is to cause the patient to partake freely of white of egg or milk, and in ten minutes give an emetic.

Imported Cabbage Worm

Pieris rapae Linn

The imported cabbage worm is a very common insect and is found in every garden or field in which cabbage is grown. When full grown it is about one-and-one-eighth inches long, is about the same shade of green as the leaf, has an indistinct golden line down the back and when examined under a hand lens is seen to be densely covered with very short green hairs dotted with black specks. This hairy covering easily distinguishes it, even when very small, from any other green caterpillar which may be present.

The adults are the white butterflies seen flying about every year. These have a wing expanse of about one-and-three-quarter inches. The wings are all white except a small black area at the tip of the front wings, two small black dots on the front wings of the female, but only one on those of the male, and a single black dot on the hind wing of both sexes.

Food Plants.—The favourites are cabbage and cauliflower. Next to these are turnips, rape, Brussells sprouts, kale and radish. In addition the caterpillars occasionally feed on various weeds and wild plants of the cabbage or mustard family (Cruciferae).

Injury.—Some years the caterpillars are not abundant enough to do much damage but about every second or third year on an average they become so numerous that they strip whole fields of cabbage and cauliflower of almost all their leaves except the midribs and larger veins. They also attack the heads and eat large cavities out of them. At the same time they deposit their dark green excrement in large quantities upon the heads, which, in the case of cauliflower especially, stains the head and makes it look most unsightly. The result is that a large part of the crop of both plants is rendered unmarketable. Usually late or moderately late sown plants suffer worse than the early sown ones, though at times the latter are also much injured.

Life History.—The winter is passed in the chrysalid or pupal stage on the plants in the field or on boards or rails of fences or in any other sheltering quarters. The chrysalids are about three-quarters of an inch long, are roughly triangular in outline and vary in colour from green to grey or brown. From them the butterflies begin to emerge in May and in a short time commence laying eggs. These are yellowish, and are attached singly by the end to the leaves,

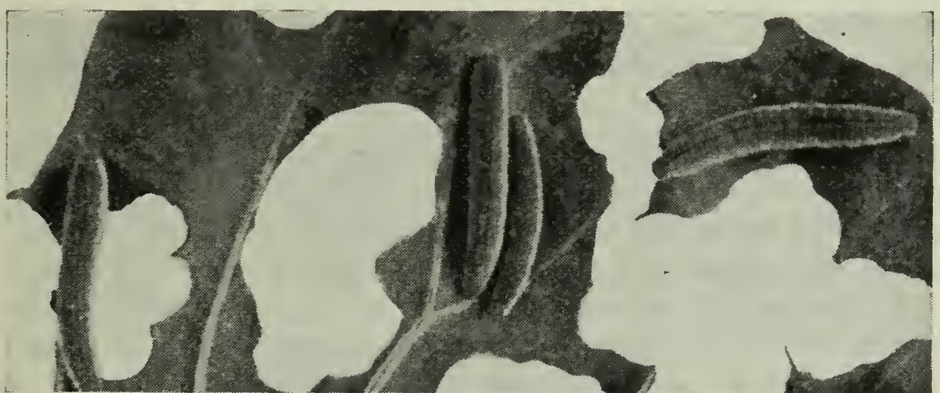


Fig. 22.—Imported cabbage worms, natural size (after Britton).

Fig. 23.—Work of imported cabbage worms on cabbage.

chiefly on the under side. The eggs hatch on an average in five days. The larvae require two to three weeks to mature. They then change into pupae or chrysalids chiefly on the leaves or stems and in about nine days the butterflies emerge. The life cycle from egg to egg is therefore four to five weeks. There are at least three generations in the province and in the warmer portions probably a partial fourth. Larvae may be found in fields from about the first of June until the severe frosts come.

Control.—If taken in time the worms are easy to control but if left until they have attacked the heads of the plants control is sometimes rather difficult. The simplest method is to dust the plants as soon as caterpillars are present and in any case just before they begin to head, with one of the following mixtures:

(*a*) Arsenate of lead one part (by measure) to three parts of hydrated lime or gypsum;

(*b*) Paris green one part (by measure) to eight or ten parts of hydrated lime or gypsum. The dusting should be thorough, covering every leaf so far as possible, and should be put on at a time when there is no wind and preferably when the plants are moist as with dew in the early morning.

Arsenate of lime in our experiments did not give so good control as either of the above.

Spraying may be substituted for dusting but is seldom so satisfactory. The same poisons may be used: arsenate of lead at the strength of two pounds to forty gallons of water; or one ounce to one-and-a-quarter gallons of water; or Paris green one pound to forty gallons of water or one ounce to two gallons of water. If two pounds of soap dissolved in water are added to every forty gallons of either of the above mixtures it will help the mixture to spread and stick better. Three ounces of calcium caseinate mixed up first into a paste with a little water may be substituted for the soap.

Cabbage may be re-dusted or re-sprayed whenever necessary after heads have formed without any danger to the consumer, provided there are no deep cavities present for the poison to lodge in. As cabbage heads grow from the inside, not the outside, the practice of taking off the outer leaves before shipping or using removes all the poison on the surface. It is dangerous, however, to use poison on cauliflower heads after they have begun to form; hence the importance of treating these plants thoroughly just before they are tied up or begin to head.

If cauliflower heads or cabbage heads with deep cavities are being attacked and must be protected the safest method is to mix one ounce of pyrethrum powder in one or one-and-a-half gallons of water and spray this with good pressure directly down into the head where the worms are. It kills by contact and is not poisonous to humans. The pyrethrum should either be fresh or have been kept in an air-tight package. Concentrated extracts of pyrethrum are now being put on the market under various trade names. These should be as effective as the pyrethrum itself.

The Cabbage Looper

Autographa brassicae Riley

The cabbage looper is a pale green caterpillar about one-and-a-quarter inches long, when mature, with white longitudinal stripes on the back and sides.

The head end of the body is smaller than the rest. When the caterpillar walks it raises its body in a loop after the manner of cankerworms. This characteristic itself will easily distinguish it from the imported cabbage worm.

The adult is a dark brown moth with a conspicuous small silvery mark near the centre of each front wing. The moth is closely related to and resembles cutworm moths. It has a wing expanse of about one-and-a-quarter inches.

Injury.—The cabbage looper feeds upon cabbage, cauliflower, turnips and other closely related plants, eating holes out of the leaves and boring into the heads. The injury is so similar to that of the imported cabbage worm that it would often be impossible to decide which was responsible, if the presence of the caterpillars themselves did not give the clue. Although present to some extent every year, it is usually not so abundant as the imported cabbage worm and therefore not so destructive. There are, however, years when it is more abundant and more destructive.

Life History.—The full life history has not been worked out for this province but is about as follows: The winter is passed in the pupal stage in a white silken cocoon usually on the plants themselves on which the larvae fed. In spring about the time cabbage plants are getting well established the moths emerge and lay their eggs on the leaves, generally on the under surface. The eggs are circular, whitish, and have ribs radiating out from the centre to the circumference. They hatch in four days. The larvae become full-grown, according to our rearing experiments, in an average of twelve days. The pupal stage

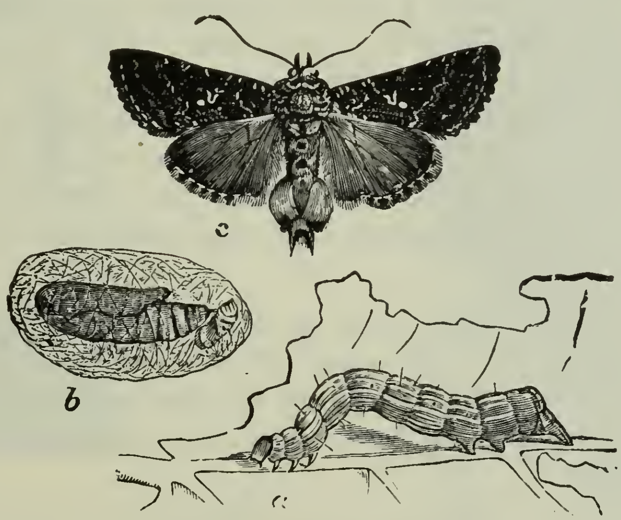


Fig. 24.—Cabbage looper—(*a*) larva; (*b*) cocoon; (*c*) moth; all natural size.

requires the same length of time. Four days after emerging the moths begin laying their eggs; hence the life cycle from egg to egg requires approximately one month. There are apparently three generations a year, larvae of the last generation being present up to the end of October.

Control.—As the habits of the caterpillar are very like those of the imported cabbage worm the same methods should be used to keep it under control. Control measures should, of course, always be applied before the insect has had a chance to do much damage and should be repeated as often as necessary.

Cabbage Aphid and Turnip Aphid

There are two species of aphids which attack cabbage, turnip and other plants of the same family and which at times cause much damage. These are the so-called "cabbage aphid" (*Brevicoryne brassicae* Linn) and the "turnip aphid" (*Rhopalosiphum pseudobrassicae* Davis). These two can be distinguished readily from each other by the fact that the cabbage aphid is covered with a whitish powder and has a greyish-blue appearance, whereas the turnip aphid is almost naked and is yellowish or light brownish-yellow in colour.

Injury.—Both are of course sucking insects and feed by piercing through the surface of the leaf with their sharp mouth-parts and extracting the juices. They live chiefly on the under surface of the leaves and during severe outbreaks may literally cover that side of the leaves and then swarm over onto the upper surface as well. The result is that in a short time the leaves become so drained of their juice that they turn a sickly yellow colour and the plants either die or are much dwarfed. If the attack occurs late in the season turnips often begin to decay and the odour may be detected half a mile away. Sometimes, however, disease, parasites and other natural enemies step in and save the crop just when it seems doomed. Fortunately most years neither species is abundant enough to do much harm. Of the two, the cabbage aphid is the more common, but outbreaks even of it usually occur only about one year in five.

Control.—It is difficult to combat either species successfully without great care and considerable expense. Of several methods tested none was found satisfactory except dusting the plants with a two to two-and-a-half per cent. nicotine dust made by mixing together in a mixing machine five to six pounds of nicotine sulphate with 95 to 94 pounds of hydrated lime. This must be heavily applied to the under surface of the leaves with a hand or a power duster so that every aphid may be hit. To the power duster there should be attached a trailer made of cotton fastened to a light frame to hold the dust down and concentrate it on the plants. At least 50 pounds of dust are required per acre. Dusting should of course be applied promptly once the aphids are seen to be numerous enough to justify it.

As many aphid eggs winter over on the leaves and stalks the feeding or ploughing under of these will help some to lessen the number which will survive but will not completely control the insects for the next season, as winged forms, which are produced from time to time, will fly from one field to another and thus establish new colonies.

Diamond-Back Moth

Plutella maculipennis Curtis

The diamond-back moth is the adult of a small light-green worm, which attacks cabbage, cauliflower, Brussels sprouts, turnips and many other closely related plants.

The larvae can be distinguished readily from the imported cabbage worm and the cabbage looper by its size: when full grown it is a little less than half-an-inch long; whereas the other two larvae are each an inch or more in length. Its head is greenish-brown with many darker brown spots on it; the heads of the other two species are either pale or dark green with no noticeable markings. Under a hand lens the imported cabbage worm, even in its immature stages, is seen to be densely covered with very fine hairs with little dark specks among them; the diamond-back larva is hairless except for a few short spines. The cabbage looper has white stripes down the back and sides, the diamond-back has none.

The adult is a small greyish-brown moth with a slender, dark brown body and a wing expanse of about two-thirds of an inch.

Injury.—Though this insect is not nearly so important as either the imported cabbage worm or the cabbage looper yet it is present to some extent every year and occasionally becomes so abundant as to cause much damage. The larvae feed chiefly on the under side of the leaves and eat small areas almost through them. The epidermis immediately above these areas dies and a hole soon forms. If the larvae are very numerous they do so much feeding that the plants at a distance look almost bleached. In such cases the crop is of course largely ruined. When Brussels sprouts are attacked the insect often bores into the nubs and makes them unsaleable. The worst attacks recorded in Canada have taken place in June, July and August.

Life History.—The life history of this insect has not been carefully worked out in this province. There seems no doubt, however, that the winter is passed

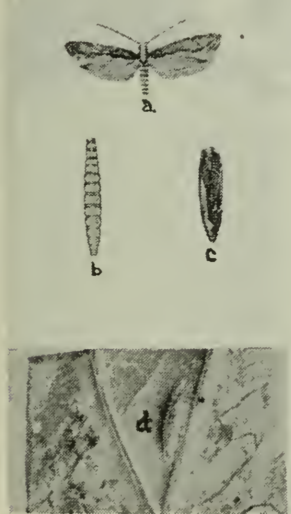


Fig. 25.—Diamond-back moth—(*a*) adult; (*b*) larva; (*c*) pupa; (*d*) cocoon on leaf. (*a, b, c* adapted from Marsh, U.S.D.A.; *d* original). All about natural size.

Fig. 26.—Work of diamond-back moth on turnip leaf. (After Marsh, U.S.D.A.).

in the moth stage under leaves or any other hiding places. The pupae seem unable to withstand even a moderate degree of frost and so must all perish with the advent of winter. In the spring, soon after cabbage and other allied plants are set out, the moths appear and lay their tiny yellowish to whitish eggs on the under side of the leaves. These hatch in a few days and larvae may become numerous in June. When full grown the larvae construct a thin lace-like, silken cocoon on the leaves and pupate in this. The whole life cycle from egg to adult may be passed in about 25 days, hence, as all stages are found up to the end of the season, we are safe in inferring that there are at least three generations and possibly four.

Control.—The same control measures should be used as given for the imported cabbage worm.

Turnip Flea Beetle

Phyllotreta vittata Fab.

Many a farmer in this province has from time to time had his turnips destroyed by a little black beetle about one-twelfth of an inch long with a wavy inconspicuous yellow stripe down each wing cover. The injury is nearly always done during the first week or two after the plants have come through the ground. It is brought about by the beetles eating so many holes in the little leaves that these wither up and the plants die. Farmers usually speak of the insect as the "turnip fly." It is, however, not a fly but a beetle and is called by entomologists the turnip flea beetle or the striped cabbage flea beetle.

The larva is a yellowish white worm with a brown head. It is slender and one-third of an inch in length when mature.

Fig. 27.—Work of turnip flea beetle on radish leaves, natural size.

Food Plants.—Although the injury to turnips is greatest yet radishes, cabbage and cauliflower are also sometimes severely attacked, the latter two often in seed beds. In addition the insect attacks wild mustard and several other plants of the cabbage family, whether wild or cultivated.

Life History.—The life history does not seem to have been carefully studied. The winter is passed in the beetle stage under leaves or rubbish or anything else that affords good shelter, usually near where the insects have been feeding. In May the beetles come forth from winter quarters and begin feeding on the various food plants. When turnips, radishes or cabbage appear above ground the insects often migrate from nearby places to them and eat holes in the leaves. Eggs are laid around the base of the food plants, sometimes in cavities eaten in the main root. The larvae from these eggs feed upon the roots but they evidently do little harm. Pupation takes place in the ground. There is little doubt that there is only one generation a year. The beetles of the new generation appear in summer and feed upon the leaves of their regular food plants until the appearance of frost, when they go into winter quarters. Almost no damage is done by this feeding as the leaves are then enlarged and can withstand a lot of feeding.

Control.—The destruction of weeds, especially those of the cabbage or mustard family, such as all kinds of mustard, peppergrass and shepherd's purse, will lessen the number of beetles in the vicinity and so lead to less injury of cultivated plants the following year. Feeding off or ploughing under all remnants of cabbage, turnips and closely allied plants in the fall of the year would also help in the same way.

Seed beds of cabbage and cauliflower may be protected by cheesecloth screens, which must of course be put on before the beetles appear in spring and kept on until the plants are about ready to be transplanted.

Turnips sown after the 21st of June are seldom severely attacked, as the beetles will largely have disappeared by the time such plants are through the soil; hence if the early sown turnips are killed it is usually safe to work the soil up again and re-sow at once.

When young plants are being attacked the beetles may to some extent be driven off by spraying the plants heavily with Bordeaux mixture 4, 6, 40 formula or with two pounds arsenate of lead to forty gallons of water or by dusting with arsenate of lead one part and hydrated lime ten parts by volume. It has recently been found in British Columbia that a 3% nicotine dust will kill the beetles and thus protect the plants. Recent tests at Guelph with a commercial pyrethrum soap spray indicates that sprays of this character will be effective. In spraying the nozzles should be held close to the plants and the same should be done with the outlet of the duster when dusting. This is to save material and to concentrate the liquid on the tiny plants themselves. Any treatment should usually be repeated in about four days, or as soon as the beetles have again become abundant.

Zebra Caterpillar

Mamestra picta Harris

Fig. 28.—Zebra caterpillar and adult.

The zebra caterpillar is a pretty larva with alternate black and yellow longitudinal stripes on its back. It, of course, receives its name from these conspicuous markings. The caterpillar when full grown is nearly two inches long.

The adult is a stout, dark, reddish-brown moth with a wing expanse of one-and-a-quarter inches.

The larvae usually are not abundant enough to do much harm but every once in a while they occur in great numbers in autumn, especially on turnips and cabbage, and almost entirely defoliate these plants. They sometimes are fairly numerous also on celery and a few other vegetables.

Life History.—The winter is passed in the pupal stage in the ground. The moths emerge in May and lay eggs in clusters on the leaves. From these come the first brood of caterpillars. These work during June and early July. When full grown they pupate in the ground, and from the pupae moths begin emerging late in summer and produce the fall brood of larvae which feed in September and early October and are almost always more injurious than the spring brood.

Control.—The caterpillars can be destroyed with considerable ease by dusting the plants heavily with Paris green mixed with about ten times its own bulk of hydrated or air-slaked lime or gypsum. Arsenate of lead or arsenate of lime with about four times their own bulk of lime or gypsum may be substituted for the Paris green. It must always be borne in mind, however, that an arsenical should not be used at this time of the year on any foliage which is likely to be fed to cattle or other livestock or which human beings may use.

INSECTS ATTACKING CORN

European Corn Borer

(*Pyrausta nubilalis* Hübn)

Fig. 29.—European corn borer adults, female on left, male on right, natural size (J. Marshall).

The European corn borer* is apparently the most serious insect pest that has at any time been introduced into North America and seems capable, unless control measures are carried out thoroughly, of destroying the corn industry in all the main corn-growing areas of Canada and the United States. It is particularly destructive to sweet corn, because it readily attacks the ears and renders the crop unmarketable.

The borer itself is a whitish or brownish white caterpillar sometimes with a pinkish tint and is, when full size, about one inch long. The head is dark brown and there are many small dots over the body.

*For a fuller account see bulletin No. 358, The European Corn Borer, by L. Caesar and R. W. Thompson, Ontario Agricultural College, Guelph.

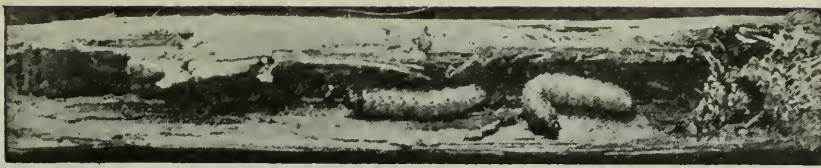


Fig. 30.—European corn borer in burrows in pieces of corn stalks, a little reduced; the larvae should be about one inch long (G. Spencer).

The female adult is a creamy-yellow moth with brownish markings on the wings. The male is a little smaller than the female and darker in colour, being pale brown with creamy-yellow markings. (See figure 29.)

Food Plants.—In Ontario nearly all the eggs are laid on corn, no variety being exempt, but a few are also laid on oats and barley with an occasional one on gladioli, dahlias, zinnias and sugar beets. The borers which hatch from the eggs on oats and barley practically all die, because these plants ripen too early for the borers to complete their growth. Hence corn in Ontario is the only plant on which the borer breeds to any appreciable extent. Borers are, however, often found in stout weeds in corn fields; but in such cases they have come out of the corn into the weeds and did not breed on them.

In corn the borers work into and make burrows in any part of the plant large enough to conceal them, from the tassel down to the root. A severely infested corn field is a saddening sight: almost every tassel is broken off; every

Fig. 31.—Field of corn badly broken down by borers. (Photo by H. G. Crawford, August 19th).

leaf killed and either fallen off or hanging close to the stalk; the ears are broken down, many of them are rotten, the remainder are stunted and most of them are riddled by borers; the stalks are punctured by borer holes on the outside and darkened with filthy burrows and borer castings inside; thus the whole field is reduced to a tangled mass of worthless, rotting plants.

Life History.—The winter is passed as full-grown borers in burrows in any part of the corn plants, including the stubble, large enough to hide them, and also in weeds among or very close to the corn. Early in June the borers begin to pupate and about the end of the month or early in July the moths begin to emerge and continue to do so for a month or a little more. Egg-laying commences in three or four days after the moths appear. The flat, white eggs are laid in little clusters of from two or three to about seventy on the underside of the leaves. They hatch in about four days. The larvae, soon after hatching, work their way into the plants and make tunnels in the interior, usually working first in the stem of the tassel and causing it to fall over. They become full grown and cease feeding in the latter part of August or early September and remain over winter either in the burrows where they fed or in new ones made for the purpose in corn or stout weeds among the corn. In the counties of Essex and Kent pupation of borers and emergence of moths begins about a week earlier than in most of the rest of the province.

Control.—By far the simplest, most practical, and economical method yet discovered of controlling the corn borer is to kill the larvae either in fall or spring while they are still in the corn plants, or their remnants, including the stubble, or in the weeds which grew up among the corn in the field. This can be done by ensiling or feeding or burning all the corn stalks or pieces of stalks or cobs and by ploughing under completely all the stubble or other corn remnants or coarse weeds among the corn and not dragging any of these up again when cultivating the soil or sowing the next crop, or, if they are dragged up, by picking off and burning those that have come to the surface. All such measures must of course be completed before there is time for the borers to have changed into pupae and these in turn into moths which would lay eggs on the new corn plants.

Borers are often abundant in small plots of sweet corn such as are frequently found in villages, towns, the suburbs of cities and on many farms. These plots are usually planted early, and as the borers attack early corn most heavily the plots are a serious menace unless well cleaned up each year. The easiest and best way of dealing with them is to leave the corn until spring and then pull it and all stout weeds among or close to it, put them along with any remnants into a pile and burn them, and then spade or plough the ground.

In some localities sweet corn growers make a practice of not cutting the corn but of ploughing it down so that it will make humus. If this practice is to continue the ploughing should be done as soon as possible after harvesting the crop, so that the plants will be still green when ploughed under. This makes it easier to do a good job and also causes the plants to rot before winter. Hence in the spring fewer of them will be dragged up and have to be picked off and burned. A wide furrow plough should always be used instead of a narrow, and should be equipped with a chain. A wire about nine feet long with the one end dragging in the furrow and held taut by the furrow slice may be used instead of a chain and is lighter. The field should always be rolled after ploughing to help cover the stalks better and to pack them and hasten decay.

If the stalks are to be cut and removed before ploughing they should be cut level with the ground by a heavy sharp hoe, or sometimes they can be mowed off.

Corn Ear Worm

Chloridea obsoleta Fabr.

Fig. 32.—Corn ear worm and its work, natural size.

The corn ear worm receives its name from its habit of working in the ears of corn. It occurs almost exclusively in late summer and autumn and, while seldom of much importance, occasionally becomes very abundant and then does a great deal of damage to the ears by feeding on the kernels. In 1921, it occurred in such countless numbers all over the province that canning factories in some cases had to cease canning late corn.

Many persons confuse this caterpillar with the European corn borer but they may be distinguished easily by the fact that the European corn borer is only 1 inch in length when full grown and is whitish or brownish white with many small brown dots on its body; whereas the corn ear worm is 1½ inches long, varies greatly in colour, some being blackish, others brown, others green and others pinkish. Moreover, regardless of the colour, it usually has a broad longitudinal stripe along the side and lacks the small brown spots over the body characteristic of the corn borer. Another difference is that the corn ear worm limits its work almost entirely to the ear, especially the upper half of it, whereas the European corn borer bores into any part of the plant large enough to conceal it and is more common in the stalks than in the ears.

The adults of the ear worm are stout moths with a wing expanse of about 1½ inches and the same general appearance as cutworm moths, to which indeed they are closely related. The colour varies greatly, some being dull olive green, others yellowish and others light brown. The wings are usually bordered with darker bands.

Life History.—This will not be given here in detail further than to say that apparently the insect does not winter in this province, at least to any appreciable extent, and that the caterpillars we find in the corn in autumn all or almost all come from moths which have migrated here from the southern part of the United States, where this insect is a great pest, not only of corn, but also of cotton. In this province almost all of the insects seem to be destroyed by low temperatures while in the pupal or wintering stage.

Control.—There is no satisfactory control method adapted to our conditions and of course control measures are only rarely required in this province.

INSECTS ATTACKING CUCUMBERS, CITRONS, MELONS, PUMPKINS, SQUASH AND VEGETABLE MARROW

Striped Cucumber Beetle

Diabrotica vittata Fab.

By far the most common and destructive insect attacking cucumbers, squash and closely allied plants is the striped cucumber beetle. This beetle is about ¼ inch long with black head, yellow thorax and yellow wing covers with three distinct longitudinal black stripes on them.

The larvae, which are seldom seen, because they live beneath the surface of the soil, are slender, white worms with brown heads. The average length when full grown is about 1/3 inch.

Food Plants.—The favourite food plants of the beetles are cucumber, squash, pumpkin, vegetable marrow, melon, canteloupe, and citron. In the early part of the season they feed to a considerable extent also upon wild cucumbers, beans, burdocks, stinging nettles, pigweed, peas, radishes and curled docks. In addition they may be found on the silk of corn and the flowers of asters, sunflower and several other plants.

The larvae feed on the roots of cucumber and other cucurbits.

Injury.—The main injury takes place from the time cucumbers, melons or other favourite food plants mentioned above have just come through the surface until they begin to send out runners. During this period and especially just after the plants have come through the soil the beetles attack the leaves and often kill the young plants. Sometimes 50% or upwards of the plants in a large area are thus destroyed in less than a week. After the plants are far enough advanced to have begun sending out runners they grow so rapidly that the beetles can no longer do much harm. Moreover, once the flowers appear the insects prefer them to the leaves. Fortunately they do but little harm to the flowers.

Fig. 33.—Striped cucumber beetle—adults, larvae and pupae, all natural size (J. Marshall).

Another form of injury and a very important one some years is caused by the beetles transmitting a very destructive bacterial disease, known as "cucumber wilt," from diseased to healthy plants. A plant attacked by this disease suddenly wilts and dies. So far as known the striped cucumber beetle and its close relative, the 12-spotted cucumber beetle, are the sole agents in the spread of this disease.

The larvae, even though they feed on the small roots and bore into the larger ones, causing deformities in them, seldom do much damage if the plants are thrifty; but if the soil is poor and the plants not thrifty they may cause considerable damage.

Fig. 34.—Cucumber leaf with beetles feeding upon it, natural size.

Life History.—From our own studies and those of other investigators there seems no doubt that the only stage in which the insect winters is the adult. In this stage they have been found hibernating in dense grass, under leaves in woods and beneath remnants of the crop. In the spring about the time of the full bloom of apples or a little later, the beetles come out and at once attack young cucumbers, squash, melons or similar plants which have been transplanted or have appeared above ground from the seed. If these are not present, they feed in the meantime on wild cucumbers or on some of the other plants mentioned above but quickly desert them for cucumbers, squash and other cucurbits as soon as they appear. In about two weeks egg-laying begins and continues into August. The eggs are yellow and are laid singly or in clusters in the ground at or near the stem of the favourite food plants. Eggs hatch on an average in about ten days. The larvae feed on the roots as already mentioned. The larval period usually lasts about a month. Pupation then takes place in the soil near where the larvae fed. The pupae are enclosed in little earthern cells and if these are broken they usually perish. The pupal stage requires an average of about two weeks. About the first week in August the new beetles begin to emerge and continue emerging for several weeks. There is only one generation a year. The new generation of beetles feeds chiefly on the flowers of cucurbits and other plants and does but little damage. The beetles go into winter quarters soon after frosts have come in autumn.

Control.—It is always helpful if the soil is well prepared before planting and is well fertilized, for the plants then grow more rapidly and are thus able to withstand better the attacks of the beetles.

It is also a good plan in localities where the beetles are very numerous to sow the seeds thicker than usual. Then, if too many plants are left after the height of the attack is over, these can be thinned out.

Almost any attack can be combated successfully by one of the following measures.:

1. Inspect the young plants every second or third day for beetles and as soon as they are numerous enough to do any appreciable damage dust the plants both from above and below with gypsum (land plaster) and arsenate of lime (calcium arsenate) in the proportion of 20 parts of the former by weight to 1

part of the latter. Repeat whenever the beetles begin again to become numerous. Usually three or four applications are all that are required.

2. Another method that promises to give equally good satisfaction and that kills the beetles more quickly is, when dusting with the gypsum and arsenate of lime to leave a few rows at the side of the plot untreated. The beetles will largely congregate in these rows. When they have done so, spray them with one of the commercial pyrethrum extracts now coming upon the market. The mixture kills them quickly. It is perhaps too expensive for general use at present but not for a few trap rows, which will require only a few gallons of it. Usually about three applications three or four days apart will be required.

Nicotine dusts have been highly recommended by some persons but in our experiments were a complete failure in every case, as the beetles, though stupefied at first, all recovered.

Barium fluosilicate and some of the other fluosilicates and also derris, the former applied as dusts and the latter as a spray, are promising remedies, but at present are not on the Canadian market.

Hydrated lime is sometimes used in dusts instead of gypsum, but some years causes stunting of the plants and therefore should not be used, if gypsum can be obtained. Gypsum is almost as cheap as the hydrated lime. A moderately fine grade of it is required but not the finest, as this tends to be sticky and does not dust well.

The easiest way to apply the dust is by means of a good rotary or bellows hand duster. With one of these equipped with a long outlet pipe and an enlarged spoon-like tip the dust can be applied to the under side of the smallest plants as well as to the upper side, and several acres a day done. If the grower has no duster a burlap sack will do fairly well. A few pounds of the dust should be placed in this; then the operator should walk along the windward side of each row and dust the plants by giving the bag a quick shake over each hill. The main objection to the burlap sack is that the dust does not cover the under side of the plants so well as is desirable. Dusting can be done better on a calm than on a windy day, but it is sometimes necessary to do it at once, wind or no wind. We have not found spraying with most mixtures nearly so effective as dusting.

Squash Bug

Anasa tristis DeGeer

The squash bug is a large, stout, dark-brown insect about 2/3 inch long and nearly ¼ inch wide. It attacks all our common cultivated plants of the squash family as squash, pumpkin, cucumber, melon, canteloupe and vegetable marrow. Of these, squash and pumpkin are favourites. Though the insect may be found at times over most of the province, it is somewhat rare except in the southern part along the lake counties from about Toronto west to Windsor.

Injury.—Both adults and nymphs feed on the leaves of squash and the other plants mentioned by piercing through the surface with their sharp mouth parts and sucking up the juice. In the course of this operation it is believed they inject a poison into the tissues which increases the injury. The first evidence of attack is usually the formation of pale green areas here and there on the leaves. These areas later turn brown, die and wither. If the insects are very abundant many vines may have all their foliage turn brown and die, much as if a fire had run over them; but it is seldom that the injury is nearly so severe as this, the bugs usually being only numerous enough to destroy a few plants or a number of leaves here and there throughout the plot. Probably their habit of feeding together in groups while they are young helps to prevent more general injury. Occasionally some damage is done to the fruits by the insects feeding on these and

Fig. 35.—Squash bug, showing different stages of nymphs, an adult and egg mass on leaf, all natural size (J. Marshall).

making small cavities on the surface, but usually these are insignificant; for fruits are seldom attacked until after frosts have killed the veins. The insect, however, is capable of doing great damage and the fact that it seldom does much seems to be due to its being well kept under control by natural factors and by the practice of cleaning up fields in the fall of the year. Usually gardens in towns and villages suffer more than open fields, probably because the surroundings in such cases afford more favourable hiding places for winter-quarters for the bugs than they could secure in the open.

Life History.—The winter is passed in the adult stage in any good shelter, such as afforded by barns, sheds, heaps of stones, piles of boards or of firewood, brush or even garden refuse. The adults usually do not emerge from these winter quarters until June, though we have occasionally seen them on plants in the latter part of May. Egg-laying begins in June, is most common the latter half of July, and ends about the first week in August. Eggs are laid in more or less loose clusters of from 4 to 50 eggs each. They are placed on the under side of the leaves, but a few may be found also on the upper surface. The clusters can easily be found, as the eggs are large and conspicuous. When laid they are yellowish cream, but soon turn light brown and before hatching a dark chestnut brown. They hatch in 7 to 17 days. The nymphs for a few hours after hatching are green, with red heads, antennae and legs. The red soon turns black and the green of the body becomes in all the later nymphal stages gray or grayish brown. For some time after hatching all the nymphs from a single egg cluster feed together, usually on the under side of the leaves. As they grow large they separate. The nymphs mature slowly, usually requiring a month or more to reach the adult stage. Often the later ones are still in the nymphal stage when frost kills the vines. In such cases both nymphs and adults may be found feeding together on the fruits. All nymphs either become adults or perish before winter.

Control.—1. Cleaning up the plot and burning all remnants of the crop before winter helps to destroy many adults that would otherwise winter over. So likewise does the removal of all rubbish, brush, lumber piles, etc., in the vicinity which would afford convenient winter-quarters for the insects.

2. If there are only a few plants to protect, this can usually be done most cheaply by collecting the adults from time to time in June and early July and throwing them into a vessel containing a little kerosene alone or kerosene and water. A search should also be made at the same time for egg masses, and these either crushed or removed. The collecting of the bugs can be made easier by placing a few pieces of boards or shingles here and there among the plants. The insects will hide under these at night and can thus be collected readily in the mornings.

3. If large areas require control measures the best method we have found is to use nicotine dust—a dust containing 2% of nicotine guaranteed to be 100% free, the remainder being hydrated lime. This has killed with us practically every nymph and adult which was hit. If this dust cannot be secured conveniently the next best is an ordinary nicotine dust made by mixing together 6 to 7½ pounds of nicotine sulphate 40% and 94 to 92½ pounds of hydrated lime. This gives a dust containing about 2½ to 3% of nicotine. These dusts are expensive but usually 50 pounds will treat a large area, because only those plants need be treated on which the bugs are seen to be present. In dusting it is necessary to treat the under surface as well as the upper so as to hit all the bugs present, and if the 2½ to 3% nicotine dust, mentioned above, is used instead of 100% free nicotine dust, it will be necessary to treat also the ground beneath the plants heavily; because if this is not done many of the bugs will be merely stupefied and after falling to the ground will recover; whereas if there is dust there it will insure the destruction of a much larger percentage of them. About the middle of a hot calm day is usually the best time to apply the dust.

4. Pyrethrum extract sprays will kill the younger nymphs, but not the older nor the adults.

Melon Aphid

Aphis gossypii Glover

The melon aphid is so rarely troublesome in Ontario that only a brief account of it is given here.

The aphid varies in colour from nearly white to dark green. Its favourite food plants are melons and cucumbers, but it also feeds to some extent on many other plants, including weeds. It is fairly common in greenhouses. In addition it is one of the chief agents in disseminating the disease known as cucumber mosaic.

In the field melons are not usually attacked by the aphids until the vines have just begun to run. When, as occasionally happens in the south-western part of the province, these aphids become abundant, the leaves are curled, the plants become sickly, dwarfed, and some of them die, and the whole crop is greatly lessened.

The aphids winter over in the egg stage on a garden plant, which often runs wild, known as live-for-ever or common orpine (Sedum purpureum). They also winter in greenhouses, where breeding continues all through the winter.

Control.—The same method of control should be used as for other aphids attacking vegetables, namely, dusting the plants with a 2% nicotine dust. This must be applied thoroughly to the under side of the leaves on a warm, calm day. Dusting should be done promptly once the aphids are seen to be likely to injure the plants. In greenhouses the usual fumigation with tobacco or with hydrocyanic acid gas will control the insect. Repeat the dusting or fumigation if necessary.

INSECTS ATTACKING ONIONS

Onion Maggot

Hylemyia antiqua Meigen

The onion maggot is the most important pest attacking onions in Ontario. It is a small white maggot resembling closely the cabbage maggot and having similar feeding habits except that instead of attacking cabbage and allied plants it attacks onions.

The female adult is an ashy-gray or olive-gray coloured two-winged fly so like the female fly of the cabbage maggot that the grower cannot distinguish between them. The males are darker and a little smaller than the females, and they, too, are almost identical with the males of the cabbage maggot.

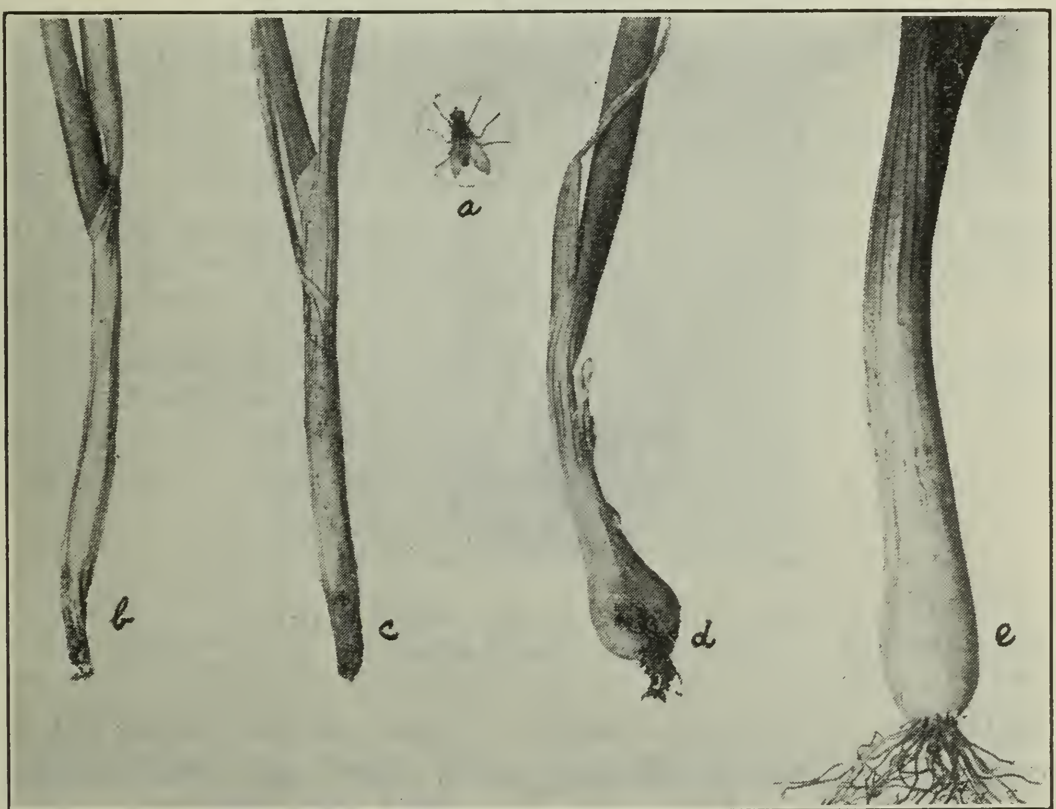


Fig. 36.—(*a*) Onion maggot adult, about natural size; (*b*) and (*c*) young onions with lower part of stem destroyed by the maggot; (*d*) young onion with both root and bulb attacked; (*e*) uninjured onion from seed sown at same time as *b, c* and *d*.

Injury.—The maggots bore into the leaves, stems and bulbs of the young onions and by tearing the tissues and sucking the juices kill the plants. When one plant is killed the maggot often migrates to another. In this way several plants may be destroyed while still small by the same maggot or maggots. When the plants get larger the maggots limit themselves chiefly to the bulbs and by working in them make them unfit for sale. Often rot enters infested bulbs and not only increases the damage but also causes a sickening odour. The amount of loss from the maggots varies greatly from year to year; some years little damage is done, others a great deal, some fields having 50% or more of the crop destroyed. All varieties of onions except Egyptian are attacked. The thick hard skin on the Egyptian onion seems to protect it.

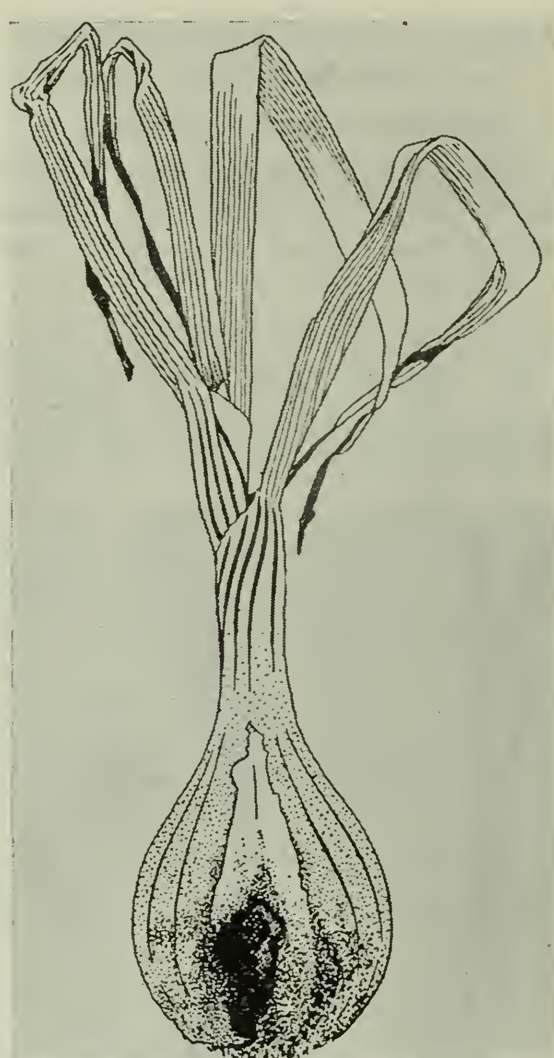


Fig. 37.—Work of onion maggot. (After Gibson and Treherne.)

Life History.—The winter is passed as pupae (puparia) in the soil near the plants fed upon the previous year. The pupae are reddish-brown and resemble large grains of wheat. In May, about the time bloom is beginning on apple trees, the flies begin to emerge and continue to do so for several weeks. In 4 to about 10 days after emerging the females begin laying eggs. These are white and of the same size and shape as those of the cabbage maggot (See fig. 20). In the early part of the season nearly all the eggs are laid in the soil near the onions themselves; later many are laid on the bulbs and some in the axils of the leaves. The eggs hatch in about 5 days on an average. The maggots feed as described above, and usually become full-grown in about 15 days. They then pupate in the soil. The pupal stage also requires about 15 days. Then the adult appears. Thus the length of the life cycle is approximately six weeks. There are usually three broods a year of the insect in this province. The first brood of larvae being present in May and June, the second, roughly speaking, in July and August, and the third in September and October. The second and third broods are not full broods but only partial. Larvae are present in the bulbs right up to the time of severe frosts, in fact, some of them are carried into storage in the bulbs and mature there.

Though there are three broods each year it is usually only the first that does serious damage.

Control.—The most popular method of control to-day is by spraying with a 2% lubricating oil emulsion. This emulsion can be made by the grower, and will cost about 70 cents for every 100 gallons. There are several ways of preparing it, but the most common is by using the following formula:

Lubricating oil	2 gals.
Water	2 gals.
Bluestone	4 oz.
Hydrated lime (fresh)	4 oz.

Dissolve the bluestone (For methods of doing so see page 4) and dilute with water to 1 gallon. Then to the other gallon of water add the hydrated lime and stir. Then pour this gallon into the gallon of bluestone and at once mix well. This makes 2 gallons of Bordeaux mixture. Now pour the Bordeaux mixture into the 2 gallons of oil and with good pressure pump the mixture through the spray pump back upon itself for three or four minutes until it is thoroughly emulsified. This makes 4 gallons of what is called the stock emulsion, and is just the right amount when diluted with water to make 100 gallons of lubricating oil emulsion of the strength of 2% of oil, for two of the 4 gallons were oil.

By keeping the proportions given in the formula as much stock emulsion as is desired can be made up at one time, but it is not wise to make more than just enough for each day's work, as the emulsion is not a very stable one.

How to Dilute the Stock Emulsion.—To determine how many gallons of the stock emulsion are required for any particular size of spray tank to be used remember that a 100 gallon tank requires 4 gallons.

Therefore a 5 gal. tank will require 5/100 of 4=1/5 gal.
a 20 gal. tank will require 20/100 of 4=4/5 gal.
a 40 gal. tank will require 40/100 of 4=8/5 gal.

That is, divide the number of gallons in the tank to be used by 100 and multiply the fraction obtained by 4. The result gives the number of gallons of the stock emulsion which must be put into any particular tank so that when it is filled with water it will contain 2% of oil.

Grade of Oil to Use. There are two grades of oil that are used, one of these being lighter than the other. For the present we think it wiser to use only the heavier grade, known as red engine oil. This oil should have the following specifications: Viscosity, 200 seconds, gravity (Baume) 25, and flash point of about 370°F. This oil costs about 30 cents per gallon, and can be obtained from any of the large oil companies.

Time to Apply.—If the onions are planted early wait until about the time the apple blossoms begin to appear and if the little white eggs can then be found in the ground around any of the plants spray at once, otherwise wait until the blossoms on apples are about 90% off and then spray. If the onions are planted after the apples are in full bloom wait until the rows can just clearly be seen and then spray at once. The first spray is nearly always the most important, and great care must be taken in timing it well; a few days' delay may spoil the results.

Number of Sprays Required and Length of Interval Between Them.—Four sprays at intervals of a week between them should be sufficient even for early planted onions and three for late.

Method of Applying the Spray.—The handiest and quickest way is to use one of the modern garden tractors specially equipped with a sprayer for onions. If this is not available, either a knapsack sprayer or small hand pump sprayer holding about 10 or 20 gallons and mounted on a frame like that of a wheelbarrow works fairly well. One man pushes the sprayer and keeps up the pressure while the other applies the mixture to eight rows in turn at each halt. The spray machine is equipped with one line of hose about 20 feet long and a rod about 3 feet long. The nozzle should be held near the plants so that the spray will be concentrated on them. The ground immediately around each plant should be thoroughly wet and about 140 gallons used to the acre at each application. Much lighter than this will not give satisfactory results.

Oil applied on a very hot day is likely to burn, so the growers are advised to postpone spraying on such days until about 4.00 p.m.

The material sometimes checks onions a little for a few days, but they soon grow out of this.

A second method of control is to use corrosive sublimate at the strength of 1 ounce to 10 gallons of water in place of the oil emulsion. The applications should be made at the same times as recommended above for the oil emulsion. The method of mixing and applying the material is the same as for the cabbage maggot. (See page 31.) In a very dry spring the corrosive sublimate has given us better yields than the oil emulsion, but is more costly than the emulsion.

As weeds interfere greatly with the success of the spraying every effort should be taken to keep these under good control. It is also a good plan, so far as possible, to destroy all infested onion bulbs at harvesting time, as they are a source of danger for the following year.

Onion Thrips

Thrips tabaci Lindeman

After the onion maggot the onion thrips is the most destructive insect enemy of onions, and in dry, hot seasons sometimes causes very great loss. In a cool, wet season it is usually not abundant enough to do much damage, partly because such weather is in itself unfavourable to it and partly because drenching rains wash off and kill a large percentage of the tiny creatures.

The light-yellow to brown adult is very small, being only about 1/25-inch long. It has two pairs of very frail, feather-like wings fringed with hairs. (See

Fig. 38.—Adult onion thrips, greatly enlarged (R. Ozburn).

fig. 38.) With such wings the insect is not a good flier against the wind, but can fly fairly long distances with it.

The nymphs have the same general shape of body as the adults, but are, of course, smaller and have no wings. They are either white or pale yellow.

Food Plants.—Onions are the favourite food plant; but cabbage, cauliflower, cucumber, tomato and, in fact, most truck crops are fed upon freely and often serve as secondary breeding plants. Weeds and grasses are also infested to some extent. Moreover, the thrips is common in greenhouses.

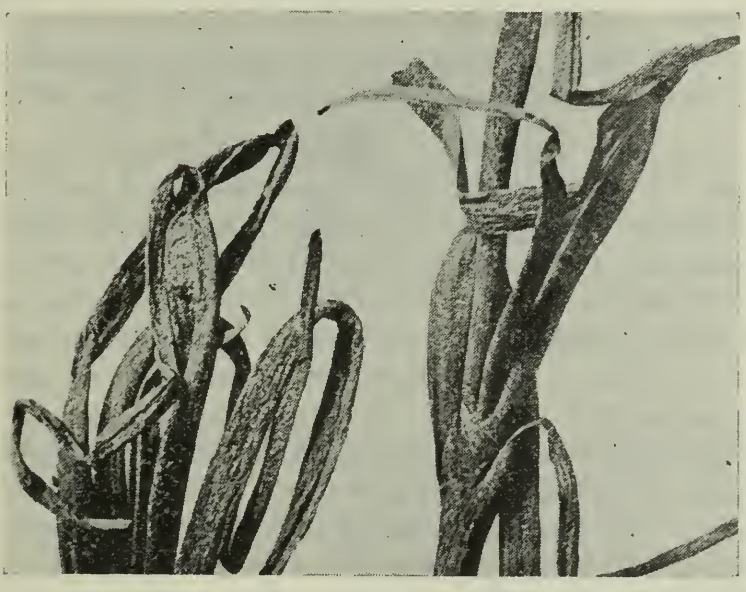


Fig. 39.—Work of onion thrips. (After Horsfall and Fenton).

Injury.—Both adults and nymphs attack the onions throughout the season and feed by rasping or tearing the tissues and then sucking the juices. Wherever they work a small white or silvery blotch appears. When the thrips are very numerous the whole field soon begins to show a whitish, bleached appearance and the leaves wilt and fall over as if struck by some sudden blight. The result is that the crop is either almost ruined or very much reduced in quantity, especially if the attack takes place early or moderately early in the season, when the plants are still far from mature.

Life History.—The winter is passed in the adult stage under piles of onion refuse, such as tops, screenings and culls, or among any green onions that have been left growing in the field. It also winters in dense or weedy places and in fields of alfalfa. Many, too, are in greenhouses, where they continue to breed all winter. In spring, soon after growth has begun, the adults in the outside hiding places become active and gradually find their way to onion fields or often first to early cabbage and other plants, and later from these to onions. Greenhouses are also a source of infestation in spring. Eggs are laid in the leaves of onions or other host plants. The eggs are very small—too small to be seen by the naked eye—and are inserted by a saw-like ovipositor into the tissues of the plants. They hatch in about four days. In six or seven days more the nymphs become full grown and then enter the soil about two inches to pupate. The pupal stage requires an average of about four days. Hence the life cycle from egg to adult may be passed in two weeks. As the insects are present and breeding from May until October there are many generations in a season; thus, even though there may be only a few adults in May, the rate of reproduction is so rapid there may be countless numbers in July, August or September, if weather conditions are favourable.

Control.—The most important thing in control appears to be prevention: Leave no suitable places for the thrips to winter over in, or destroy them in these places in spring before they become active. Hence in fall a complete clean-up should be made of the onion field, so that there will be no green onions left and no piles of tops or of culls or screenings. All these should be burned or ploughed under thoroughly. In spring all headlands and all weedy and grassy places should be burned over carefully before the thrips become active. At the same time the thrips in greenhouses in the neighbourhood should also be destroyed by fumigating the houses several times at intervals of a week or ten days with tobacco or hydrocyanic acid gas, or by spraying with nicotine sulphate 40% and soap.

In addition it is wise, wherever it can be managed, not to grow onions near alfalfa fields or any kind of field likely to provide good cover for the thrips in winter. In the onion field itself the crop is likely to be worse infested if a practice is made of growing sets, as these come on earlier than the seed onion, and so the thrips get a start on them and then gradually spread over to the seed onions, often causing a much worse infestation than if there had been no sets. If, however, sets are grown it is wise to spray them very thoroughly as soon as the thrips are seen to be present with nicotine sulphate 40% and soap at the strength of ½ pint of nicotine sulphate 40% to 40 gallons of water to which has been added four pounds of soap dissolved in boiling water. Common laundry soap or a soft soap may be used. The spraying should be repeated in seven to ten days to destroy the nymphs which will have hatched in the meantime from the eggs—for the eggs are not affected by the spray—and also to destroy adults which will have come from the pupae in the soil.

It is often recommended that the whole onion crop should be sprayed with the above mixture from time to time throughout the season. When the plants are young, spraying, if repeated in a week or 10 days, will do a great deal to prevent loss at that time of the year; but once the plants become large, it is not very satisfactory, because the dense foliage then makes it almost impossible to do sufficiently thorough work to prevent large numbers of the thrips being left alive.

In spraying it is very important to use high pressure and to cover every side of the plant with special care and especially to see that the liquid is driven forcibly right down into the centre where many of the thrips are hidden in the axils of the leaves. In large plantations, to avoid injuring the plants by hauling a spray machine up and down many times, large arms or booms may be attached to the frame of the outfit and to these long lines of hose fastened. Then by swinging the arms out gradually quite a wide area can be done each round and thus only a few rounds be necessary to complete the field. There are also on the market small garden tractors equipped with an outfit for spraying onions. These seem to be coming into common use in the United States. They run between the rows without injuring the plants.

Dusting with nicotine dust will kill a good many of the thrips, but has not proven nearly so satisfactory as spraying.

It is important not to forget that the richer the soil the better the plants withstand attack by thrips, hence it is a good plan to use commercial fertilizer on a poor soil and to prepare the seed bed as well as possible.

INSECTS ATTACKING PEAS

Pea Weevil

Mylabris pisorum Linn

The pea weevil is much the worst of all pea insects and has been responsible for great losses and for many farmers abandoning pea-growing.

The adults are stout, oval, brownish beetles, about 1/5 inch long, with white and black mottling on the back.

Food Plants.—Peas are the only plants fed upon.

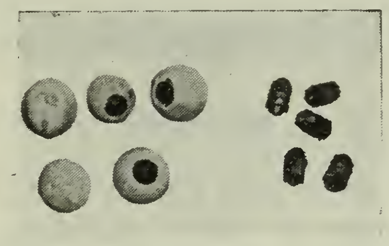


Fig. 40.—Pea weevils and their work, natural size.

Life History and Injury.—The beetles emerge from their winter-quarters in spring about the time field peas are ordinarily coming into bloom. They feed a little on the blossoms or stems and then lay their yellow eggs upon the pods soon after these are formed. The larvae on hatching bore through the pods and enter the tiny peas. The entrance holes soon heal over and the larvae feed in concealment until full grown; then they pupate just where they are. By the time the peas are ready to harvest the pupae have changed into adults, each pea containing only one adult. The great mass of the adults remain over winter in the peas, concealed from view, though the darker colour above their chamber reveals their presence. Some of the beetles, however, leave the peas in the field. These winter over outside in any good shelter that they can find. Others come out of peas in the barn, most of them at the time of threshing. These winter over in or around the barn.

As infested peas have half or nearly half the interior devoured their food value is greatly lessened. Moreover, a high percentage of them either will not germinate or will produce weak plants; hence it is easily seen that if half or, as often happens, much more than half of the seed is infested the loss to the grower is great.

Control.—1. All infested peas should be cut or pulled as soon as they are ripe, or preferably while they are still a little on the green side, and should, as soon as they are dry, be gathered carefully and threshed at once. After threshing all the seed should be fumigated promptly while the weather is still warm, with carbon bisulphide. (For methods of doing this, see under "Bean Weevil," page 22.)

2. Hogs should be allowed to run in pea fields after removal of the peas, as they will eat many of the infested seed and thereby help lessen the number of weevils which will winter over.

3. Infested peas, even though there are few weevils in them, should never be sown without first destroying the weevils by fumigation. If, however, the

seed has been kept for two years in tight bags, the weevils present will have come out, and being unable to escape will by this time be dead, so that such seed may safely be sown.

4. If weevils are very bad in any community that community should cease growing peas for a year. This will result in the destruction of all the weevils in the district and the farmer can then start off afresh, but should be careful to see that all the seed sown has first been fumigated.

5. Though our winters do not kill all pea weevils as they do bean weevils, if exposed, yet they destroy a great many of them, and it has been noted that the colder the district the lighter the infestation from this pest. It would appear, therefore, as if pea growing might be carried on with greater success so far as the pea weevil is concerned in New Ontario, than in any other part of the province.

Pea Aphid

Illinoia pisi Kalt

The pea aphis is light green in colour and about ⅛ inch long. Like other aphids it is sluggish in movement and has sharp mouthparts with which it pierces through the surface of its food plants and extracts the juices from within.

Food Plants.—Peas—including sweet peas—are the favourites. In addition clover—including sweet clover,—alfalfa and vetches, are attacked.

Injury.—The injury takes place chiefly from about the time the peas are coming into bloom until they are nearly ready to harvest. The aphids during this period sometimes attack them in so great numbers that they almost cover the plants, and by sucking out the juice of the leaves, stems and blossoms soon cause the plants to turn yellow and die before the seed is nearly mature. In this way in a season favourable for the aphids, the greater part of the crop may be ruined over large areas. Every field, however, will not suffer equally, because of difference either in time of planting or of proximity to clover, or because of moisture or other natural factors which play a great part in determining the abundance or scarcity of the insect.

Life History.—The winter is passed in the egg stage chiefly on clover and probably to a lesser extent on alfalfa and vetch. The eggs hatch in spring about the time growth has clearly begun. The aphids feed upon the winter host plants for a considerable time. Then winged forms are produced which fly chiefly to peas but also to some extent to alfalfa and vetch. When the peas are ripe many of the aphids perish but the winged ones migrate either to late peas, if any, or to clover or other food plants.

Control.—1. Plant peas early. Late peas suffer much worse than early.

2. If practicable, plant them at a considerable distance from clover, as the closer they are to the clover, the more likely they are to become heavily infested.

3. Garden peas grown in rows can be saved by dusting them thoroughly with 2 to 3% nicotine dust as soon as the aphids are seen to be abundant. Do the dusting in the heat of a warm calm day and, if a power duster is used, attach a trailer of cotton or of some other light cloth behind to concentrate the dust.

4. Spraying with nicotine sulphate 40% at a strength of ⅜ pint to 40 gallons of water may be substituted for dusting, especially in the case of sweet peas or of small garden areas of field or table peas.

INSECTS ATTACKING POTATOES, TOMATOES AND EGG PLANTS

The Colorado Potato Beetle

Leptinotarsa decemlineata Say

There is scarcely any insect better known to farmers and vegetable growers than the Colorado potato beetle. It occurs in every part of the province where potatoes are grown, being even up in New Ontario. Everywhere it is the most destructive insect pest of potatoes, and is often so abundant that a great part of the crop would be almost ruined if the plants were not protected by spraying or dusting. Some years, however, it is so reduced in numbers by unfavourable weather conditions, predaceous enemies and parasites that very little damage takes place even though no control measures are used.

Food Plants.—Potatoes are much preferred to any other plant, but it is not uncommon to find tomatoes, egg plants and the common nightshade (Solanum nigrum) also attacked, though to a much less extent than potatoes.

Life History.—The winter is passed in the adult stage beneath the surface of the ground in the same field or plot where the beetles fed during the preceding summer. The depth to which they go varies from about 2 to 18 inches, large numbers being near enough to the surface to be turned up by the plough in fall or early spring. Towards the end of May the beetles emerge and soon fly away in search of potato plants. On finding these, they at once proceed to feed, mate and lay eggs. Egg-laying continues at intervals for a month or more. A single female may lay at least 1,000 eggs, but the average is probably less than half this number. The eggs are oval in shape, yellow to nearly orange in colour and are usually placed in clusters of about 5 to 150 each on the underside of the leaves. The incubation period is approximately one week.

The larvae soon after hatching begin to feed upon the leaves and eat small areas out of them. As they approach maturity they do much more damage and quickly strip the plants of all their foliage, leaving only the stem and main branches. It requires from two to three weeks for a larva to become full grown. It then enters the ground from 1 to 6 inches, transforms there into a pupa and in a week or a little more, emerges as a beetle.

Many of these new beetles, especially of those that emerge earliest, lay eggs and produce a second generation, but a large number, especially of the later emerging ones, do not lay eggs but merely feed a while and then enter the soil for winter. The larvae of the new generation also pupate in the soil and change into adults. These, like the other adults which did not lay eggs, feed for some time and then they too enter the ground for winter. Thus we have in Ontario one full generation and a partial second one.

It is interesting to know that while most of the beetles which appear in the spring die before winter a number of them live through a second winter and even lay fertile eggs the next spring.

Control.—A few growers protect their plants by picking off the beetles, but this is such a slow labourious process that spraying or dusting has come to be the regular method of control. Whichever of these two methods is used it should be applied as soon as the eggs have begun to hatch, because the larvae are much more easily killed while small than later, and by destroying them early the plants are saved from the injury that would otherwise take place.

The best mixture to use is 1½ to 2 pounds arsenate of lime (calcium arsenate) to 40 gallons of Bordeaux mixture (4, 6, 40 formula). The arsenate of lime may be used with water instead of Bordeaux, but in this case it is perhaps wise to add about 3 pounds of hydrated lime to every 40 gallons to guard against possible

Fig. 41.—Colorado potato beetle larvae feeding on potato leaves, natural size. (Adapted from Britton).

burning. It is better, however, to use the Bordeaux, because it not only helps ward off fungus diseases such as late blight, but also controls the leaf hoppers and flea beetles and keeps the plants more vigorous, thus increasing the yield.

Arsenate of lead, 2 to 3 pounds to 40 gallons, may be substituted for the arsenate of lime, but is much costlier and kills more slowly.

Paris green, 1 to 2 pounds, is another substitute but it also is dearer than arsenate of lime and washes off much more quickly than either it or arsenate of lead.

A fourth substitute is 1 pound arsenate of lead and 1 pound Paris green. This is quite effective but is much dearer than the arsenate of lime and gives no better results.

The most common dust is a Bordeaux-arsenate of lime mixture, the common formula for which is 12 pounds dehydrated bluestone, 80 pounds hydrated lime and 8 pounds of arsenate of lime. This dust by having the bluestone and lime in it, acts as a fungicide as well as an insecticide. If for any reason it cannot be secured a good dust against the beetles may be made of 1 pound of arsenate of lime mixed with 10 pounds of hydrated lime. This, of course, is not a fungicide. Dusting should be done when there is no wind and preferably when the plants are moist, as from dew or recent rain.

In either dusting or spraying the plants should be covered thoroughly, even if this means having to go over them twice on the same day.

Usually two thorough sprayings or dustings, one, as mentioned, when the eggs begin to hatch and the other as soon as the larvae again begin to be abundant, will give satisfactory control, but some years it is necessary to give an extra treatment a week or so later. The main thing to remember is to get the first application on early and thoroughly and never allow the insect a chance to get a good start.

Potato Flea Beetle

Epitrix cucumeris Harris

The potato flea beetle is a small insect, about the size of the head of a common pin, with a black body and yellowish-brown legs and antennae.

Fig. 42.—Potato flea-beetle—adults and injury, natural size.

The larvae are slender white worms with brown heads. When full grown they are about 1/5 inch long. Very few people ever see them because they remain underground all the time.

Injury.—Although not so destructive as the Colorado potato beetle, the flea beetle is one of our important potato pests. It is also some years quite injurious to tomatoes during the first week or two after the young plants have been set out. By far the greater part of the damage is done by the beetles themselves. These feed upon the leaves of potatoes and tomatoes in May and June and when abundant make so many holes in them that the leaves are greatly weakened and sometimes turn brown and dry out. Later in the season, in August and September, potato leaves may sometimes again be attacked and severely riddled, though tomatoes are seldom fed upon at this time.

The larvae in this province have caused very little damage. They feed in the soil upon the roots of potatoes and to some extent of other plants too and perhaps also upon decaying vegetable matter. Occasionally they attack the tubers and make little tunnels in them or cause pimply growths upon the surface.

Life History.—The winter is passed in the adult stage under leaves, rubbish or any other kind of good shelter. In May the beetles come forth and may be found on the foliage of many kinds of weeds and other plants, though they seem to feed very little on these. As soon as potatoes or tomatoes are available they fly to them and feed as described above. Egg-laying takes place in June and early July. The eggs are very small and white and are laid singly in the soil. The larvae on hatching feed as described above. When full-grown they pupate in the soil. From the pupae new beetles begin to emerge in late July and become most numerous about the first week in September. These feed upon the foliage until cold weather drives them into winter quarters. There is apparently only one generation a year.

Control.—This insect is easily controlled. All that is necessary is to spray thoroughly with Bordeaux mixture (4, 6, 40 formula) as soon as the plants are seen to be attacked and repeat, if necessary, in about 12 days. The Bordeaux must be applied to both sides of the leaves, as the beetles feed on both. Poison is not necessary but may be added to destroy the Colorado potato beetle, if this is present.

Dusting with Bordeaux does not seem to give nearly so satisfactory results as spraying.

Potato Leaf Hopper
Empoasca mali Le Baron

Fig. 43.—Potato leaf hopper adult, greatly enlarged. (R. Ozburn.)

Fig. 44.—Potato leaf hopper nymph, greatly enlarged. (R. Ozburn.)

The potato leaf hopper is a very small, green, sucking insect which both in the adult and nymph, or immature stages, feeds on the under side of the leaves of potatoes. Here it pierces the tissues with its sharp beak and extracts the juice. When very abundant it may injure the plants considerably through the loss of juice. The main damage, however, is done in a very different way, namely; by the insect inserting a poison into the part where it feeds. This causes the leaves to turn yellow along the margin, usually at the tip first. Then the margin gradually turns brown and curls upwards and inwards. Often every leaf is thus affected, with the result that the entire plant soon dies. Whole fields some years are blighted in this way. This type of injury is called "hopperburn." Most of the disease which farmers previously called early blight or tipburn has now been proven to be hopperburn. Hot dry weather may be said to favour the disease, but chiefly because it favours the growth and increase of the leaf hoppers.

The adult leaf hoppers are only about one-eighth of an inch long and are pale green with a few white markings, chiefly on the head and thorax. They leap and fly quickly.

The nymphs just after hatching from the egg are white to whitish green and so small that they look like a mere dot. As they grow older and larger they become pale green. They are much the same shape as the adults but have no wings and are smaller and paler in colour. They seldom leap but if disturbed run quickly to shelter.

How to Distinguish Leaf Hoppers From Green Potato Aphids.—Both have the same habit of piercing the leaves and sucking the juices but while the leaf hoppers confine themselves almost entirely to the under side of the leaves, the aphids cluster not only on the under side but also on the leaf stem and tender upper portions of the plants. When disturbed they move very slowly compared with the rapid movements of the leaf hoppers. Aphids are also much broader and stouter in proportion to their length than leaf hoppers, and have a pair of little horn-like tubes towards the rear end of the body. Most of them have no wings, even in the adult stage.

Fig. 45.—Hopperburn—injury to potato leaves, caused by potato leaf hopper adults and nymphs. (After Fenton and Hertzel.)

Food Plants.—Potatoes seem to be the favourite food plants of the leaf hoppers, but they breed freely also on beans, sugar beets, raspberries, apples, and to a lesser extent on several other plants.

Life History.—The winter is passed in the adult stage in weedy or grassy places or among brush or rubbish of any kind where they can find good shelter. In spring, soon after vegetation has well begun, they come out of their hiding places and feed on weeds or other plants until potatoes are far enough advanced to give them an abundance of food. Then they migrate to these and also to some extent to the other host plants mentioned above. Soon after migrating, they lay their eggs in the leaf stems and leaf veins. The eggs are small and white and are inserted so deeply into the tissues that they are not visible. Egg-laying continues for a month or more. The eggs hatch in about 12 days and in 2 weeks or a little more the nymphs become full grown and change into adults. This new brood of adults appears in late July or early August. Eggs are then laid during several weeks for another generation. There are thus two generations a year, or at least one full generation and a partial second. As implied above, no nymphs but only the adults winter over. During the summer it is customary for the adults to migrate from a field of old or dying potatoes to a field of healthy late planted ones.

Control.—Spraying the plants with Bordeaux mixture (4, 6, 40 formula) (see page 4) will give good control. The spray, however, must be applied to the underside of the leaves, because the insects feed there. It must also be done thoroughly, so that all the underside will be completely covered. The Bordeaux destroys the nymphs and drives the adults away. The first spray should be when the leaf hoppers begin to attack the plants, which will usually be when they are about 4 inches high; the second in 10 to 12 days and the third after the same interval. Poison is not needed with the Bordeaux for the leaf hoppers, but should of course be added to the first and second applications for the Colorado potato beetle.

Fortunately, Bordeaux mixture will not only control the leaf hoppers but also the flea beetles and the late blight disease. For the last of these more applications have to be given in a wet season.

Potato Aphids

Several species of aphids attack potatoes, but by far the most common are the so-called "potato aphid" (*Macrosiphum solanifolii* Ashmead) and the peach or

Fig. 46.—Potato aphids. (After Britton.)

spinach aphid (*Myzus persicae* Sulzer). Most individuals of both species are green but some, especially of the former, are pink. They are small insects about ⅛ inch long.

Life History.—Throughout the growing season all the aphids are females and all produce living young. As there are many generations in a season, reproduction is very rapid when weather conditions or absence of natural enemies permit. Usually both wingless and winged forms are present. The latter often fly to other potato fields or to weeds or other vegetables and feed and breed there. In the fall of the year the first species mentioned above migrates to rose bushes, lays its eggs on them and passes the winter there in the egg stage. The other species flies chiefly to peach trees and winters on these in the egg stage. In spring the eggs of both hatch about the time the buds are bursting. After feeding a couple of weeks on their respective winter hosts, both species produce winged forms which fly back to potatoes and to some extent to other plants, many of the peach aphids to spinach.

Injury.—Aphids have very fine, sharp, piercing mouthparts, which they insert into the leaves and tender stems of the potatoes and suck out the juice. When abundant they nearly cover the plants and are specially numerous on the under side of the leaves. Under such circumstances the great amount of juice extracted causes the leaves to become a sickly yellow colour and often to die. However, it is only rarely in this province that potatoes are killed or even greatly weakened by aphids. The chief damage they do is of an entirely different nature; namely, the transmitting of two common potato diseases—mosaic and leaf roll. These diseases are introduced through the seed but once in the field spread, so far as is known, from plant to plant only by means of aphids. The aphids get the virus of the diseases into their body by feeding on diseased plants and when they insert their beak into a healthy plant they inject some of this virus into it and thereby inoculate the plant.

Control.—It is comparatively seldom that potato aphids are so abundant in Ontario as to require any artificial control measures. Wherever treatment is necessary the best method is to dust the plants thoroughly both from above and below with a two per cent. nicotine dust made by mixing together five pounds nicotine sulphate 40 per cent. and 95 pounds hydrated lime. The dusting should be done on a warm calm day. Spraying with one pint of nicotine sulphate 40 per cent., five pounds soap or one pound calcium caseinate to 100 gallons of water or of Bordeaux mixture is fairly satisfactory if applied well to both surfaces of the leaves, but it is not so effective as the dust.

It is impossible to annihilate aphids in any potato plot because the insects breed, as said above, on many other kinds of plants and will fly in from these and thus reinfest the potatoes. For this reason and also from the fact that the cost of dusting or spraying for aphids is high the best way to control mosaic and leaf roll is by careful inspection and roguing of fields and by planting only certified seed.

As one species of potato aphid winters on rosebushes it stands to reason that, if rosebushes were sprayed with nicotine in spring when their buds are bursting, or soon after, this would lessen the number of aphids that would fly from the rose to the potato.

Blister Beetles

Blister beetles are large, rather slender, nearly cylindrical beetles. They are about two-thirds of an inch long and about one-sixth of an inch broad. There are at least three species in Ontario which at times attack potatoes: namely, the black (*Epicauta pennsylvanica* DeGeer), the ash-grey (*Macrobasis unicolour* Kirby), and the striped (*Epicauta vittata* Fabricius). Of these three the black is much the most common in old Ontario at least, and may readily be seen feeding on goldenrod flowers almost any year in August and September.

Injury.—The adults do all the damage, the larvae being considered beneficial as they feed largely upon grasshopper eggs. Potatoes are the chief cultivated crop which is injured, but the beetles feed also at times upon many other cultivated plants and upon the leaves and flowers of many wild plants. Injury to potatoes in the writer's experience is most common in districts where there is much waste land or where woods have been cut over or burned. In such places the beetles sometimes in great swarms attack the plants and do great damage by eating large areas out of the leaves or even by completely defoliating the plants. Injury, however, is seldom general in any district, as usually it is only a field here and there which is attacked. Sometimes, too, the beetles feed only for a short time in one field and then fly away to another.

Life History.—As the life history is too complex to give here in detail it will suffice to say that the beetles are present from June or July on into September. The eggs are laid in the ground. The larvae are very active and search out and devour grasshopper eggs, though they doubtless feed also on other things. The winter is passed in the soil in the nearly mature larval stage. Pupation takes place in spring and adults appear in June or July. Thus there is only one generation a year.

Control.—Experiments in Louisiana in 1925 on dusting the beetles on Soy beans showed that sodium fluosilicate either alone or mixed with equal parts of hydrated lime not only caused the beetles to cease feeding almost at once but

Fig. 47.—Blister beetles, enlarged, the line to the right shows natural size.

also killed almost 100 per cent. of them. Though these experiments were carried out on a different species of blister beetle there is very little doubt that our species would be just as susceptible to this poison. It is also probable that barium fluosilicate would be equally as effective as sodium fluosilicate.

Spraying infested plants with two pounds arsenate of lead or one-and-a-half pounds arsenate of lime or one pound Paris green to 40 gallons of water or of Bordeaux mixture drives the beetles away, but it is doubtful if it kills them. Dusting may be substituted for spraying. In that case dilute each pound of arsenate of lead with about five pounds hydrated lime or of arsenate of lime with about seven pounds, or of Paris green with about ten pounds.

Tomato Worm

Phlegethontius quinquemaculata Haworth

The tomato worm is the large green worm with a horn at the posterior end. It is often found eating the leaves of tomatoes and of tobacco. These worms when full-grown are sometimes four inches long and about half an inch in thickness. Along each side of the body there is a row of large V-shaped white markings which distinguish this species from others looking much like it. The worms are nearly the same colour as the leaves and so are difficult to see. As a rule they are not very abundant, but some years there are sufficient of them to defoliate many plants.

The adults are large hawk-moths which fly around in the evening and at night, insert their long, slender, sucking tube into the flowers of tobacco, thorn-apple or other plants with long, tubular, bell-shaped flowers and suck the nectar out of them. The wing expanse of the moth is from four to five inches. The upper wings are grey, marked with irregular black lines. The hind wings are whitish grey with a broad margin of grey and with heavy wavy black bands across them. The body is grey, spindle-shaped, stout and one-and-a-half to two inches long. On each side there is a row of five large yellow spots margined with black.

Life History.—The moths appear in June and lay their yellowish green eggs singly on the leaves, usually on the under side. The eggs hatch in about a week and the larvae become full grown inside of a month. They then enter the ground, make an earthern cell and pupate. The pupa is dark brown, about two inches

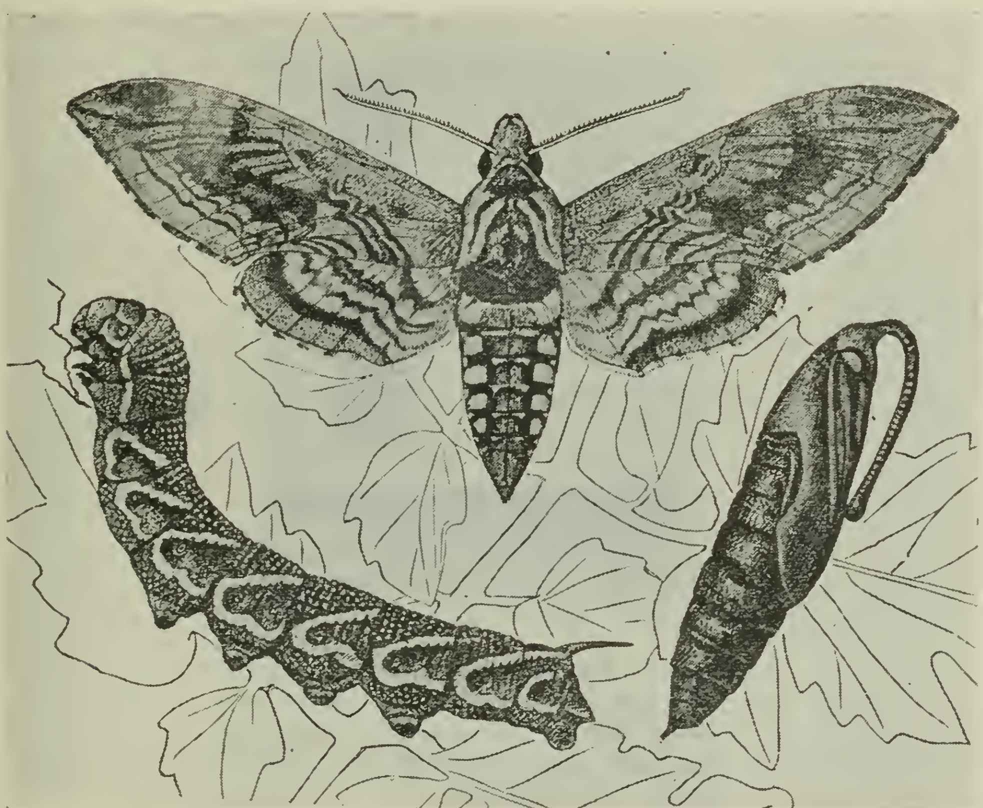


Fig. 48.—Tomato worm—adult, larva and pupa. (After Howard, U.S.D.A.)

long and half an inch thick and has a conspicuous handle-like structure at one end, which in the moth becomes the proboscis or sucking tube. The winter is passed in the pupal stage in the ground. Normally there is only one generation a year, but sometimes in a warm season in the south-western part of the province there is a partial second generation.

Control.—The usual method of control is to pick off the larvae by hand and kill them. If, however, they are seen to be too numerous for this they should be sprayed at once with two or three pounds of arsenate of lead or one-and-a-half pounds calcium arsenate or one pound Paris green to 40 gallons of water.

Dusting may be substituted for spraying, the arsenate of lead being diluted with two or three times its own weight of hydrated lime, the arsenate of lime with three or four times its weight and the Paris green with five or six times.

RHUBARB INSECTS

The Rhubarb Curculio

Lixus concavus Say.

The rhubarb curculio is a large slaty-black beetle with a long snout, is about two-thirds of an inch in length and can readily be recognized by its large size, long snout and the yellow powder which in nature covers its body.

The larva is white, stout and about three-quarters of an inch long when full-grown. It is legless and has a brown head.

Food Plants.—In addition to rhubarb the beetle attacks curled dock and in some places also thistles and sunflowers, but the writer has found it in this province only on rhubarb and dock.

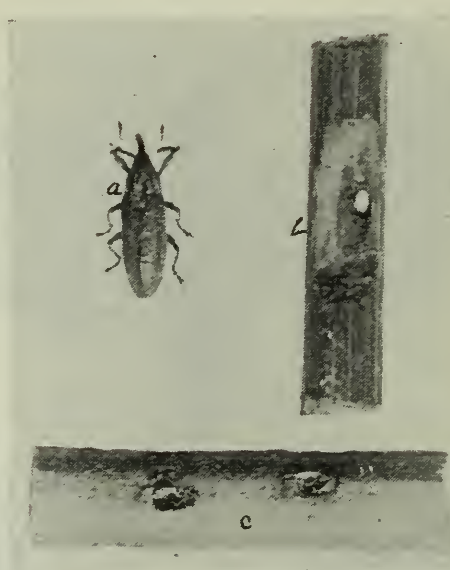


Fig. 49.—Rhubarb curculio—(*a*) adult; (*b*) egg in curled dock, the surface being removed to reveal it; (*c*) feeding and egg-laying injury in curled dock; all natural size.

Injury.—The injury to rhubarb is caused by the beetles alone; for the larvae in these plants die very soon after hatching from the eggs, probably because of the great amount of acid present. The beetles during June and early July eat oval or round holes about one-eighth of an inch deep in the stems and leaf veins. This is done for feeding and egg-laying purposes. Gum usually exudes from these holes and in most cases the affected area dries out and turns brown, though occasionally rot may set in. There may be a dozen or more injured places on a single stem. The resulting scars make the stems unsightly and unsaleable. Fortunately the marketing season is nearly over before the beetles begin to attack the plants. Severely infested plants frequently are so weakened that they break off with heavy winds. Injury in commercial plantations is usually rare, but is not uncommon on rhubarb plots on farms or in gardens in villages and towns wherever docks are growing in the vicinity of the rhubarb.

Life History.—The beetles begin to appear and attack the rhubarb and docks about the beginning of June. In a short time egg-laying commences and continues for a little over a month. The larvae from the eggs laid in rhubarb, as mentioned above, die before they do any damage but from from the eggs in docks they live and soon bore down through the stem to the ground. Here they continue to feed until full-grown, then change into pupae and about September the new beetles begin to emerge. These, after feeding a short time, go into winter quarters, apparently under rubbish or leaves in the vicinity.

Control.—As the insect breeds entirely, or almost entirely, in docks the simplest method of combating it is to prevent docks from growing in the neighbourhood of rhubarb. If the beetles are present and attacking rhubarb it is a good plan to leave the docks until all eggs are laid, which will be about July 15th, and then cut the plants with a spade or weed spudder several inches below the ground so as to be below where the larvae are situated. Then gather the docks and burn them as soon as they are dry.

BULLETIN No. 360 FEBRUARY, 1931

Ontario Department of Agriculture

**Ontario Agricultural College,
Guelph, Ontario.**

Farm Underdrainage

By F. L. Ferguson, Director of Drainage,
Drainage Division, Department of Agricultural Engineering.

Drainage is an Investment

From a financial standpoint, underdrainage can be considered as a long time investment. Tile drainage of agricultural lands is a comparatively expensive improvement and the capital expended in drainage work cannot be recalled or transferred, but owing to the permanent nature of the work properly installed drainage systems should continue to return dividends for many years. Just how many is problematical, but in a general way tile drains may be said to last a lifetime. Underdrainage, unlike most other long-time investments, will often pay dividends sufficient to return the original capital in two or three years.

All Soils Not Naturally Drained Require Drainage

These generally exist as:

1. Cultivated areas with fair surface drainage but exhibiting a heavy clay subsoil.

Fig. 1.—Is it practical to let a wet field like this hold up good men and horses?

2. Heavy clay soils with very little or no surface drainage.

3. Rolling areas with an impervious subsoil.

4. Areas, large and small, saturated long enough each year to destroy the physical condition of the soil interfere with spring seeding and harvesting operations.

5. Pot-holes and swamp areas.

Drainage Benefits Farm Crops

1. Earlier spring seeding is permitted.
2. The land is more easily worked.
3. Germination percentage is higher.

Fig. 2.—A swamp area tile drained in 1925 which has given a real crop every year since. The first crop paid all drainage expenses.

4. The soil is more favourable for root development—hence more moisture and plant food is available.—See Fig. 3.

5. Weeds are more easily controlled.

6. Winter killing is decreased.

7. Crop yields are increased.

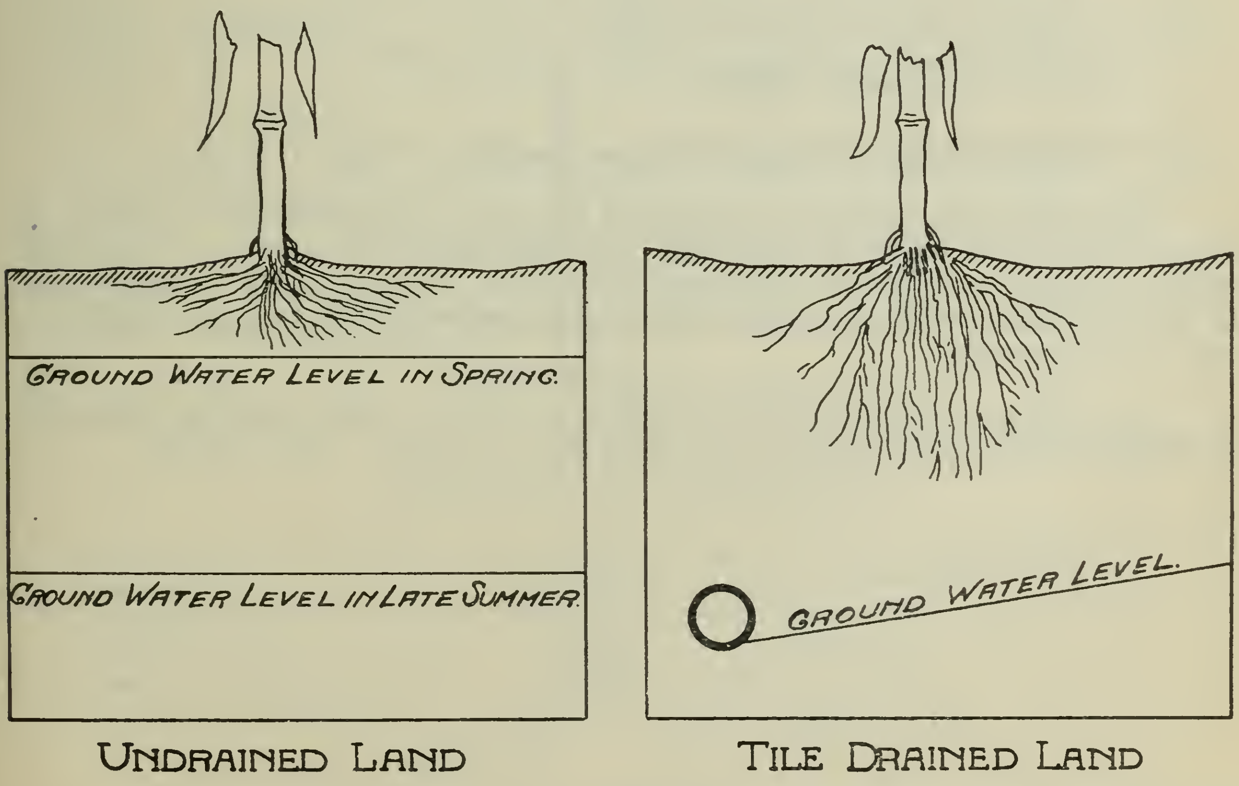


Fig. 3

Fig. 4.—In this peach orchard the first drain was placed between the second and third rows of trees instead of between the first and second, with the result that the first row died because of the wet conditions.

How Should Drainage Work Be Accomplished?

Whether the area to be drained is large or small, one drain or many, it is generally advisable to have a survey made.

The plan when prepared will show:—

1. The proper location for all mains, sub-mains and laterals.
2. The number and size of tile for each drain.
3. The possible grades and depths.
4. The best possible outlet.
5. The location of all obstructions, buildings, trees, fences, etc.

With this information at hand the farmer is in a position to put in as much as his time, help or financial circumstances will permit. The main drains should be installed first and the others added at will. Further, he is in a position to let a contract and has a basis on which to calculate the cost of his system.

By reason of the fact that the same area often lends itself to different drainage schemes, the more economical can be chosen.—See Fig. 6.

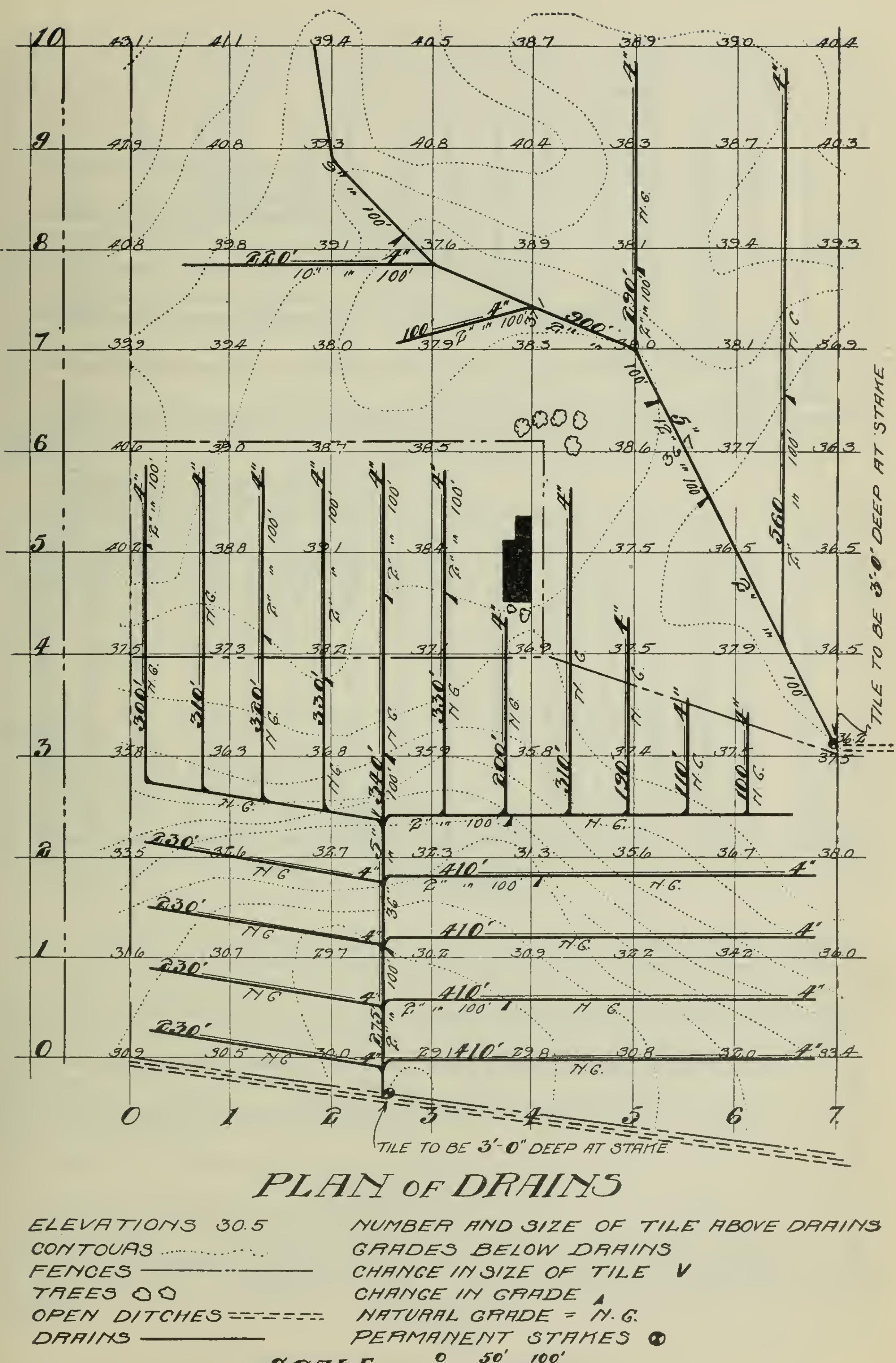
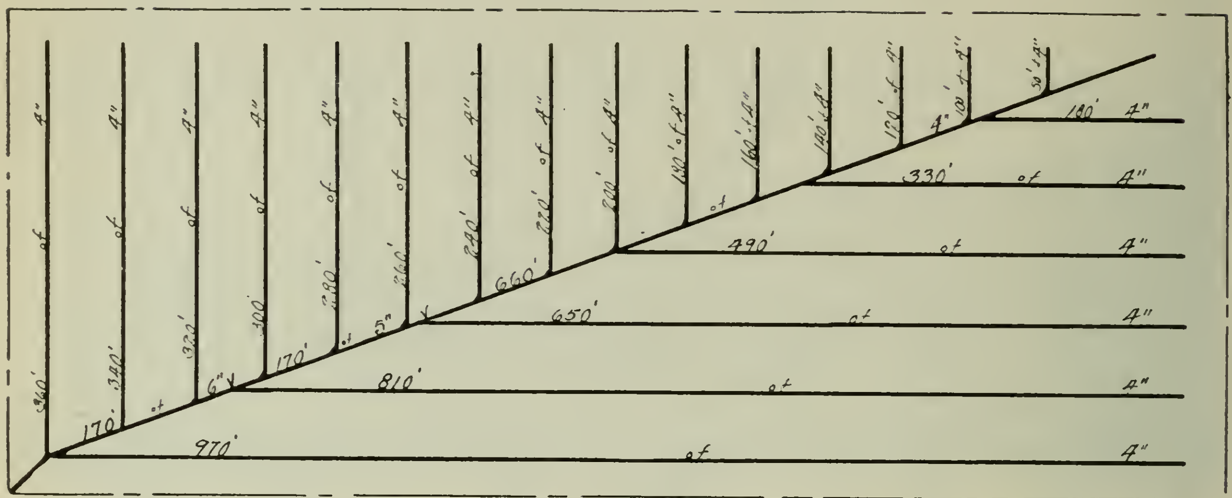
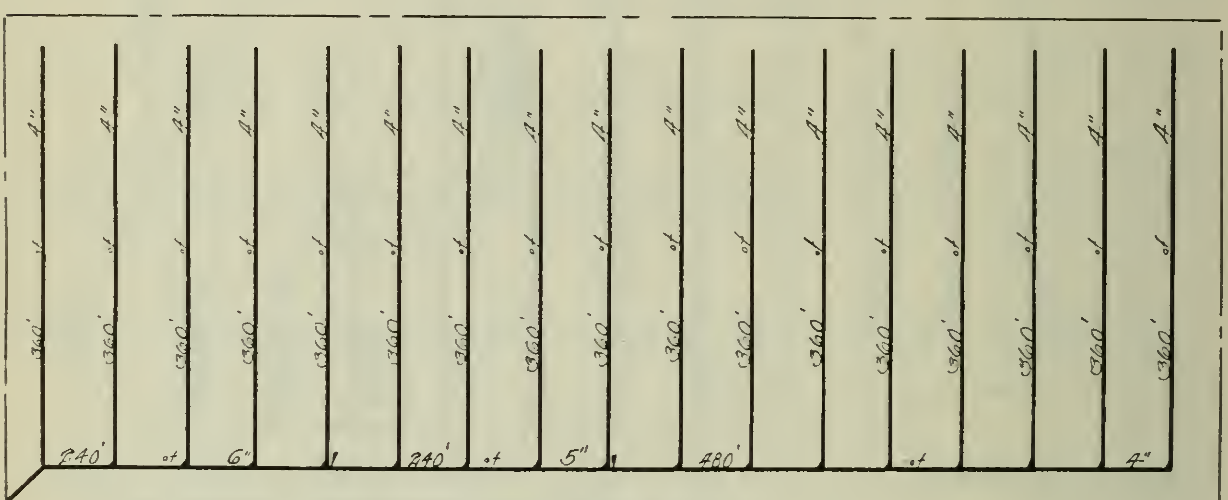


Fig. 5

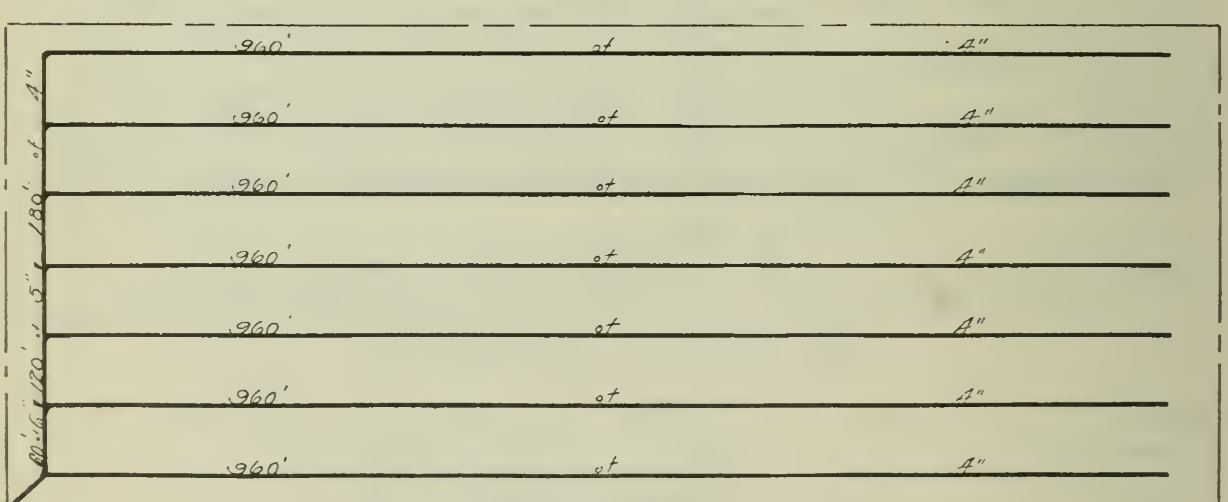
When a complete survey is made, drains to give the best results can be properly located.



PLAN "A"



PLAN "B"



PLAN "C"

Fig. 6

In Fig. 6 we have three different methods of draining the same 10-acre field. It is assumed that the slope of the land is equally favorable for any one of the three systems. Under any one of the systems shown, the field is thoroughly drained, but the cost of installation varies with each system.

Plan "A' (herringbone system) costs as follows for installation:—

466 rods of Digging @ 50c per rod	$	233.00
466 rods of Backfilling @ 5c per rod		23.30
7360 ft. of 4-inch Tile @ $25.00 per 1000		184.00
170 ft. of 5-inch Tile @ $4.00 per 1000		6.80
170 ft. of 6-inch Tile @ $50.00 per 1000		8.50
21 Junctions @ 20c each		4.20
Total for 10 acres	$	459.80

Plan "B" (gridiron system with long main and short laterals) costs as follows:—

429 rods of Digging @ 50c per rod	$	214.50
429 rods of Backfilling @ 5c per rod		21.45
6600 ft. of 4-inch Tile @ $25.00 per 1000		165.00
240 ft. of 5-inch Tile @ $40.00 per 1000		9.60
240 ft. of 6-inch Tile @ $50.00 per 1000		12.00
17 Junctions @ 20c each		3.40
Total for 10 acres	$	425.95

Plan "C" (gridiron system with short main and long laterals) costs as follows:—

429 rods of Digging @ 50c per rod	$	214.50
429 rods of Backfilling @ 5c per rod		21.45
6900 ft. of 4-inch Tile @ $25.00 per 1000		172.50
120 ft. of 5-inch Tile @ $40.00 per 1000		4.80
60 ft. of 6-inch Tile @ $50.00 per 1000		3.00
7 Junctions @ 20c each		1.40
Total for 10 acres	$	417.65

From the above figures it can be seen that Plan "A" costs $42.50 more to install than Plan "C". Plan "B" costs $5.30 more to install than Plan "C" and is a more difficult system for the machine operator to install because of the number of short drains. A study of these plans shows the advantage of having a drainage survey made by a competent engineer, whose duty it is to install the most efficient and at the same time the most econimical system possible.

Field Assistance

The Department of Agriculture, through its Drainage Branch at the Ontario Agricultural College, will, upon application, send a man to assist in the laying out of drainage work. Particulars will be furnished upon request.

Financial Assistance Necessary

The cost of drainage work varies, first, with the system required—in some cases a systematic system is necessary, while in others a few drains

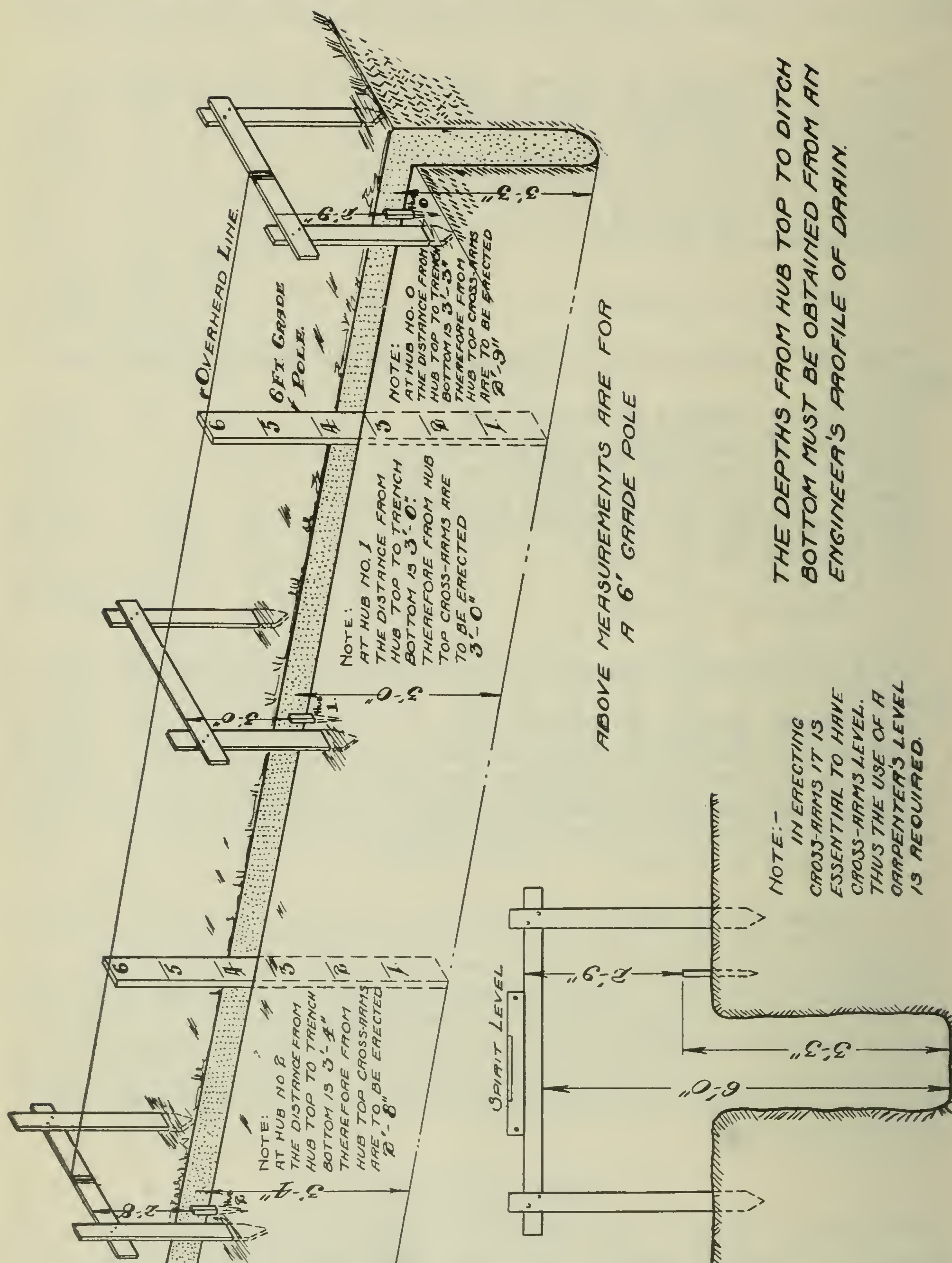


Fig. 7.—The Over-head Line—a most accurate and easy method of grading **a drain when** hand construction is necessary. The Drainage Dept., O.A.C., will furnish **further** details with regard to its use.

may be sufficient; second, the nature of the crops grown; third, the kind of digging; fourth, the location of the tile plant; and fifth, whether or not power machinery is available.

The Tile Drainage Act makes possible government loans for drainage purposes. Briefly, this Act provides for a loan secured through the municipal council of 75% of the cost of installing a drainage system. Money may be borrowed to the extent of $2,000 per 100 acres or fraction thereof. The loan may be refunded over a period of ten or twenty years at an interest rate of 5%. This means that over a twenty year period an annual payment of $8.03 for every hundred dollars borrowed retires both principal and interest.

At a cost of $40.00 per acre twenty annual payments of $3.20 would be required to retire the loan on a drainage system. If the land after tiling will not produce this extra revenue, the land is either not worth tiling or does not need it. No landowner needs to have his land untiled because of lack of capital. The township council is generally very glad to co-operate with their ratepayers in this respect and, furthermore, it is their duty to do so.

Installing the Tile

Tile may be installed either by hand or with a ditching machine. The latter, when properly operated, is quicker, more efficient and usually more economical. When hand work is necessary, one can make use of an ordinary plow, the Martin ditcher, the Little Wonder ditching machine, or some of the other hand digging machinery now on the market for drainage construction.

Fig. 8.—A nicely graded straight trench with tile well laid facilitates the flow of the water.

In either case, the following points should be kept in mind:—

1. The grade must be uniformally distributed so that depressions to collect sediment will not exist.

Fig. 9.—Martin ditcher used for backfilling. This is particularly well adapted to fruit orchards where the tree rows are narrow.

Fig. 10.—Using a log for backfilling. A stick of square timber is better. When drawn on an angle, the trench can be easily filled.

2. A solid bottom is essential—tile laid on muck or soft material are likely to shift out of alignment and obstruct the flow of water.

3. The tile should be laid as soon as the trench is completed.

4. The stones or other obstructions encountered in the trench must be removed, the hole carefully filled and tamped to give a solid bottom.

5. Only the best tile should be used.

6. Blinding and back-filling must be carefully done to eliminate the breaking of tile by rolling in stones or by horses stepping in the trench.

7. Junctions and outlets must be carefully constructed.

8. Trees likely to block the tile must be removed.

Laying Tile

Ordinarily, tile should be laid as closely together as the cut ends will permit. In heavy clay soils a little opening is not objectionable, while in sandy or sandy loam soils it is necessary to fit them closely together. In the latter it is often desirable to cover the upper half of the tile with tar paper to keep the sand from entering.

Whether tile are laid by hand or with a hook is not important so long as they are kept in proper alignment and well graded.

Junctions should be carefully constructed, in order that no obstruction offers resistance to the flow of the water.

A few inches of soil, preferably the surface soil, should be placed over the tile as soon as they are laid.

Backfilling should not be too long delayed, as frequently the soil will become baked by rain or in other ways become difficult to move.

Spacing and Depths

The depths and distances apart at which tile should be placed depend almost entirely upon the nature of the soil. The lighter the soil, the deeper and farther apart, while in heavy clay they must be placed closer together and somewhat shallower.

Quicksand

Of all the problems with which one has to contend in drainage, quicksand is perhaps the worst. The following suggestions may be helpful:—

1. Undertake the drainage of quicksand areas during the driest part of the season.

2. If possible, after opening the drain into quicksand, leave it until the water drains out. The sand will solidify and the drain may be more easily completed.

3. In some cases it will be found better to remove the last foot or so by hand, as the action of the digging wheel seems to provoke the trouble.

4. Sod thrown in the trench and around the joints is practical for short distances.

Fig. 11.—Constructing a "Y" junction. When the junction has been properly fitted, a tile is cut the proper length to fill the gap.

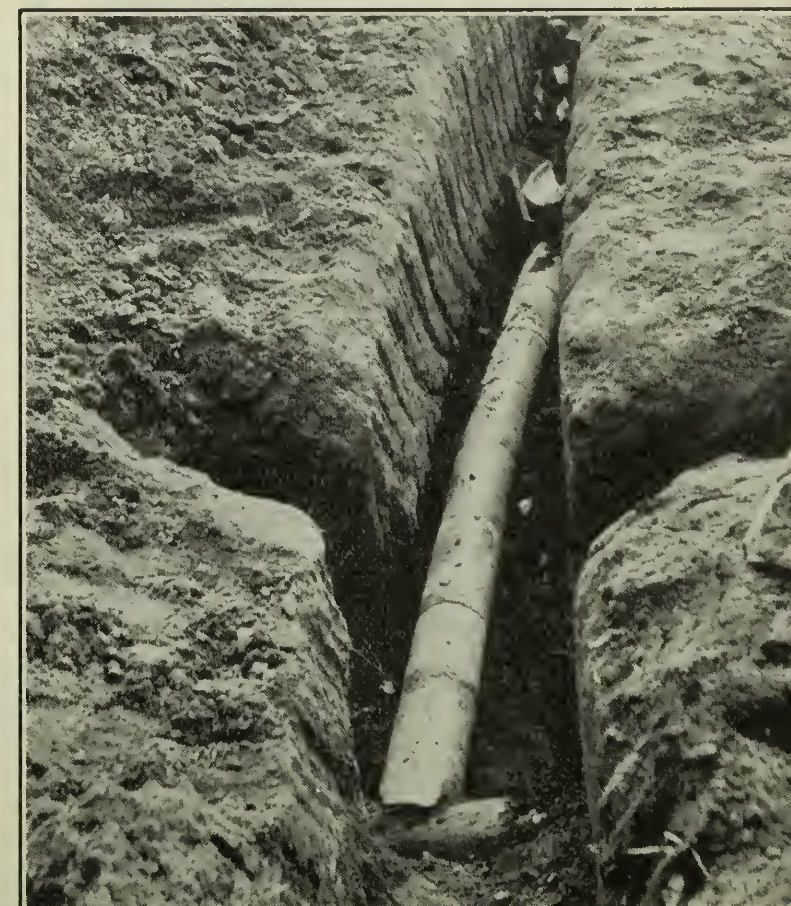


Fig. 12.—"T" junction ready to be covered with a little cement mortar to prevent a washout.

5. Straw, sawdust, shavings, gravel and cinders are often used to good advantage.

6. Cemented sewer-pipe may be found practical in some conditions.

7. A silt basin should be constructed on the line of tile as soon as possible after passing through the quicksand area.

Roots

Tree roots seldom interfere with a drain unless it is carrying spring or seepage water during the dry season.

All trees, such as willow, elderberry, poplar, soft maple and elm, should be removed from the location of the drain.

Where it is desirable to leave a shade tree, cemented sewer-pipe should be used for at least fifty feet on either side of the tree.

In fruit orchards and permanent crops, cut-off drains should be installed to remove all seepage water which has a tendency to feed the tile drain during the summer.

Outlets

The outlet of a drainage system should be well protected. The last eight or ten feet should consist of a piece of gas pipe, corrugated pipe, several lengths of sewer-pipe or even a wooden box. A concrete retaining wall may be a necessity. Some protection for the mouth of the tile to prevent the entrance of animals is essential.

Tile

Tile may be made either of clay or concrete. Either, when properly manufactured, give good results. They should exhibit the following qualities:

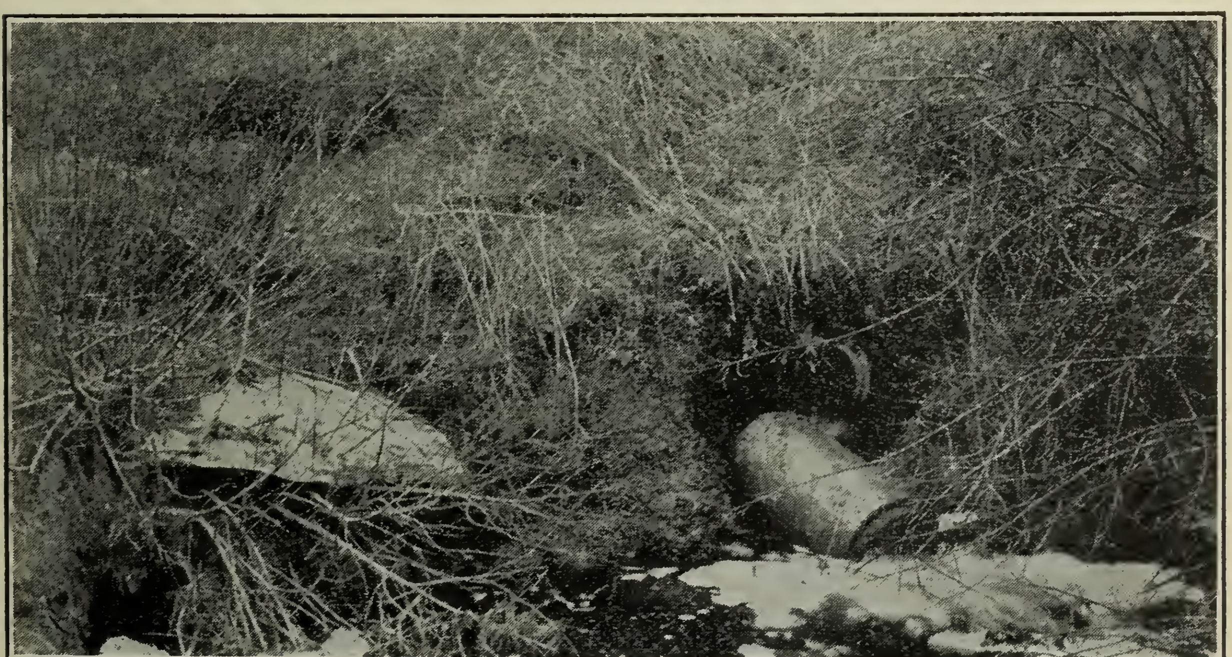


Fig. 13.—An outlet left in this condition soon becomes clogged and the whole tile system put out of commission.

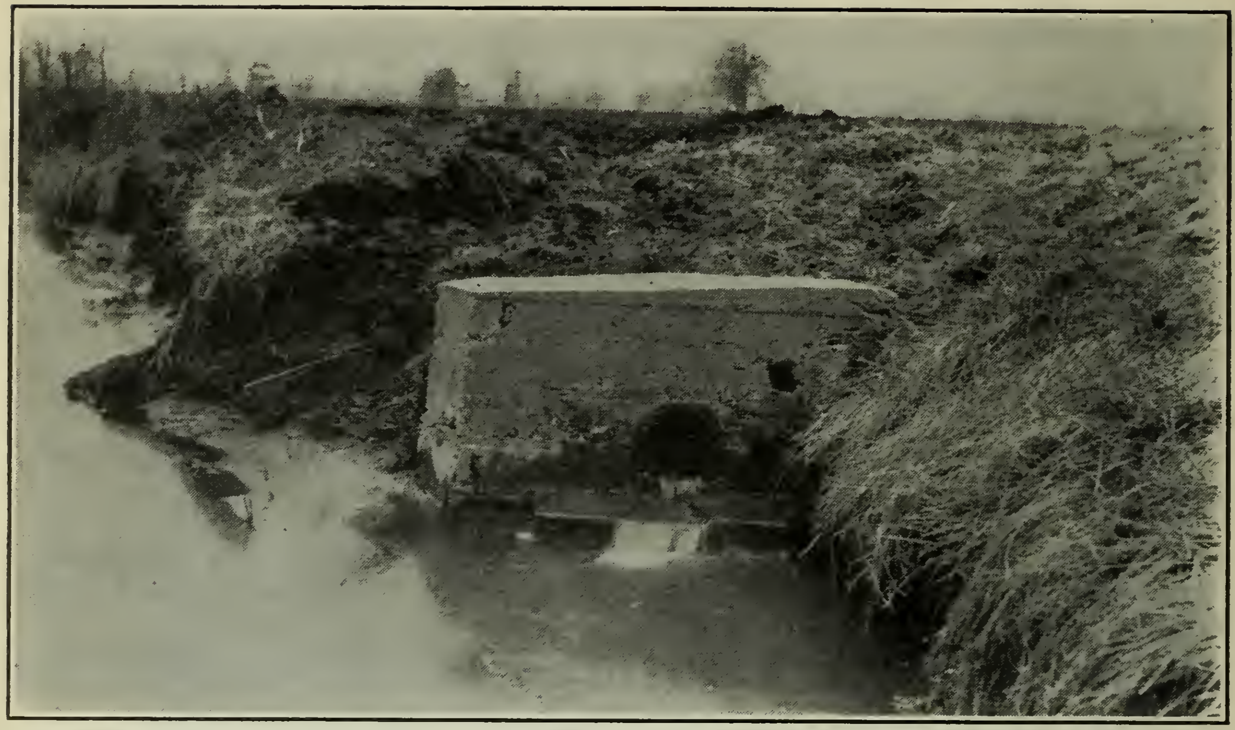


Fig. 14.—A well protected outlet—the concrete wall prevents caving, the screen the entrance of animals and the cement floor undermining of the wall.

1. Smoothness, to reduce friction and promote rapid waterflow.

2. Hardness to indicate durability—good shipping and handling qualities. The tile when struck with a piece of metal should give a distinct ring.

3. They should be well shaped—cylindrical, not warped and have clean-cut ends.

4. Clay tile should be free from burnt limestone.

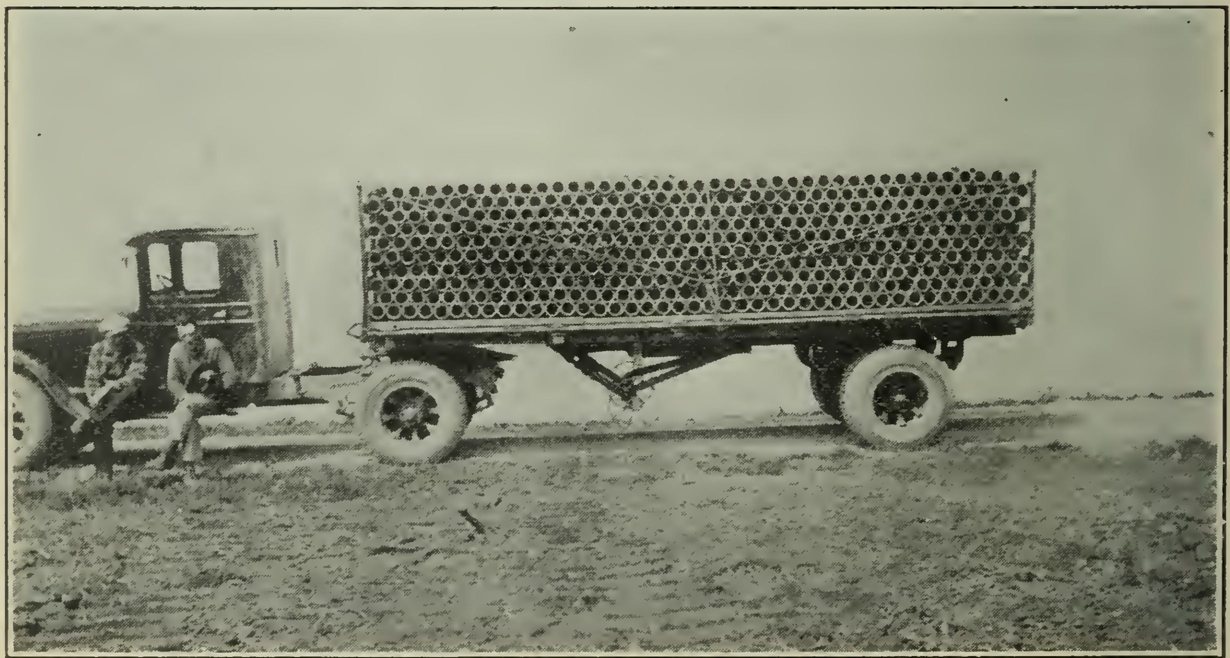


Fig. 15.—Delivering tile by truck insures a constant supply, fewer delays, less breakage and handling, as frequently they can be spread in the field along the trench lines.

TABLE 1. Size of Tile Pipe of Main Drain

(McConnell)

Acres Drained

Fall in inches per 100 ft.	3 in. Tile	4 in. Tile	6 in. Tile	8 in. Tile	10 in. Tile	12 in. Tile
60 inches	18.6	26.8	74.4	150.0	270.0	426.0
40 "	15.1	21.8	60.4	128.0	220.8	346.0
30 "	12.9	18.6	51.6	108.8	189.6	298.4
24 "	11.9	17.0	47.7	98.0	170.4	269.0
20 "	10.9	15.6	43.4	90.0	156.0	246.0
17 1-7 "	10.0	14.5	39.9	83.0	144.4	228.1
15 "	9.3	13.4	37.2	77.0	135.0	213.0
13 1-3 "	8.1	12.6	35.0	72.5	127.0	200.5
12 "	7.3	11.9	33.1	69.2	120.6	190.5
8 "	6.7	9.5	26.6	56.0	97.3	154.4
6 "	5.7	8.2	22.8	48.0	83.9	132.5
4 4-5 "	5.1	7.5	20.4	42.4	74.4	117.0
4 "	4.6	6.9	18.4	38.2	65.5	107.0
3 "	4.1	5.9	16.5	32.6	60.3	90.7
2 2-5 "	3.7	5.2	14.8	30.1	54.0	81.6
2 "	3.3	4.7	13.3	28.0	48.6	74.0
1 1-2 "	2.9	4.1	11.4	24.0	41.9	65.0
1 1-5 "	2.6	3.7	10.2	21.2	37.2	56.0
4-5 "	2.1	3.0	8.5	16.8	30.8	47.0
3-5 "	1.9	2.8	7.4	15.0	25.0	40.8

TABLE 2. DRAINS

6 rods or 100 feet apart	equals	436	feet to acre
5.4 " " 90 " "	"	484	" " "
4.7 " " 80 " "	"	544	" " "
4.2 " " 70 " "	"	622	" " "
3.6 " " 60 " "	"	726	" " "
3.0 " " 50 " "	"	871	" " "
2.4 " " 40 " "	"	1089	" " "
1.8 " " 30 " "	"	1450	" " "

TABLE 3. COST OF EXCAVATING PER ACRE

Price per Rod	30c	40c	50c	60c	70c	80c
100 feet apart	$ 7.93	$10.57	$13.21	$15.86	$18.51	$21.16
90 " "	8.80	11.73	14.67	17.60	20.53	23.46
80 " "	9.89	13.19	16.49	19.79	23.09	26.39
70 " "	11.31	15.00	18.85	22.62	26.39	30.16
60 " "	13.20	17.60	22.00	26.40	30.80	35.20
50 " "	15.81	21.12	26.40	31.70	37.00	42.30
40 " "	19.80	26.40	33.00	39.60	46.20	52.80
30 " "	26.37	35.15	43.97	52.72	61.52	70.32

TABLE 4. CAR LOTS OF TILE

(Clay)

	No. of Tile per car load
LOT 1.	2,195— 8 inch
	550— 5 "
LOT 2.	8,050— 3 "
	700— 5 "
	690— 8 "
LOT 3.	10,970— 3 "
LOT 4.	2,870— 3 "
	2,408— 8 "

	No. of Tile per car load
LOT 5.	9,700— 3 inch
	220— 5 "
	1,600— 4 "
	600— 6 "
	500— 8 "
LOT 6.	1,200—12 "

(Concrete)

No. of Tile per car load	No. of Rods per car
7,500— 3 inch	470
6,500— 4 "	406
5,000— 5 "	312
4,000— 6 "	250
3,000— 7 "	187
2,400— 8 "	150
1,600—10 "	100
1,000—12 "	62
535—14 "	50
400—15 "	37
335—16 "	31
267—18 "	25

TABLE NO. 5. TRUCK LOADS

3″—1200

4″—1000

5″— 650

6″— 500

7″— 400

8″— 250—300

10″— 160—175

12″— 120—130

Average weight—2¼ to 3 tons.

TABLE 6. APPROXIMATE WEIGHT OF TILE OF VARIOUS SIZES

Size of Tile	Weight of One Tile	Weight of 1,000 Tile
3 inches	4¾	4,750
3½ "	5½	5,500
4 "	6	6,000
5 "	9	9,000
6 "	11½	11,500
7 "	15	15,000
8 "	18½	18,500
10 "	26	26,000
12 "	34	34,000
14 "	40	40,000
16 "	47	47,000

BULLETIN 361] [DECEMBER, 1930

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE,
GUELPH, ONTARIO.

The Farm Water Supply and Sewage Disposal

FEATURING:

1. The farm water supply, wells and their construction, springs, cisterns, pumps, hydraulic ram; and water supply, plumbing and sewage disposal systems for farm homes.

by

R. R. Graham, Assoc. Prof. of Agricultural Engineering.

2. Bacterial action in the septic tank system of sewage disposal, and bacteria and the water supply.

by

D. H. Jones, Prof. of Bacteriology.

3. Chemistry of the farm water supply.

by

H. L. Fulmer, Assoc. Prof. of Chemistry.

4. The septic tank method of disposing of cheese factory and creamery waste water.

by

Frank Herns, Chief Dairy Instructor, London, Ont.

5. Appendixes: At the back of this bulletin there are a number of appendixes for the convenience of those applying for special information or assistance on any of the above-mentioned subjects.

THE NECESSITY AND VALUE OF MODERN CONVENIENCES IN THE FARM HOME.

Such home conveniences as running water and bathrooms have long been associated with city homes largely because they are required by city regulations. In these homes the value and necessity of these conveniences have been well established. If such things are so essential in the city home for improved sanitary conditions and for greater comfort and better health, why should not also the rural or farm homes have them. Such a claim has been amptly justified by those farmers who have installed these conveniences in their homes. The desire of rural people for modern home conveniences is becoming more widespread year by year, and although as yet only a small percentage of farm homes have running water and bathrooms, there is a distinct movement throughout the rural districts in the interest of better equipped homes. The fact that we receive requests daily for information about these things from people in all parts of the country is sufficient proof that the farm folk are thinking seriously about the matter, and in many cases are actually purchasing and installing the necessary equipment.

Where is running water needed more than on the farm? Think of the multiplicity of uses of water about the farm; in the house, in the stables, the dairy, the henhouse, pig pen, the garage, on the lawn, on the flower garden, etc. What a saving of labour and time is realized daily on farms where there is a water tap or faucet in each of these places! It's more than a convenience and a comfort, it's a necessity if the farmer's time is worth anything, and particularly when help is so scarce as it is to-day on the farm. Note this statement by one of our farmers in an Ontario journal, in the interest of running water on the farm.—"Our water system more than any other improvement that we have made around the place, gives us unending satisfaction and has robbed the city home of what was once its leading point of superiority. Not only have we found it quite possible to have running water, hot and cold, in a farm home, but the installation is less expensive than it is in the city."

The bathroom,—well here is what this same farmer has to say about it: "And what a comfort is a bathroom! I enjoy it to the full. I would not be without it if the cost were twice as great. The women folks are the chief beneficiaries. No more longing for the comforts of the city home! They have them right on the farm. I do not anticipate that they will be instrumental in furthering rural depopulation, for, if all reports be true, rural women who live without city conveniences have a habit of sowing seeds of discontent and taking the whole family off to town."

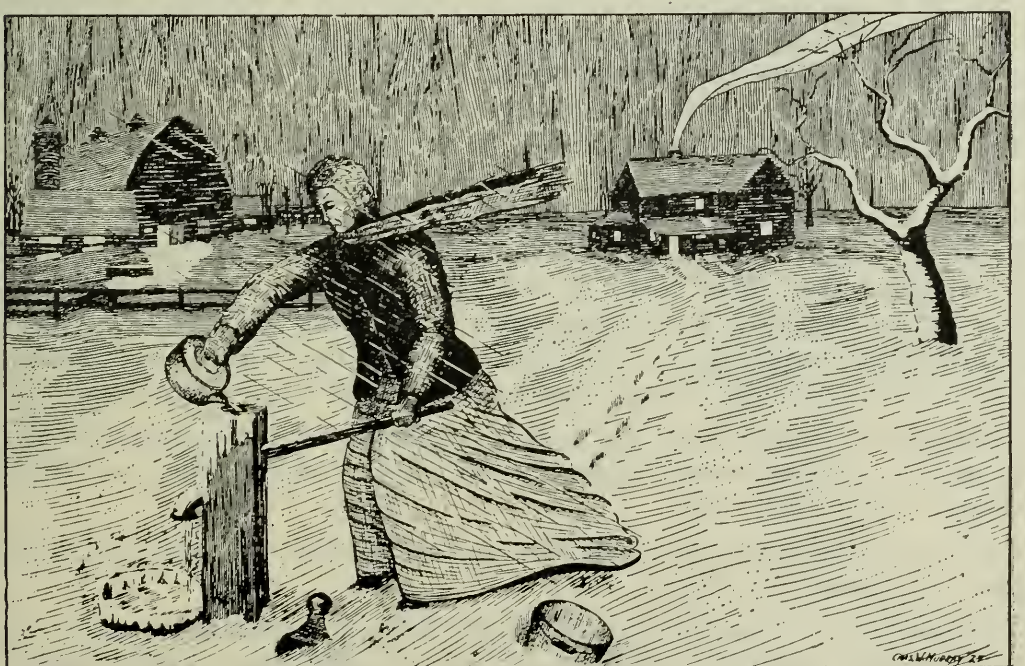
Lastly, how much more sanitary is a home where there is a modern septic tank to dispose of the daily wastes and sewage. With the advent of this modern system the outside privy with its menaces to the water supply and the health of the family has disappeared, and no longer are the kitchen slops and laundry wastes thrown out the back door to invite insect pests and other annoyances.

If running water saves time and labour, if a bathroom brings comforts and a consciousness of well-being, and a septic tank provides a sanitary environment for the home and wards off disease, surely no one can be accused of over-stating a fact when he says "that these modern conveniences are necessities in our farm homes." If in doubt ask those farmers who are enjoying their benefits to-day.

Purpose of this Bulletin.

The purpose of this bulletin is to supply information to farmers who wish to improve their water supply, to install a water system, or it may be a hydraulic ram, a bathroom and a septic tank. Applicants are advised to make use of the Appendixes at the back of the bulletin, as better service can be rendered them if full particulars of their problems are available.

Washing Dishes. Hot water on tap at sink.



Indoor water supplies and modern conveniences do away with unnecessary drudgery.

(By courtesy of the Provincial Board of Health).

1. THE FARM WATER SUPPLY

(*a*) The Manner of Occurrence and the Quantity.

In gaining an appreciation of water supply problems, and a knowledge of how to solve them, it is desirable first to make a brief study of the occurrence of underground water. The earth is composed of a number of layers or strata. Some, like sands and gravels, are loose, open, porous, and water passes through them readily; others, like heavy clay, hardpan and rock, are so compact and the pores therefore so small that water passes through them very slowly if at all. These pervious or porous layers, and impervious or non-porous ones are very important from the standpoint of water supply. Frequently they are distributed somewhat as follows: First, a pervious layer of soil on the surface, thin in some places and thick in others. Second, an impervious layer of clay, hardpan or shale rock. Third, a pervious layer of sand, gravel or shale, and fourthly, an impervious one of solid rock. But the number may be even greater than this, or the solid rock may extend right to the surface. Fig. 1 shows a possible distribution.

When rain falls upon the land shown in Fig. 1, part of it soaks into the porous layers, as at A or C, and part may run off over the surface. Also that which falls on the impervious layer as at B must find its way over the surface to the porous layers and into them or over their surface to a stream or pond. When the porous layers at the surface are saturated in part, the ground water-level would be somewhat as shown by the dotted lines. At A, A′, and C, dug wells sunk in the porous layers would give a supply of water, and the level in the wells would be the same as the ground water-level. At B the impervious layer comes to the surface and a well sunk in it would give no water until the porous layer beneath it was struck. Then the water would rise to the same ground water-level as in the well at C. A well drilled at A deep enough to strike the second porous layer would produce a flowing or artesian well. At D, where the surface layer becomes quite thin, the water would in all probability break out, forming a spring, or saturate the soil all round, causing a "springy spot." And indeed it would be possible for the water from the second porous layer to find a crevice or channel through the upper layers and produce a spring as at E.

The origin of water in the earth is not always so evident as in Fig. 1. Particularly in arid and semi-arid regions is this the case, e,g., in Saskatchewan and Alberta and in parts of Australia and India. In many such localities the precipitation is not sufficient to saturate the surface layer and produce a ground water-level in it. And drilling even to a depth of hundreds of feet may fail to locate a water-bearing stratum farther down, and yet occasionally shallow wells sunk in these areas tap veins or underground streams, rivers or lakes, whose source we do not know, nor their outlets.

In limestone formations the water occurs in crevices between the layers of rock and in underground holes or caverns or sometimes in channels, as illustrated in Fig. (2) (*a*)

In the granite types of rock, the water, if any, occurs in the cracks or cleavages, as shown in Fig. 2 (*b*).

The quantity of underground water depends primarily upon the rainfall, and secondly upon the capacity of the soil and rock to hold water. Clays and loams are good water-bearers but they give it up slowly.

Sandstone on the whole is the best water-bearer of the solid rocks, and the quality is second to none, except that from sand and gravel formations.

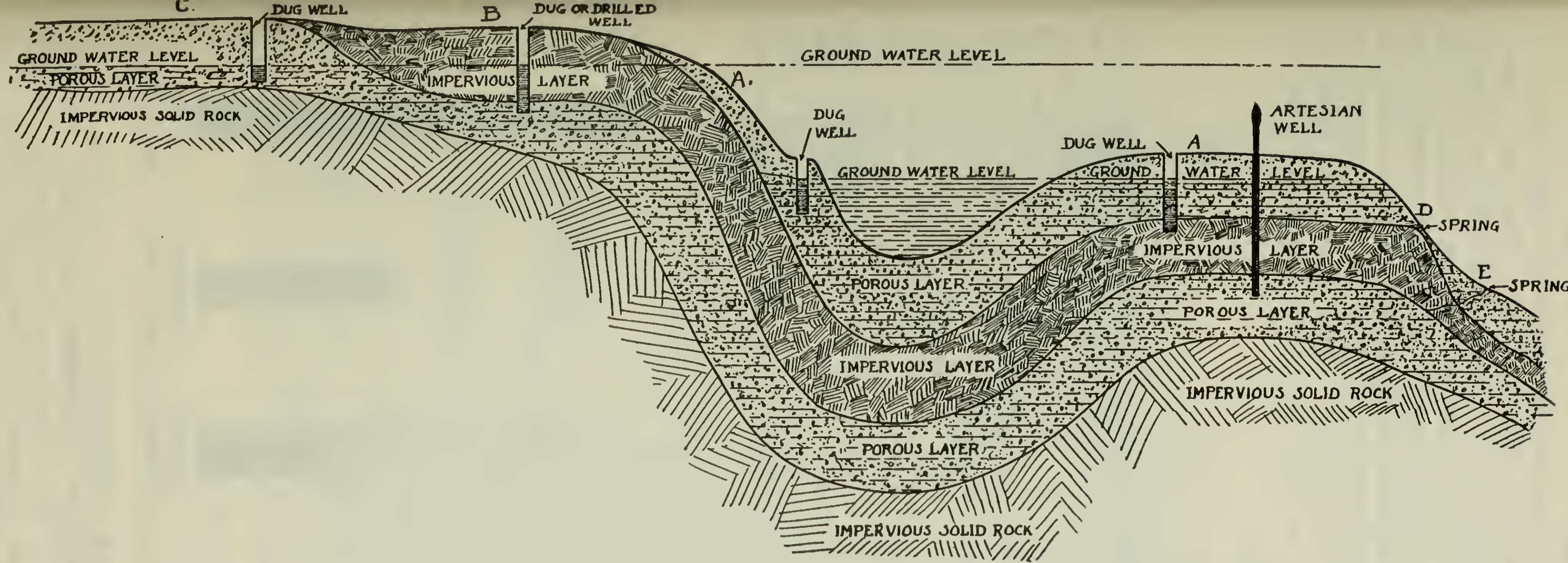
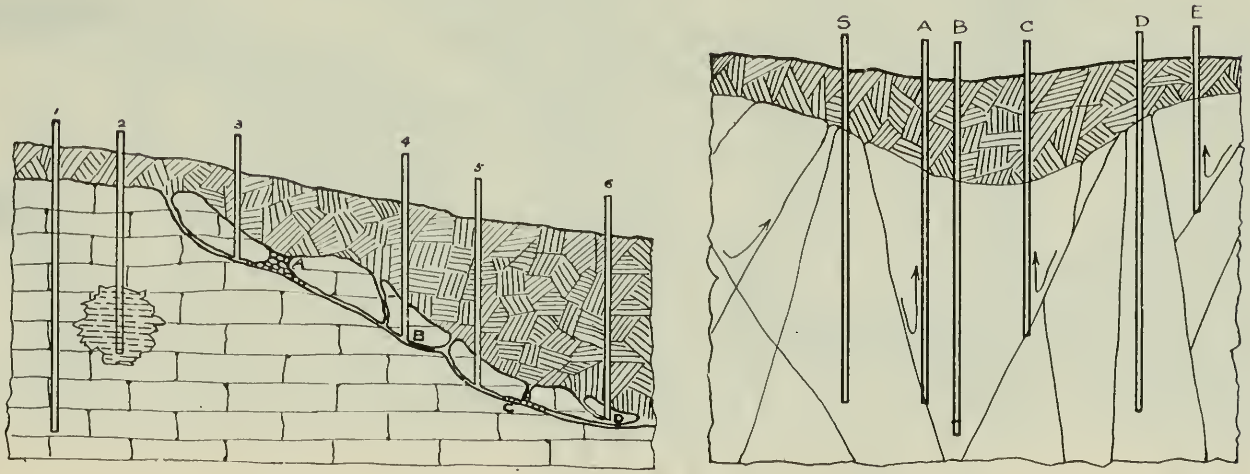


Fig. 1.—Showing soil layers, ground water levels, wells and springs.



(a) (b)

Fig. 2.—Manner of occurrence of water supply.

Limestone rock is a pretty good water-bearer, a very good supply being obtained if the well is sunk into open channels, or caverns in the rock. Granites and rocks of this type are poor water-bearers except for wells drilled into intersections of many joints in the bed rock. Sand and gravel beds usually give good supplies of high quality water, and a driller is lucky if he strikes a good bed of this material deep below the surface. Well drillers usually figure that they can get plenty of water in sandstone or limestone formations at reasonably shallow depths, 100 feet more or less, and sometimes even in solid rock like granite, if they go deep enough to intercept sufficient joints as feeders of the well. They are not so lucky in slate formations as in granite rocks, as the former are the poorest water-bearers.

(b) Finding Water.

This has always been a matter of great concern among the farmers in many localities, and unfortunately for them there is no reliable method as yet for finding water. So-called "water diviners" may help in some cases, but they fail as often as they succeed, or oftener, and therefore are not reliable indicators. The electrical water-finder likewise has failed. In view of these facts we think that the following statement taken from Fuller's text on "Domestic Water Supplies" is not far astray, "so far the only scientific basis for locating water is a knowledge of the laws of occurrence and movements of the ground water, for on these factors depend the quantity, the quality and safety of the supply." This means that the best clue to the occurrence or not of underground water is a knowledge of the soil and rock beneath the locality in question. The character and depth of the existing wells in the locality may also be a useful guide, or the logs of such wells, if available.

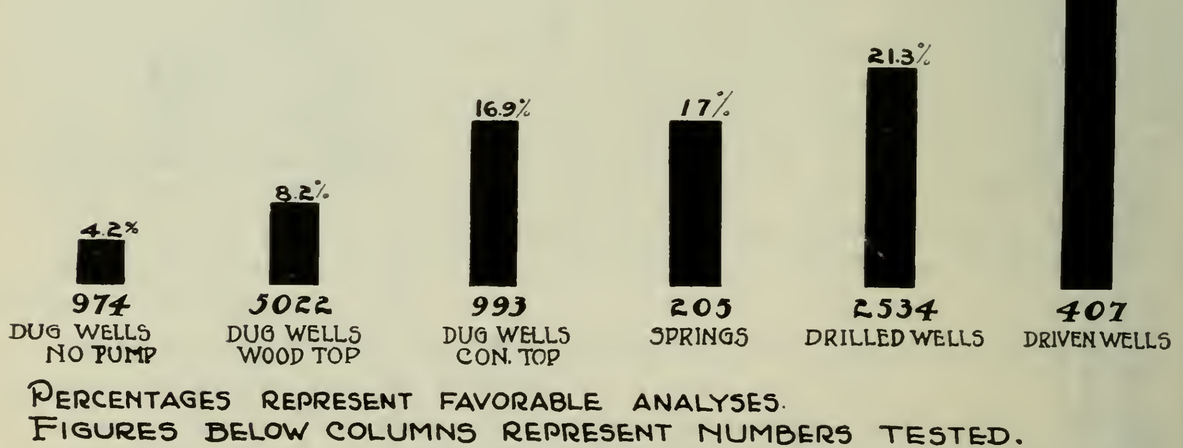
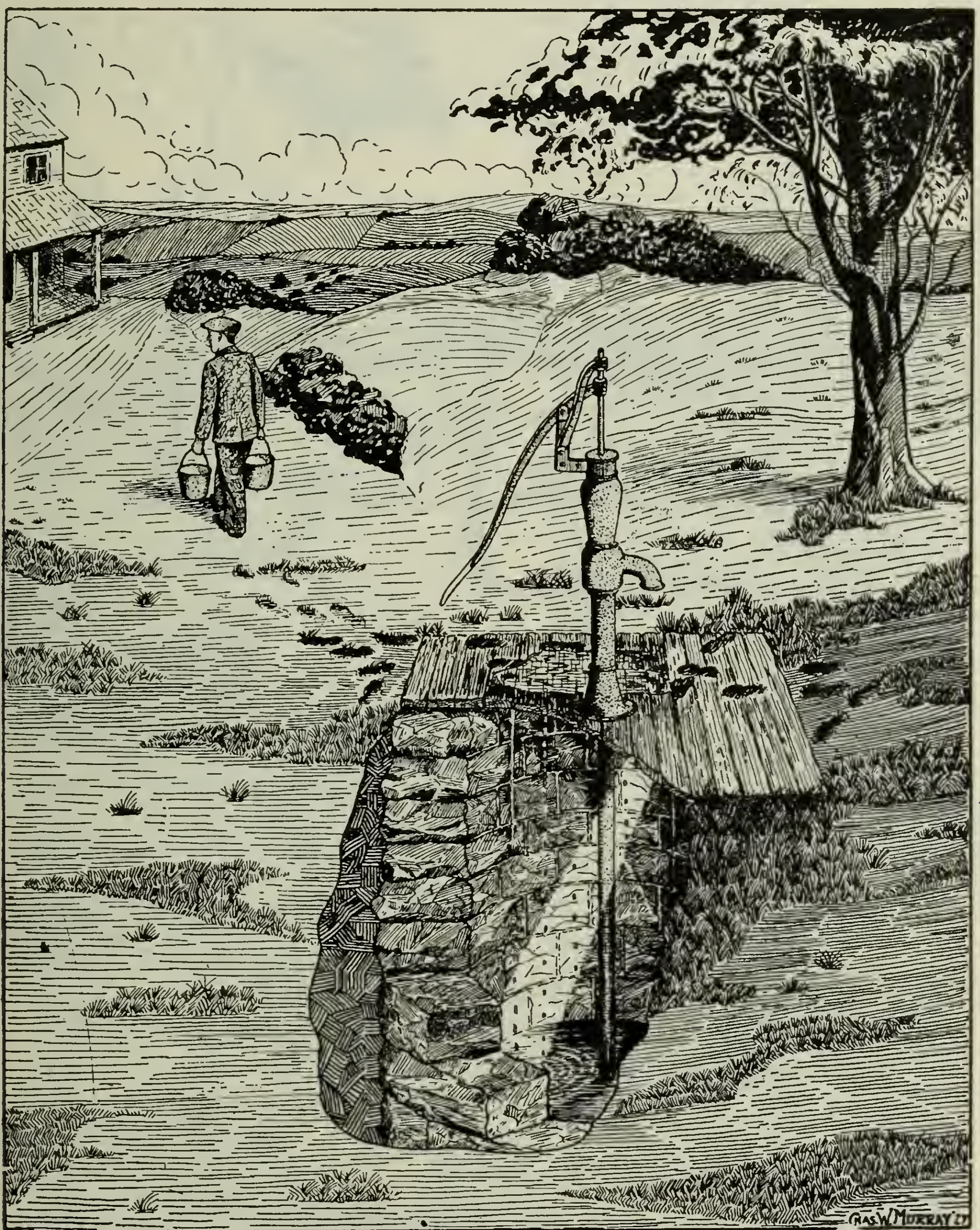


Fig. 3.—Wells of various types and percentages in each group giving favourable analysis.

(By courtesy of the Provincial Board of Health).

(*c*) Safe-guarding the Purity of the Water Supply.

All important as it is to have plenty of water on a farm, it is necessary in the interests of health that the water be free from filth and disease germs or injurious bacteria of all kinds. The Provincial Board of Health has made rather extensive tests of well water in various municipalities, and the results given graphically in Fig. 3 indicate that the water supplies of shallow wells particularly are badly contaminated.



AN UNSANITARY WELL

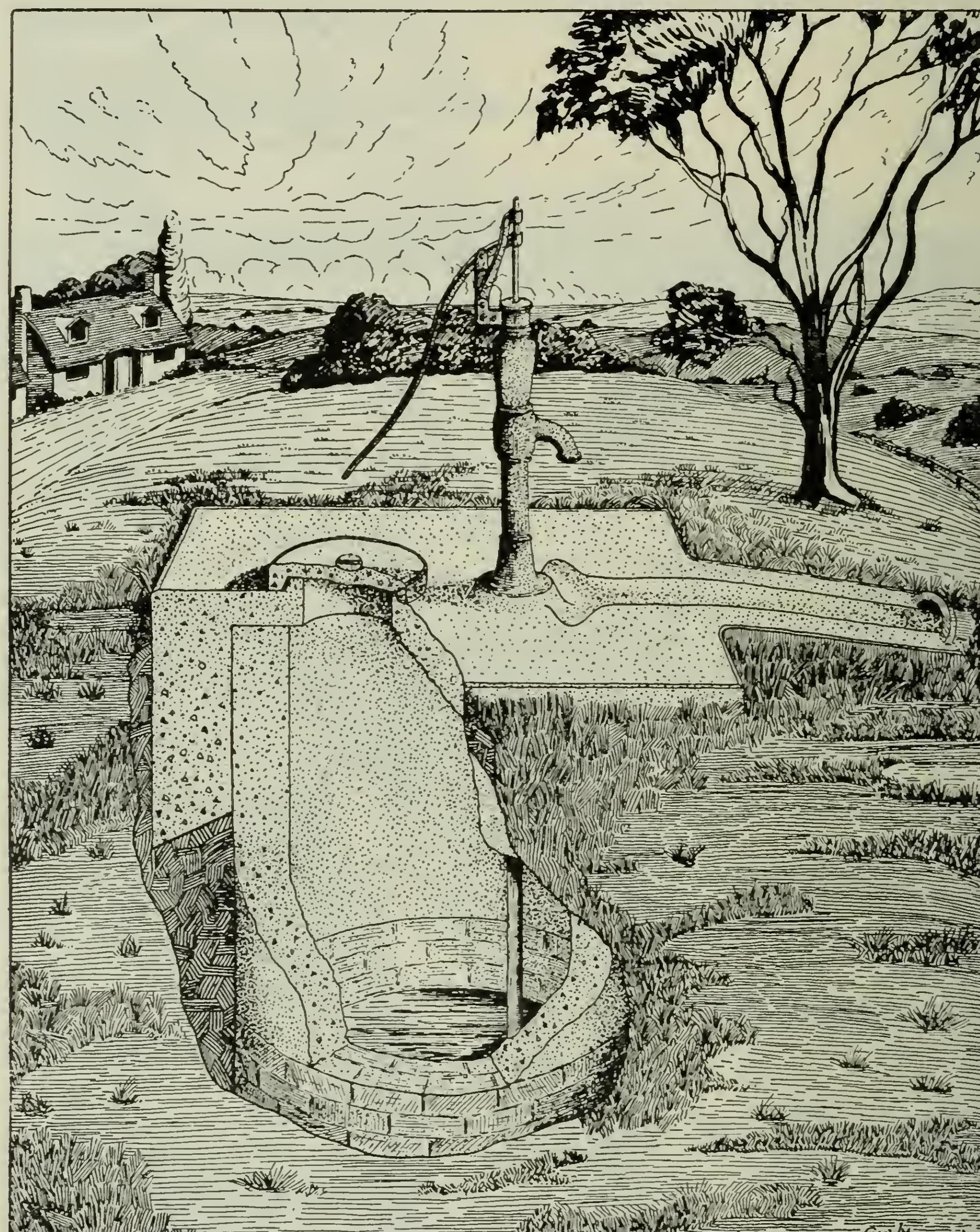
This enables filth of all kinds to gain direct and easy entrance to the drinking water.

It is found that the pollution gets into these wells through the top and the sides down a distance of a few feet. The remedies for this condition are usually quite simple and inexpensive and are as follows:—

(1) Favourable location of the well; on higher elevations than any possible source of pollution, like barnyard, cesspools, privies, etc., and removed as far as possible from such sources of contamination. No definite

"safety distance" can be recommended as a good deal depends on the type of soil and rock present. Wells in open soils and fissured rocks are more likely to be contaminated than those in more impervious types, and hence greater precautions are necessary in the former than in the latter cases.

(2) Construction of shallow wells and springs with water-tight tops and cribbing. In shallow wells the cribbing should be made water-proof for 10 feet below the surface. Different methods of doing this are indicated in Figs. 4, 5 and 6.



A SANITARY WELL

Water-tight top and sides exclude surface drainage and other filth.

(By courtesy of the Provincial Board of Health).

(3) Top of well made enough higher than surrounding levels to carry surface water freely away from the well.

(4) In case of drilled wells the casing should be driven tightly into the rock for some distance, and the top of the casing should be made fast in the cement cover or top. See Fig. 4 (*a*).

(5) In every case, whether shallow well or drilled, the pump head should be fastened with a water-tight joint to the platform or top of the well.

(6) When a drilled well is sunk from the bottom of a shallow well or dry well, the bottom should be cemented and a water-tight joint made around the well casing that passes through the cement. See Fig. 5 (*b*).

(7) Farm animals should not be permitted to come close to wells or springs.

(8) Old abandoned shallow wells should never be used as cesspools as they are very apt to pollute the other wells on the premises.

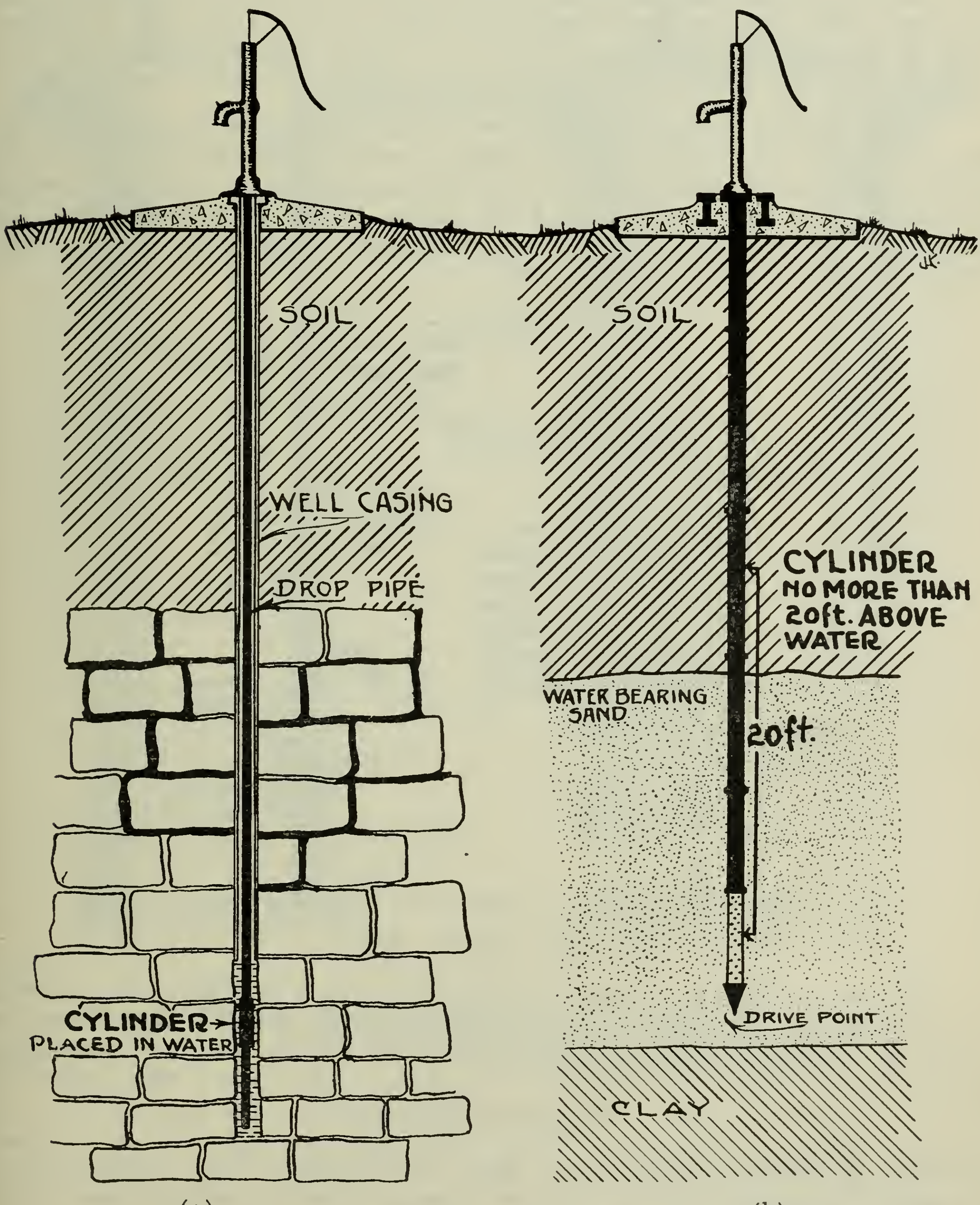


Fig. 4.—(a) Drilled well properly protected.
(b) Driven well properly protected.

2. DIFFERENT TYPES OF WELLS, ALSO SPRINGS AND CISTERNS.

There are three or four standard types of wells—the dug, the drilled, the driven, and the bored. Springs and cisterns and occasionally fresh water streams and lakes form other useful water supplies for the farm.

(*a*) The Dug Well.

When the ground water occurs in soils or loose materials that can be dug or picked, and within a reasonable depth, the dug or shallow well is the common type. Since the ground water seeps through soils very slowly, particularly the clays, the dug wells have to be made large in circumference in order to provide sufficient seepage area to let enough water into the well. As a rule, they vary in depth from 10 to 100 feet, but they may be deeper. Figs. 5 (*a*) and 6 (*a*) and (*b*) illustrate typical dug wells and how they should be cribbed and covered.

Many shallow wells go dry in time owing to changed conditions of the soil and become dry wells. In some cases it pays to dig them deeper or else bore or drive in the bottom of them until water is struck. If bored, it would be necessary to case the hole, and the casing should be brought up to the surface in order to keep out contamination that might enter the dry well. This type is illustrated in Fig. 5 (*b*).

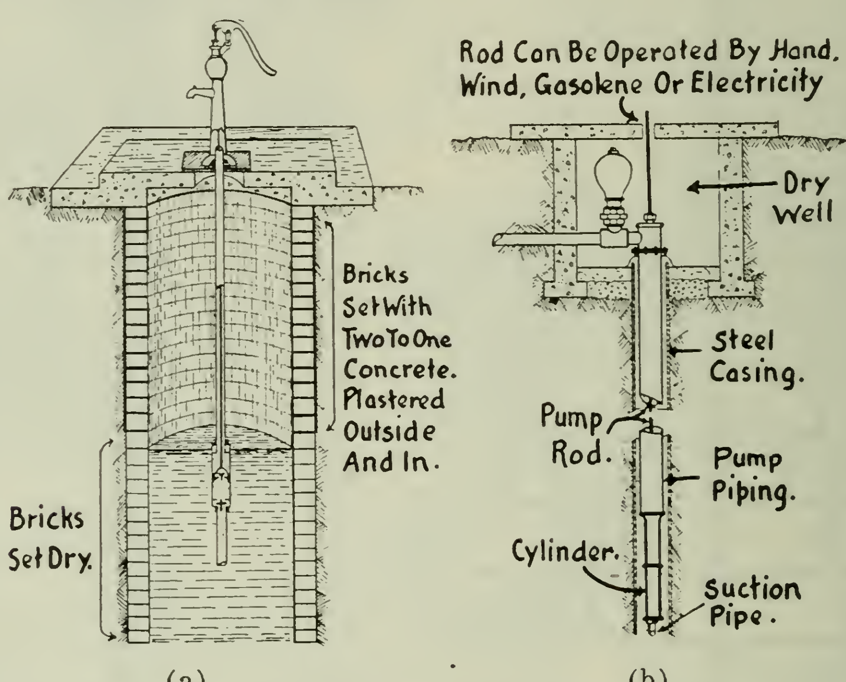


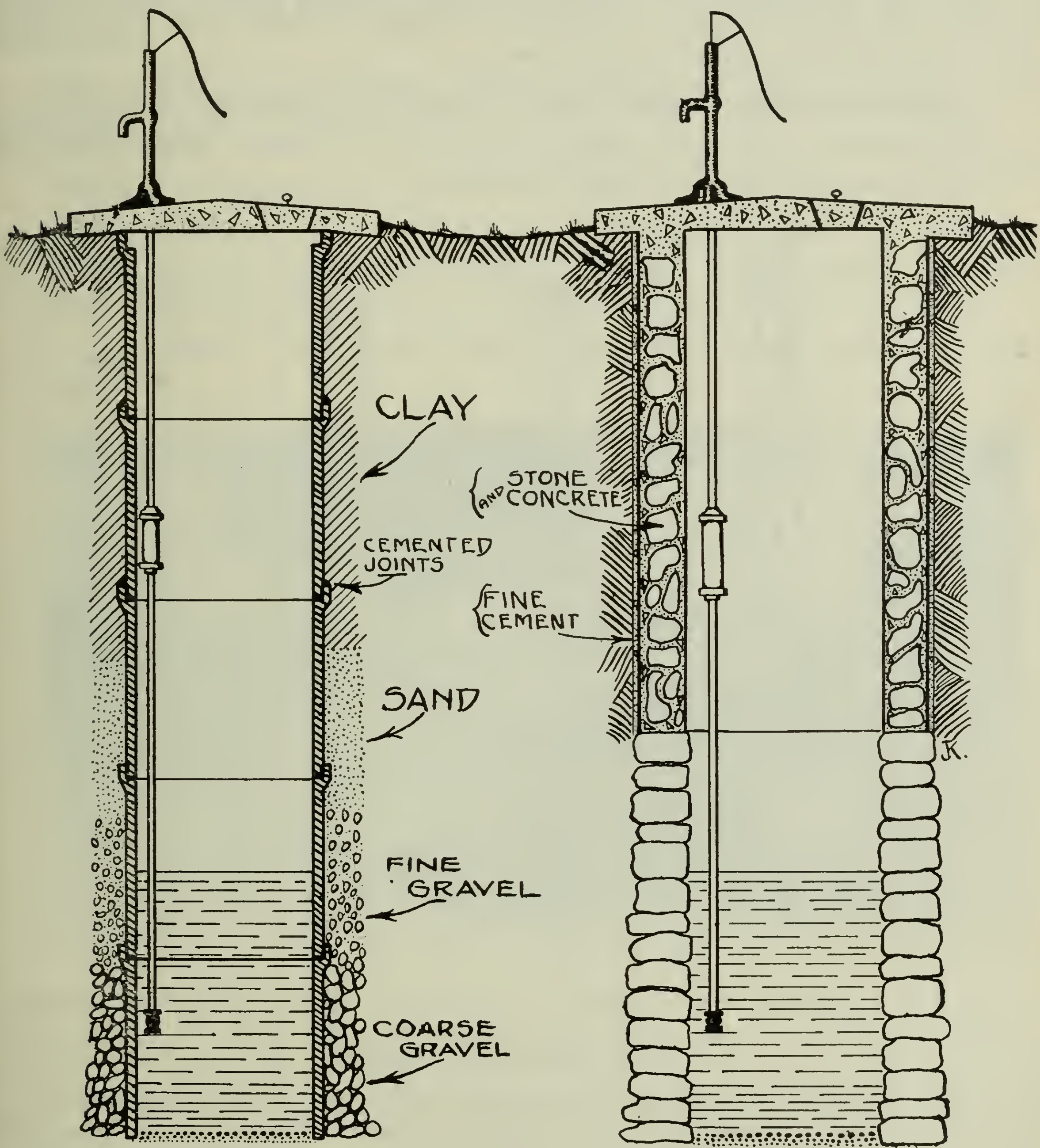
Fig. 5.—Two types of deep wells, brick and bored.

(*b*) The Drilled Well.

This is the deep type sunk through soil or rock formation by a special tool or machine operated by the professional well driller. Water may be struck at various depths, frequently from 60 to 200 feet, but sometimes much greater depths are required. Since the water comes from such low levels it is almost certain to be pure and wholesome. The quantity is variable, depending on the nature of the water-bearing strata that are tapped. The size of the hole varies from three to six inches, and it passes down through the surface layer of soil and through the non-porous layer of clay or rock below it into a second water-bearing layer beneath. The bore is protected with a water-tight wrought-iron casing, which when the rock is penetrated is driven firmly into the rock to exclude surface water, but no casing is used through the rock.

The contract for boring a well is usually made on the basis of so much per foot, which price includes casing and testing for water, etc.

The drilled well is one of our best and most reliable wells and is very common in certain areas. Various drilled wells are illustrated in Figs. 4 (*a*), 5 (*b*), 12 (*b*) and 24.



(a) (b)

Fig. 6.—(a) Dug well cribbed with cement tile.
(b) An old stoned well rebuilt with water-tight top, and sides 8 to 10 ft. deep.

(*c*) DRIVEN WELLS.

Where the soils are such that a pipe can be driven down into a porous water-bearing stratum such as sand or gravel, then driven wells may be constructed much more easily and cheaply than dug wells. The method of procedure is as follows:

1. A well point (such as shown in Fig. 7) is procured.

2. The point is screwed on to a pipe of the proper size, and a drive cap on the top of the pipe. Usually $1\frac{1}{4}$ or $1\frac{1}{2}$-inch pipe is used for ordinary farm wells.

3. The point and pipe are driven into the ground by sledge, maul, or drop weight, until the end is just above ground. Care should be taken to have the pipe perpendicular. Sometimes when a hard layer of soil is struck the pipe is withdrawn and a hole bored through the hard layer by a special auger, and then the driving continued.

4. Another length of pipe is then put on, and the operation repeated.

5. Tests for water are made from time to time. This is done by letting down a plumb bob inside the pipe.

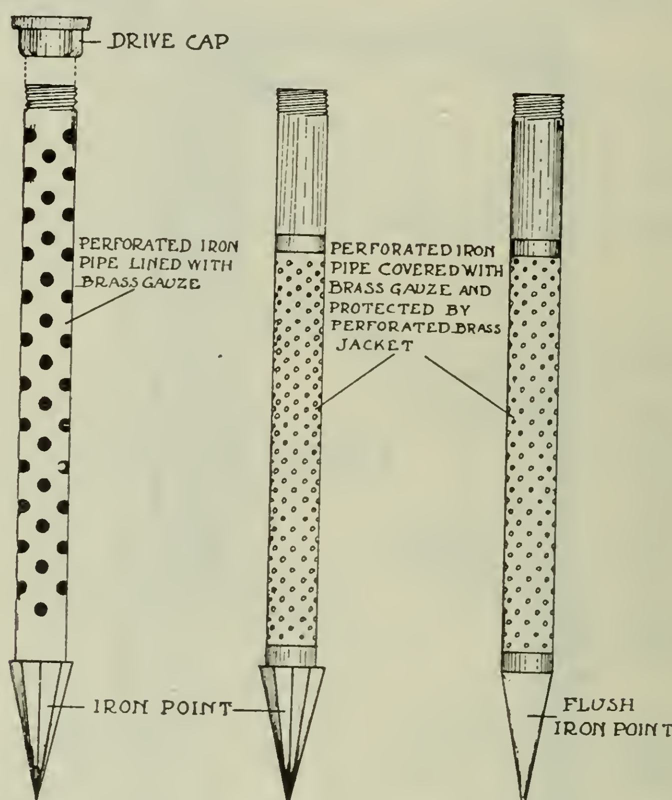


Fig. 7.—Types of well points.

6. For a satisfactory supply of water the point should be driven a considerable distance into the porous layer, but care must be taken not to drive through it into the non-porous layer beneath. To ascertain whether the supply is adequate a pump is attached to the top of the pipe and pumping is continued for several hours. If the supply fails under this test, the point should be driven deeper in the porous layer. Where the water-level is more than twenty-five feet down, the hole would have to be large enough to admit the pump cylinder to the required depth.

7. The pump is then fixed permanently in place. There are three methods of doing this: If there is no danger of freezing, the pump, including cylinder and sucker, may be placed entirely above ground, the cylinder being screwed directly to the pipe when the drive cap is removed. Or the pump may be placed in kitchen or stable, as desired. If there is danger of freezing, a shallow dry well as seen in Fig. 5 (*b*), may be dug as far down as the first joint in the pipe, when the top length is removed and the pump placed in its stead, the cylinder being down near the bot-

tom. This dry well for the pump should be cribbed and a tight cover provided, but the cribbing need not be backed with cement or puddled clay. The third method is to put the cylinder in the drive-pipe.

The driven well is sometimes constructed without a drive-point. In this case the open pipe is driven down until driving becomes difficult, when the cap is removed, water poured into the pipe and the soil after being loosened by a drill is removed by means of a sand pump. When the water-bearing layer is struck the pipe is driven a short distance into it and then the hole sunk somewhat farther by means of the drill and sand pump.

The water from a driven well is turbid at first, but after a time becomes clear, as the finer particles of soil are gradually removed from the areas about the point.

The advantages of the driven well are:

I. Its cheapness.

2. Its sanitary qualities. Surface water cannot reach the point without filtering through twenty to twenty-five feet of soil.

3. A battery of well points may be used if a larger quantity of water is needed.

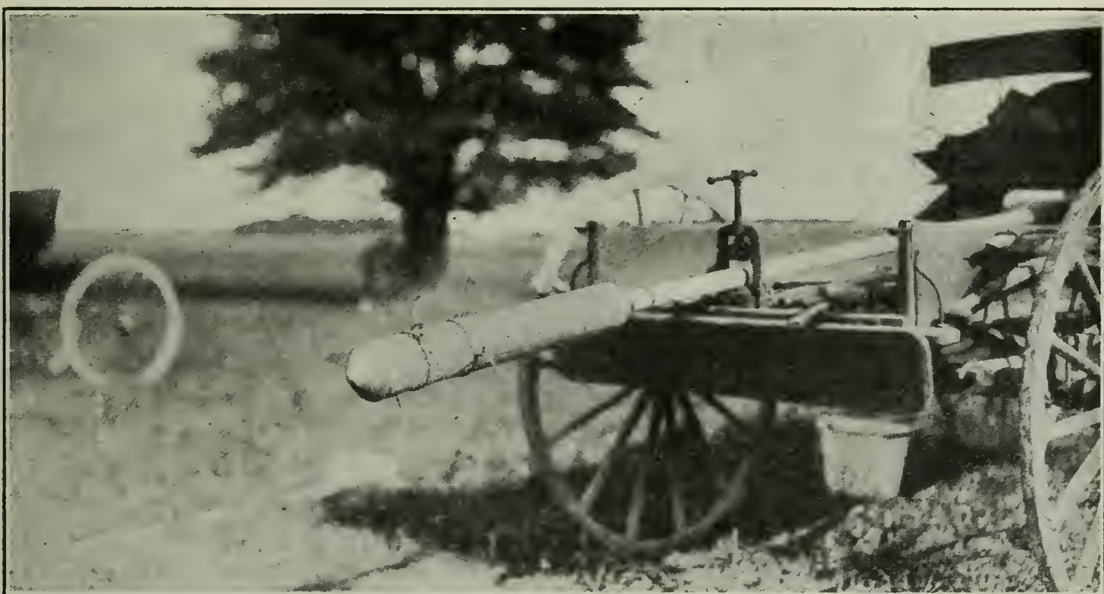


Fig. 8.—Sand filter, to be placed in open drive pipe.

Driven Well in Quicksand.

Sometimes in driven wells the sand is so fine that it blocks up the ordinary drive-point. In overcoming this considerable success has been attained by using a special filter attached to the suction pipe as shown in Fig. 8. The filter is made similarly to the drive-point, only being larger, about six to eight inches in diameter and three feet long. In this case an open drive-pipe or casing is used, and it must be large enough to admit the filter, and a jacket of gravel, usually about ten inches in diameter. A good pipe for this purpose made be made of very heavy galvanized iron sheeting, the sections being detachable and with a locking device. When the pipe has been driven down into the water-bearing area all the earth is removed from it, then a foot or so of coarse gravel placed in the bottom, the filter screwed to the suction pipe and set on the gravel, and enough fine gravel put in to fill the space between the filter and the drive-pipe. The latter is then withdrawn, and the pump attached to the top of the suction pipe.

(d) The Bored Well.

In instances where the soil is quite loose and free from stones and boulders, and where a good water-bearing layer of material lies within twenty or thirty feet of the surface, at any rate not exceeding fifty feet, the well or hole may be sunk by an auger, if hole is two or three inches in diameter, or by a special soil auger or well borer for larger holes.

In the small-sized ones the hole is not big enough to admit a cylinder, and consequently the water must lie within the suction distance, say twenty to twenty-five feet from the surface where the cylinder must of necessity be located.

The smaller wells are cased with iron pipe 1½ to 2 inches in diameter and the larger ones with wooden casings or cement tile. The casings should be forced to a depth a little lower than the water level, and if soil at the bottom of the hole is not loose or gravelly the lower portion of the casing should be perforated to facilitate ingress of water. If quicksand or very fine material is encountered, a drive point or screened pipe may have to be attached to the lower end of the suction pipe. If coarse gravel be dropped around this filter or screen it will often be beneficial in preventing clogging of the pipe by entrance of sand.

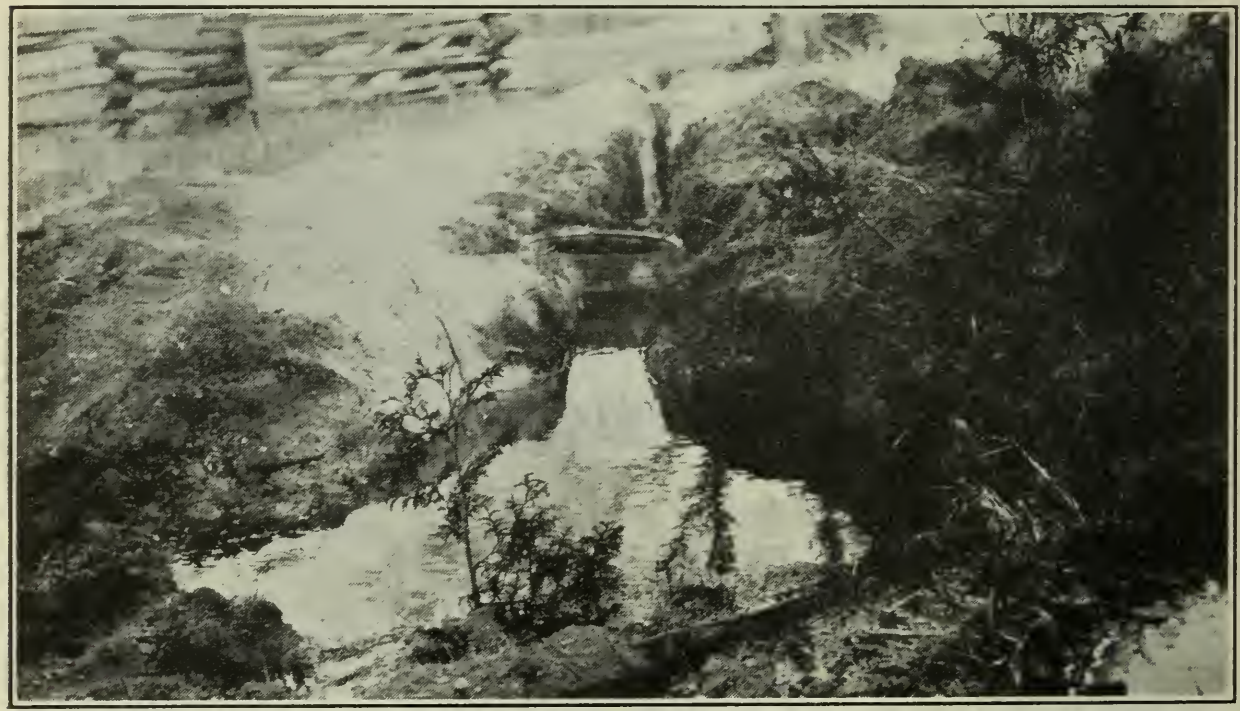


Fig. 9.—This abundant spring is piped to the farm buildings many hundred feet distant, the water flowing there by gravity. See Fig. 27, page 36.

(e) Springs.

Next to wells as a source of water supply are the springs. In certain areas the geological formation is very favourable to the occurrence of springs, in others it is quite the reverse. Springs vary in respect to mode of origin, manner of emergence, in size, depth of origin, and the nature of the water. Springs, as a rule, produce the purest and most wholesome water we have, and a large share of them yield a lot of water the year round, and never fail even in the severest droughts.

The service rendered by springs depends upon their capacities, and their elevation and location in respect to the farm buildings. If a good spring is located reasonably close to the home and on higher ground, the water may be supplied by gravity to the buildings, as shown in Fig. 26, or if on lower ground it may be pumped up by the hydraulic ram, as described and illustrated on pages 40 to 48, or if the spring be close to the buildings the water may be carried or pumped into the buildings. Again, if springs are located in the pasture land they afford excellent watering-places for the stock during the pasturage season or maybe even in the winter time if they are not too far away.

If springs are to be used as regular supplies of water, it is worthwhile to improve and protect them by cleaning out and probably deepening the basin, cribbing them and putting on a lid or top to exclude foreign matter, as illustrated in Fig. 33.

(f) Cisterns.

Cisterns or reservoirs for storing rain water caught from roofs of farm buildings are useful supplements to the regular hard water supplies. To be of the greatest service the soft water should be clean and pure and it should be piped to the kitchen, laundry and bathroom. In this case the range boiler should be located in the soft water line. Cistern supplies can be kept reasonably clean and pure by a sand and charcoal filter, and by thoroughly cleaning out the cistern twice a year. The size of cistern required varies considerably according to size of family, and the extent to which soft water is used in the home. The amount that can be caught varies with roof area, and the extent and frequency of the rainfall. To provide for a constant supply of soft water the cistern should be large enough to hold from 2,000 to 3,000 gallons of water, or cistern 5′ x 8′ x 8′ and 5′ x 10′ x 10′ respectively if located in the cellar. If built outside, a greater depth than 5 or 6 ft. is advisable. Concrete is the most common and practical material to use in cistern construction. They should be carefully built and well plastered to make them absolutely water-tight.

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3. FARM PUMPS.

(a) Classification of Pumps.

1. House lift and force pumps. Figs. 10 and 15.

These consist of pitcher spout and cistern lift pumps for shallow wells and cisterns, and house force pumps for hand use in domestic water supply, either with base or bracket support. This class includes the two newer types, namely, double action oscillating, and tandem. In the ordinary house pumps the cylinder is usually in the standard, but it may be lowered as a separate unit, if necessary, in order that it may be within 22 ft. of the water level.

2. Set length lift and force pumps. Fig. 14.

The clinder is below the platform. Non-freezing outdoor pumps for shallow wells and cisterns for both hand and windmill use. The set length or pipe between head and cylinder varies from 4 to 6 ft. according to severity of winter season.

Fig. 10.—Four types of modern hand force and lift pumps.
A is a semi-rotary pump. B is a cog-geared wall pump. C is fitted with bracket at base.
D is a section view of double internal cylinder pump marked E.
All are very easy to operate.

3. Well and windmill pump standards. Fig. 14.

Heavier pumps than the preceding, either lift or force and for either shallow or deep wells, the cylinder or working barrel being separate and usually submerged. The ordinary windmill pump is typical of this class. May be operated by hand, windmill or by gasoline engine.

4. Deep well working heads. Figs. 11 (*a* and *b*), 12 (*b*) and 24.

These are strongly built. Newer types have automatic oiling, have brass, artesian well and other special types of cylinders. Operated by electric motor, gasoline engine or windmill. Cylinder is submerged. Pumps directly over the well.

5. Horizontal, single and double acting, the latter being power driven.

Many uses, such as contractors' use, water tank service in factories and mills. Pneumatic tank service for large estates, bowling green water service. Figs. 12 (*a*) and 18.

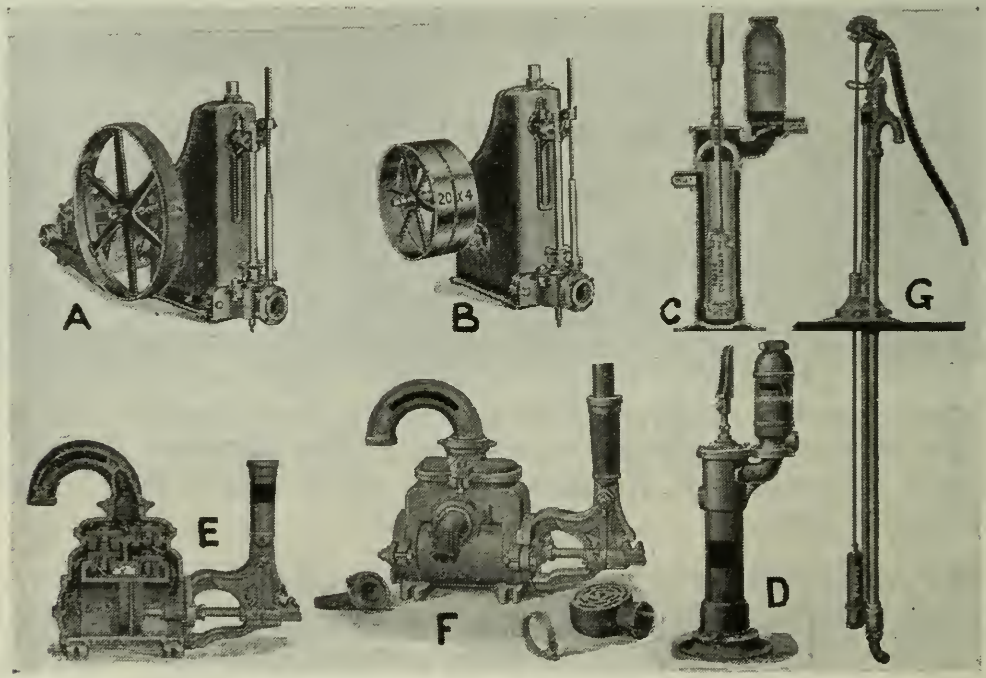
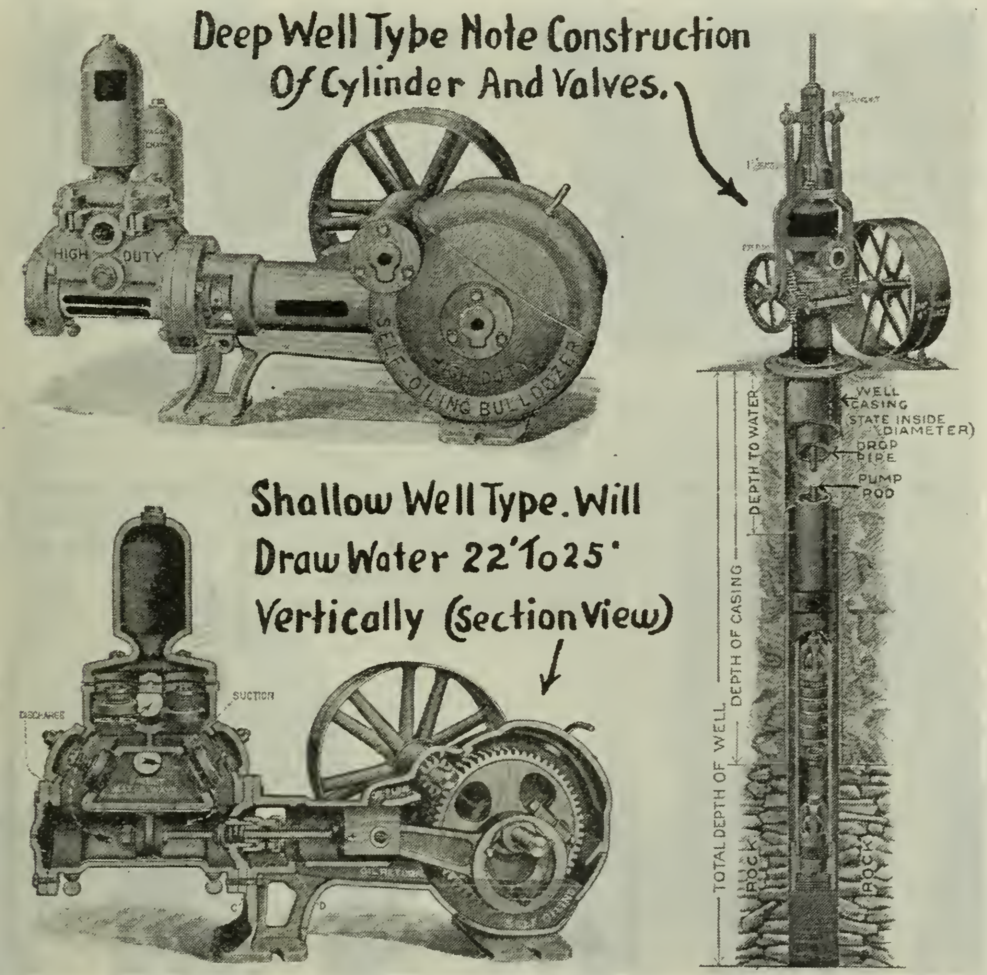


Fig. 11.—Various types of shallow, deep well heads and pumps. Hand ,electric, gasoline and wind engine driven.

6. Hydro-pneumatic water systems.

These may be shallow or deep well types. All are supplied with air valve, operated by hand, electric motor, windmill or gasoline engine. These types are used for pumping water into compression tanks for supplying private homes, large estates and institutions with water service. Fig. 20.



(a) (b)

Fig. 12.—Two types of heavy duty pumps.

(b) Principle of Pumping Water.

In this connection the reader is referred to Fig. 13 as aids to fully understanding just how the ordinary pump is able to lift and force water from one level to another.

In the first place the atmosphere at the sea-level has pressure enough to sustain a column of mercury thirty inches long or its equivalent, a column of water thirty-four feet long, water being 13.6 times as light as mercury. This means that if the cylinder shown in Fig. 6 (*a*) were placed thirty-four feet above the water level, and all the air removed from it, the atmospheric pressure on the water in the well would raise the water into the cylinder and fill it. After this had occurred the function of the plunger or bucket would be to lift the water to the surface and deliver it.

The principle of pumping, therefore, is an inequality of pressure in the pump clyinder and on the water surface in the well or other source of supply. Since the atmospheric varies over the earth's surface, being less than thirty-four feet at most places and chiefly because it is not possible to maintain a perfect vacuum in a pump cylinder, it is not feasible to use a suction distance of thirty-four feet, but only about twenty-two feet.

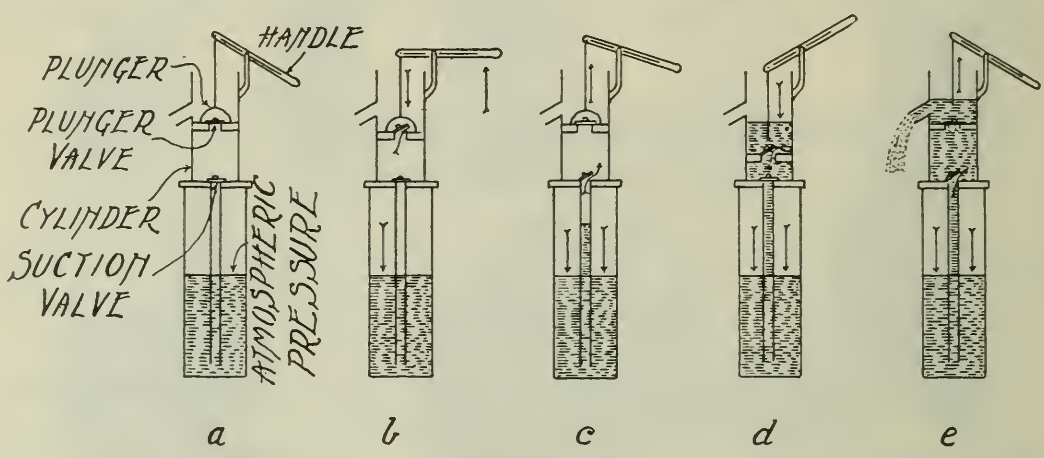


Fig. 13.—Stages in the action of the suction pump.

(a) The pump before use, both valves closed.
(b) First up-stroke—air in cylinder being forced out through valve in plunger.
(c) First up-stroke—air pressure in cylinder reduced. Atmospheric pressure on water in well drives water part way up the suction pipe.
(d) The water has reached cylinder, plunger moving down.
(e) Up-stroke—water begins to flow from spout.

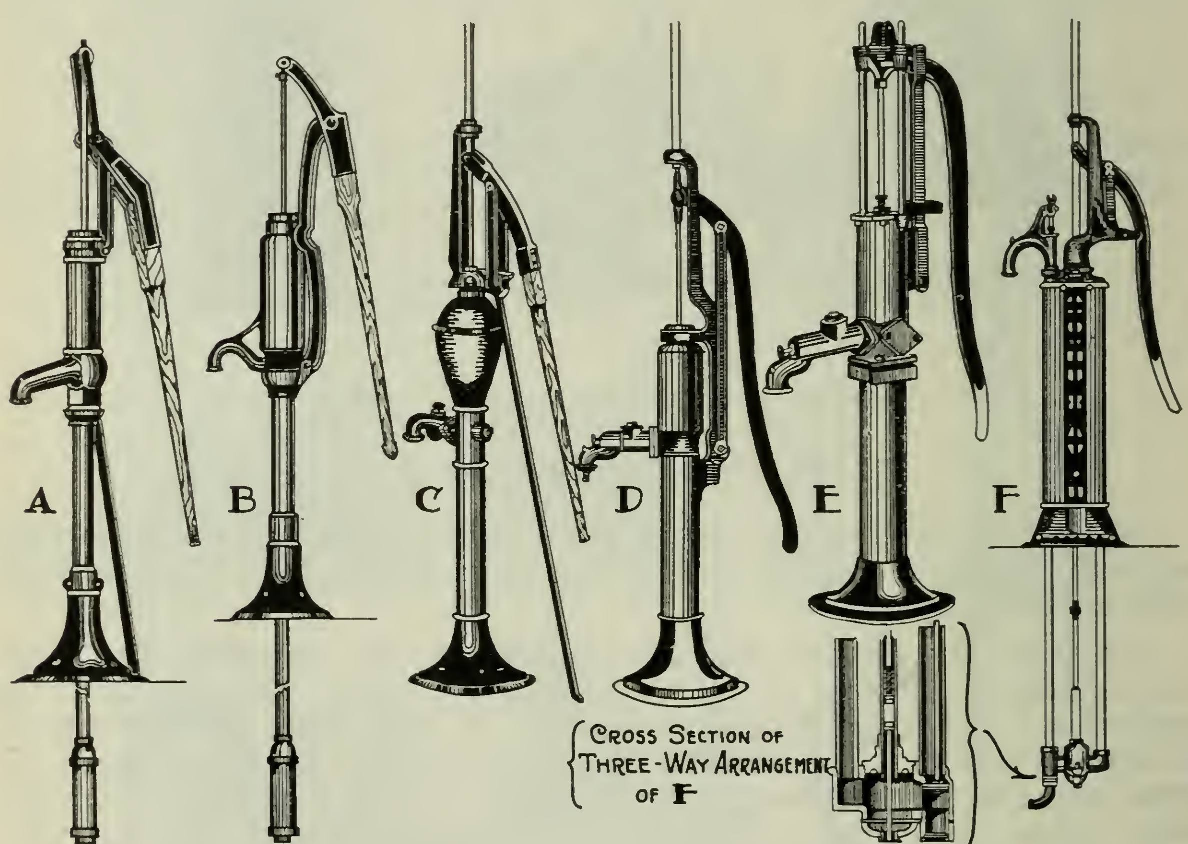


Fig. 14.—Standard Types of Farm Pumps.

A and B, shallow well hand pumps.
C and D, types suitable for operation by windmill or gasoline engine.
E, deep well standard.
F, the popular 3-way pump for operation by windmill or gasoline engine.

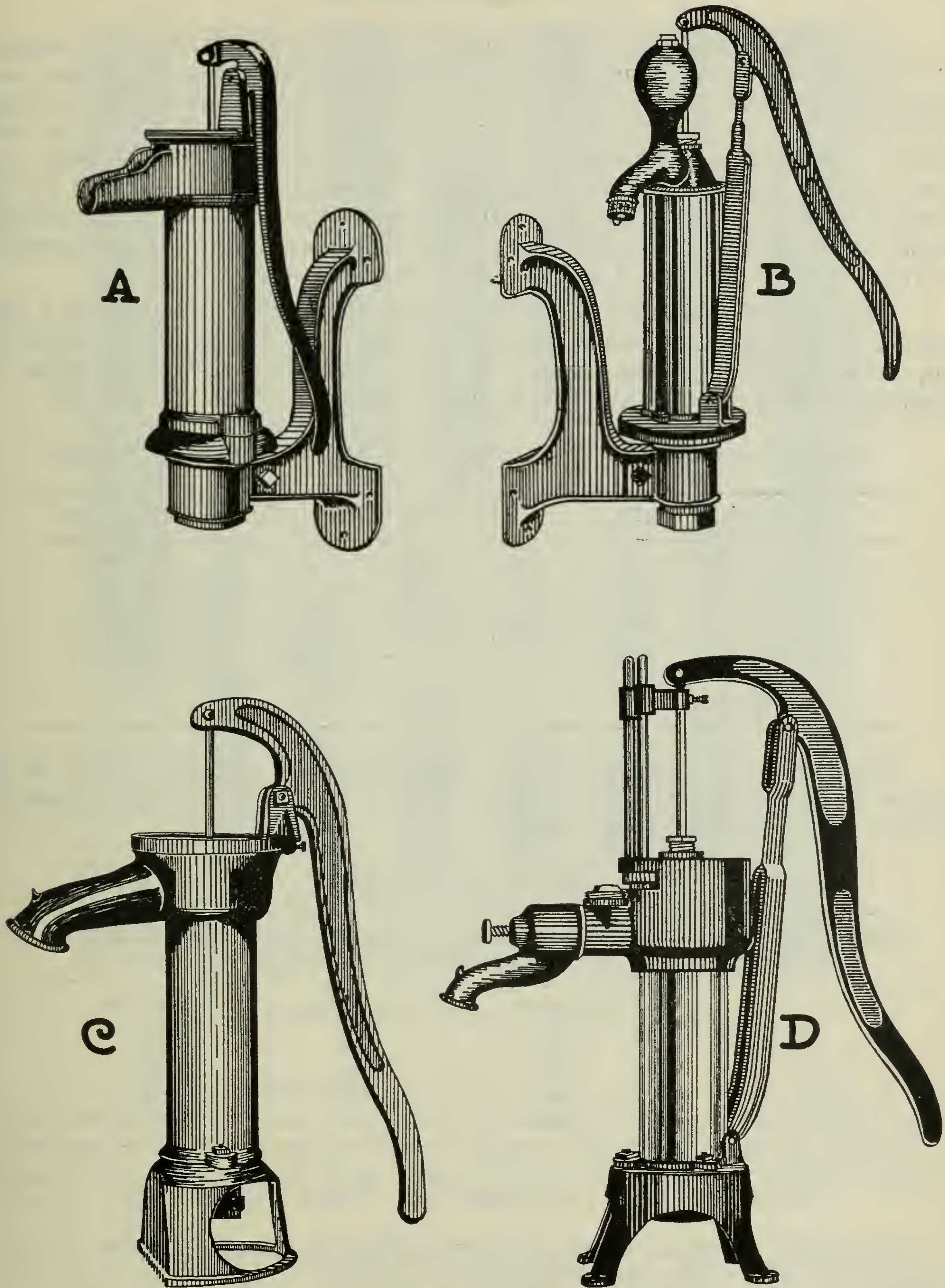


Fig. 15.—Standard types of cistern pumps.
A. Open spout.
B. Force pump.
C. Closed spout with long cylinder and handle.
D. Force pump of recent design.

NOTE:—A and B show how these pumps may be attached to the wall by brackets if desired.

(c) Pump Cylinders.

The pump cylinder is the cylindrical chamber in which the plunger or bucket operates. They are constructed of metal, the best ones, and particularly those used in deep wells, are made of seamless drawn brass tubing or else of iron lined with brass or some alloy. The shallow well type of cylinder is illustrated in Fig. 17, A, B and C, and the deep well ones in Fig. 17, D. The chief difference between the construction of the two types is the manner of attaching the caps, the former having outside, while the latter have inside caps. For this reason the largest possible cylinder can be put into a given size of well casing.

The size of cylinders is rated by the diameter in inches and the length of the stroke. The following table may be found useful in deciding upon the proper size to use in any well. The different types of plungers and styles of valves are clearly shown in Figs. 16 and 17.

Size of Cylinders and Suction Pipe for Wells of Various Depths.

Depth of Wells.	Size of Cylinders.	Size of Suction Ppie.
20 feet or less	6 inches.	3 inches.
25 " "	5 "	2½ "
35 " "	4 "	2 "
50 " "	3½ "	1½ "
75 " "	3 "	1½ "
150 " "	2½ "	1¼ "
200 " "	2 "	1¼ "

The following table gives the capacities for cylinders two to six inches in diameter and on a basis of forty strokes per minute in case of 6-inch, 8-inch and 10-inch strokes.

Capacity of Cylinders.

Diameter of Cylinder in inches.	Gallons raised per hour at the rate of forty strokes per minute to level of pump.		
	6-inch stroke.	8-inch stroke.	10-inch stroke.
2 inches.	163	220	275
3 "	365	487	608
4 "	625	869	1,086
5 "	1,020	1,360	1,700
6 "	1,460	1,947	2,433

Types of Pump Cylinders and their Special Use.

The most common types of pump cylinders are illustrated in Figs. 16 and 17. They may be classified as follows:—

(1) *Iron cylinders with outside caps,* as shown in Fig. 17, A. They are the cheapest cylinders and are used on dug or shallow wells where there is a total head of about 25 ft. Only one leather is used on the plunger.

(2) Same as above except that they are lined with brass. They cost a little more, but give better and longer service. They may be used on either shallow wells, or deep wells too, where well is large enough to take cylinder with outside caps. See Fig. 17, B. Fig. 17, C is same as B except that the plunger and check valve are different in design.

Fig. 16.—Deep well cylinders, plungers and checks.

(3) *Solid brass cylinders* (Fig. 17, D). These are designed for drilled wells. Inside caps are used. Number of leathers on plunger vary according to depth of well. Two leathers for 75 ft. well and 3 and 4 leathers for deeper wells and where pump is working against heavy pressures.

(4) *Working barrels* (Fig. 16, A. B and C). This type has no caps but is threaded on each end and is coupled in the drop pipe at a point below the water level. They are made of either brass or iron shell lined with brass. Its internal diameter on the lower end is reduced slightly in size to accommodate the check valve, as shown in Fig. 16, A and C. The check valve may be removed by lowering the plunger and screwing it into the check valve and pulling both both up the drop pipe to the surface. Working barrels are recommended for wells 80 ft. or more in depth, and a wooden pump rod is better than an iron one with this type of cylinder. In Figs. 16, A and G is shown how this cylinder may be used with a drive-point in case of a driven well. Spring controlled valves are commonly used in this type of cylinder.

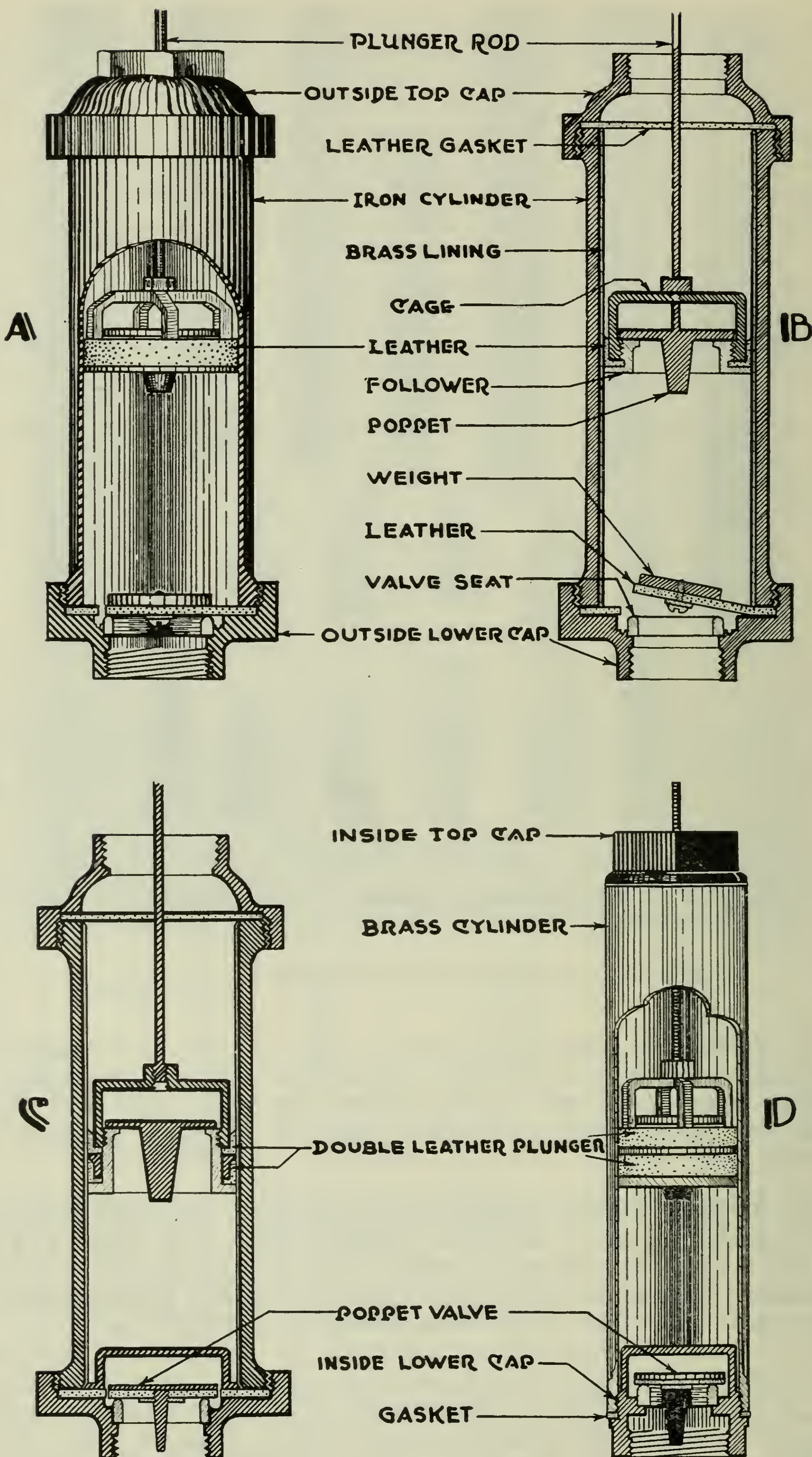


Fig. 17.—Shallow and Deep Well Cylinders.

(*d*) Capacity of Pumps.

The capacity of pumps depends on three things, namely, the inside diameter of the cylinder, the length of the working stroke and the number of strokes per minute.

Rule for calculating capacity of a pump in gallons per minute.

Square the diameter of the cylinder in inches by length of stroke in inches by number of strokes per minute and divide the product by 352.

(*e*) Power Required to Operate Pumps and how to Calculate it.

The power required for pumping depends primarily upon two factors, —the weight of the liquid to be pumped per minute and the vertical height it has to be raised from the source of supply to the point of delivery. Besides this, allowance must be made in practice for the power needed to overcome the losses in the pumping outfit and the friction in the pipe lines.

Either of the following rules may be used to calculate the actual H.P. for pumping water.

$$\text{H.P.} = \frac{\text{W x H}}{\text{33000 x E}}$$

Where W is weight of water pumped in lbs. per minute, H is the total head in feet including friction in pipe lines, and E is the efficiency of the pump. E may be taken at 80 or 85%, or

$$\text{H.P.} = \frac{\text{G.P.M. x H}}{\text{3960 x E}}$$

When G.P.M.=gals pumped per min., H=total head and E is efficiency of the pump.

Suppose we wish to pump 30 gals. of water per min. against a combined lift and force of 200 ft., through a pipe two inches in diameter and 300 ft. long.

Friction loss in 100 ft. of two-inch pipe discharging 30 gals. per min. is according to the table below, 2.73 ft. Therefore for 300 ft. of pipe friction loss would be 2.73 x 3=8.19 ft. Adding this to the pumping head of 200 ft. the total head=208.19 ft. W or weight of water pumped per min. is 30 x 10 (lbs. in 1 gal. Imperial) or 300 lbs. Take E to be 85 per cent.

$$\text{Actual H.P.} = \frac{\text{W x H}}{\text{33000 x E}} = \frac{\text{300 x 208.19}}{\text{33000 x .85}} = 2$$

Friction Table.

Friction of water in pipes one-half to three inches in diameter and discharging one to fifty gals. per min.

Loss of Head in feet due to Friction, per 100 feet of New, Smooth Wrought Iron Pipe.

Gals. per Min.	½-inch Pipe	¾-inch Pipe	1-inch Pipe	1¼-inch Pipe	1½-inch Pipe	2-inch Pipe	2½-inch Pipe	3-inch Pipe
	Fric.	Fric.	Fric.	Fric.	Fric.	Fric.	Fric.	Fric.
1	1.50							
2	5.30	1.40						
3	11.30	2.90	0.90					
4	19.20	5.00	1.52	0.40	0.19			
5	29.00	7.50	2.32	0.60	0.28	0.09	0.05	
10	105.00	27.10	8.40	2.18	1.02	0.36	0.12	0.05
15	....	57.00	18.90	4.65	2.25	0.81	0.25	0.11
20	....	97.00	30.10	7.90	3.70	1.29	0.43	0.18
25	....	....	45.50	11.90	5.60	1.96	0.66	0.27
30	....	....	64.00	16.90	7.80	2.73	0.92	0.38
35	....	....	85.00	22.30	10.30	3.66	1.23	0.51
40	....	....	109.00	28.50	13.30	4.68	1.57	0.65
45	....	....	....	35.20	16.60	5.80	1.97	0.80
50	....	....	....	43.20	20.20	7.10	2.38	0.98

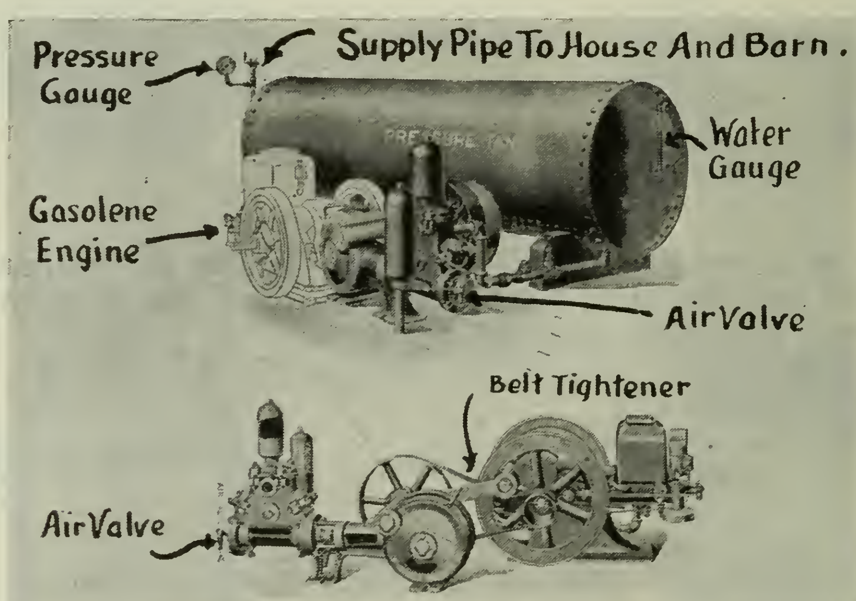


Fig. 18.—Heavy duty pumps with and without tank. Shallow well pumps will pump air and water.

Power Required for Pumping Water.

Under ordinary conditions very little power is required, as indicated for a few instances in the following table:

Size of Cylinder in inches.	Gals. pumped per hour on a 10-inch stroke.	H.P. for 100 ft. elevation.	H.P. for 200 ft. elevation.
2-inch	200	⅛	¼
3-inch	735	¼	½
4-inch	1,300	⅗	1
5-inch	2,000	⅘	1½
6-inch	2,935	1¼	2

Note.—The H.P. values given in the table are theoretical, to get the actual size of gasoline engine required multiply these values by two. Size of electric motor multiply them by one and a half.

Pump Jacks

In connecting up a gasoline engine to the ordinary well pump, either shallow or deep, some form of jack is required, common types being shown in Fig. 12 (*b*). They are back-geared at certain ratios, say five to one, eight to one, etc., so that the speed is reduced to give the proper number of strokes to the pump rod, provided that the right size of pulley is used on the engine. In the regular power pumps of modern design, both for shallow and deep wells, illustrated in Figs. 11 and 12, respectively, the gearing is wholly encased and runs in oil, which is an excellent feature.

How to Calculate size of pulley, either driver or driven.

Rules:—(1) $$\text{Diameter of driven} = \frac{\text{speed of driver x its diameter}}{\text{speed of driven.}}$$

(2) $$\text{Diameter of driver} = \frac{\text{speed of driven x its diameter}}{\text{speed of driver.}}$$

Problem:—An engine has a speed of 400 R.P.M. The pulley on the jack is twelve inches, the back gear is five to one. What size of pulley is required on engine to run pump at forty strokes per minute? The driven pulley in this case is the one on the jack, and its R.P.M. is 40 x 5 or 200.

Therefore diameter of driver (pulley on engine)

$$= \frac{200 \times 12}{400} = 6 \text{ inches.}$$

By following Rule 2 the diameter of the driven (pulley on jack) may be similarly calculated.

Pump Troubles and How to Remedy Them.

1. If pump fails to deliver water first see if there is any water in the well or not.

2. If pump loses its prime, the suction valve (see lower valve, (Fig. 17) is defective or something has lodged under it and preventing it from closing tightly. Remedy is to repair or clean it.

3. If pump is delivering a good deal of air and too little water, there is an air leak in the suction line or cylinder, probably a loose joint or hole in pipe, or well is running dry.

4. If the handle works up and down without apparent resistance, and delivers little water or none at all, it indicates that the plunger leather is worn and not creating a vacuum in cylinder, or else suction valve is not working properly. Probably suction pipe is too low or well is filling up. Remedy is to take pump apart and make necessary repairs.

5. If pump works hard or handle jerks up when pushed down, it is evident that something is preventing the water rising in the suction pipe to cylinder. This may be due to too long or too small a suction pipe, or end of pipe is choked by something in bottom of well.

6. If a lift pump and the water splashes out at the top of pump, it is a sign that the cylinder is too large for the head. If pump is taking in air below the cylinder, it will also have a tendency to do this.

7. In power-driven pumps, types used on compression water systems, for example, may become noisy. This is due to dirty valves or one or more valves sticking fast, or dirty strainer may cause pump to pound. Another case where noise will develop is where the suction line loops upward, for example, extending upwards and over the top of the cistern wall and then down to pump on floor. The remedy here is to put an air-chamber at the highest point, a two-inch pipe about eighteen inches long will serve all right for air chamber in this case.

NOTE.—A knowledge and an application of these few principles would increase the efficiency of farm pumps, generally speaking, fully 50 per cent.

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4. FARM WATER SYSTEMS.

A good water supply is a wonderful asset to any farm. Its full value or service is possible only when it is "on tap" in the house and stables, or when a good water system is an integral part of the farm plant. The following table will serve as a guide to estimating the quantity of water required under farm conditions:

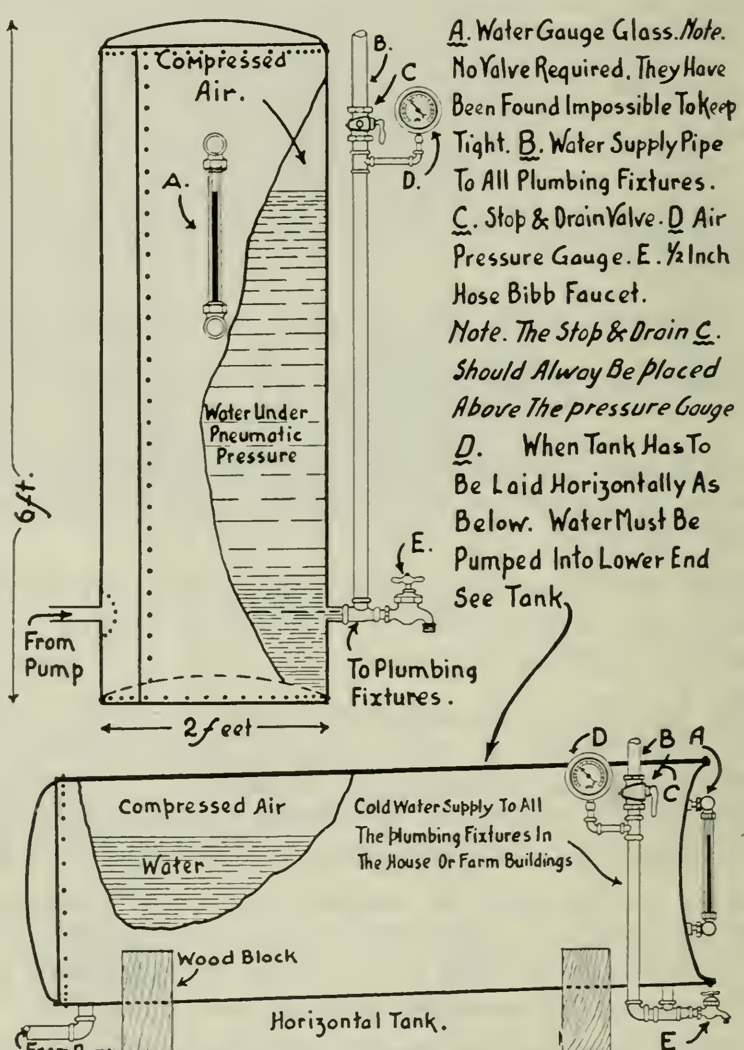


Fig. 19.—Principle governing pneumatic pressure water systems for farm and rural homes.

(*a*) Water Consumption on the Farm.

Water carried	8	gals. per person per day.
Pump at kitchen sink	10	" " "
Faucet at kitchen sink	12	" " "
Running hot and cold water in kitchen	18	" " "
Complete plumbing with water under pressure	30	" " "
Bathtub*	8-20	gals. each time used.
Closet*	3-5	" " " "
Lavatory (wash basin in bathroom)	1-2	" " " "
Sprinkling lawn	8	gals. per 100 square feet.
Soaking lawn	20	" " " "
Cow	15	gals. per day.
Horse	10	" "
Hog	2	" "
Sheep	½	" "

*Water for these purposes is included in the item above entitled "Complete Plumbing and Water under Pressure."

The most common and efficient types of water system for farm use are described and illustrated herewith.

(*b*) Pressure or Pnuematic Water Systems.

The water system commonly installed in farm homes to-day is the pressure system. It is a popular system because it is efficient, simple to install, easy to operate, reasonable in cost, and adaptable to a wide range of conditions. The principle is simple, being the application of a well known law of physics, viz. the pressure of an enclosed mass of gas or a mixture of gases like air varies inversely as its volume, provided the temperature is kept constant. Its application in this instance is illustrated in Fig. 19. It is evident that as the water is pumped into a closed tank the original tank full of air is reduced to a fraction of its original volume. To be more specific, if tank were one-half filled with water the air would be reduced to one-half its original volume but its pressure now would be twice its original pressure or 2 atmospheres or approximately 28 lbs. Since the pressure gauge on tank is graduated so that its 0 mark represents atmospheric pressure, the gauge now would read about 14 lbs. If tank were pumped up to ⅔ its capacity, the gauge pressure would be 28 lbs., at ¾ capacity gauge pressure would be about 42 which is usually about the maximum pressure for regular service.

(*c*) Pressure Pumps and their Features.

General Type.

The general type of pump used on farm pressure systems is the reciprocating double-action force pump either shallow or deep well type. See Figs. 20 and 24.

Methods of Operation.

They may be operated by hand (Fig. 20, D), by gasoline engine (Fig. 18), by windmill (Fig. 25), or by an electric motor (Fig. 20). The last-mentioned is rapidly becoming the most common and also the most popular method of drive.

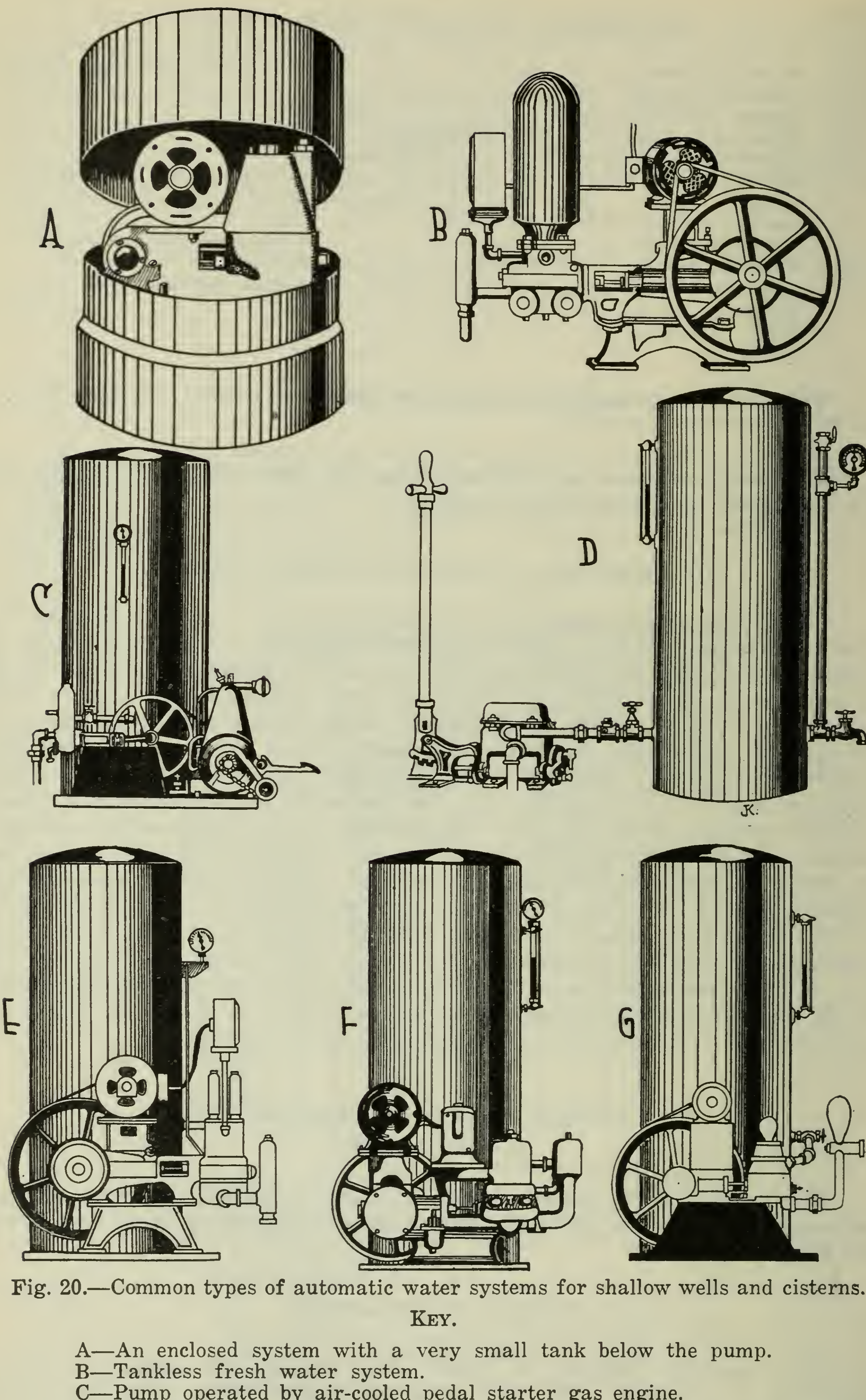


Fig. 20.—Common types of automatic water systems for shallow wells and cisterns.

KEY.

A—An enclosed system with a very small tank below the pump.
B—Tankless fresh water system.
C—Pump operated by air-cooled pedal starter gas engine.
D—Hand operated system.
E—A standard type with automatic air control.
F and G—Two other standard types.

Capacity.

The capacity of these pumps for farm service vary from 250 gals. to 500 or 600 gals. per hr. For household use only 250 or 300 gals. per hr. is usually sufficient; but if the stables, etc., are to be supplied by the same pump as the house is, its capacity should be about 500 gals. per hr. If the matter of fire protection is considered, nothing less than 600 gals. per hr. should be used. The small electric pumps are made both in the single and duplex sizes to meet farm needs.

Special Features.

These pumps have been wonderfully improved since the inception of the pressure system a few years ago. The modern ones are self-oiling, and driven by noiseless V-shaped belts; valve caps are very accessible, designs are simpler and more compact. There is a greater tendency toward sectional structure, units are most self-contained, some are entirely encased, all must be equipped with some form of device to pump air into the tank when necessary, packing glands are more efficient, filters are used in the intake to cylinders, priming chamber keeps valves flooded when once primed, and the main bearings are improved in some cases, and main parts such as valves, piston, etc., are very simple in structure and very easy and inexpensive to repair. There are several designs on the market, some of which are illustrated in Fig. 20.

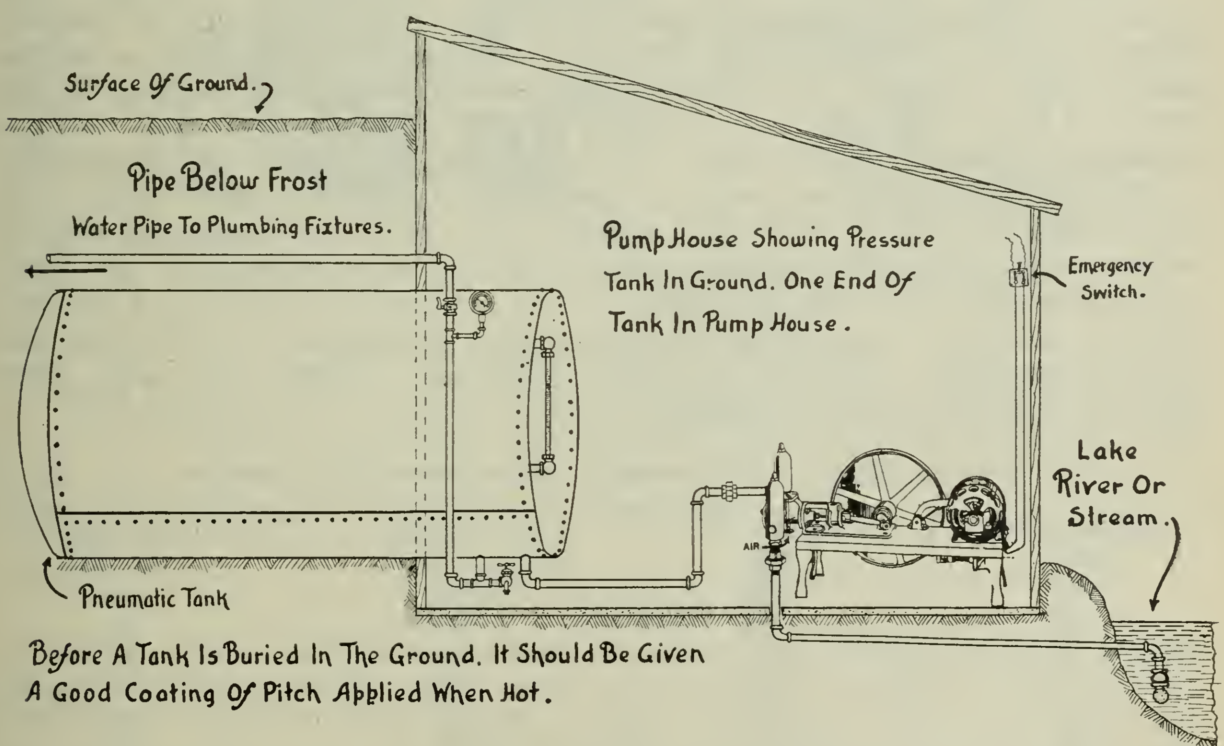


Fig. 21.—Complete water system in small pump house situated near source of water.

(d) Pressure Tanks.

Pressure tanks are made cylindrical in form, and of iron plate strong enough to resist internal pressure of 125-150 lbs. per sq. inch. The margin of safety is large as the maximum pressure in actual service does not exceed 50 or 60 lbs. They may be set up vertically or horizontally, depending on space available.

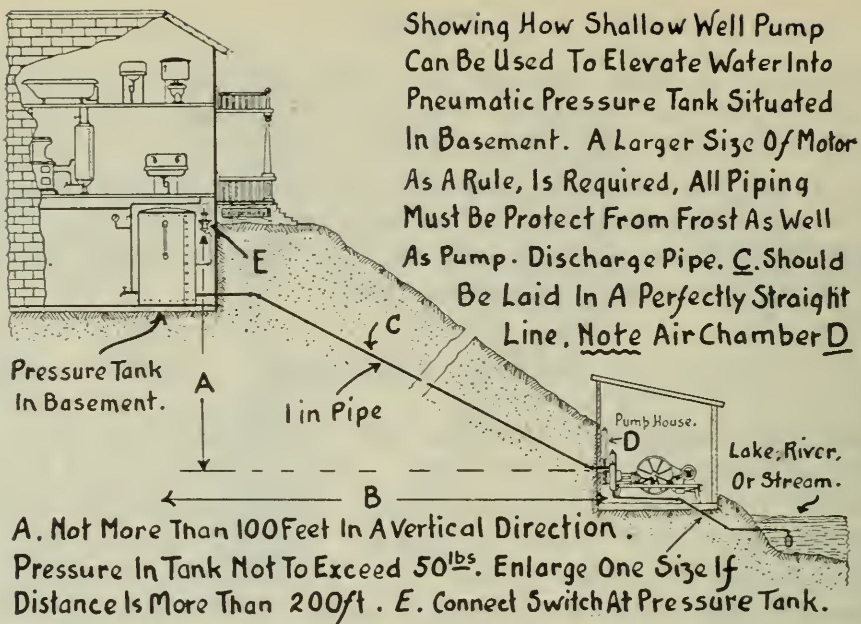


Fig. 22.

NOTE.—There should be a gate-valve between the pump and the tank in Fig. 22.

SIZE.

The size of tank to use depends chiefly on the amount of water used, the kind of power to operate pump, and the depth of well. If electric pump is used on shallow well and the plant is for house only, a 40-gal. tank is large enough, but if the system serves stock, etc., as well as the house an 80 or 100 gal. tank is best. If the pump be operated by gas engine or windmill larger tanks are necessary, 120 to 220 gal. depending on the quantity of water used. A good many electric systems with very small tanks of only 2 or 3 gals. capacity are used for household service to-day; but, generally speaking, they are not as satisfactory as those systems having 40 or 80 gal. tanks. They are really fresh water systems and best adopted to supplying the house with well water for drinking and cooking purposes. Somewhat larger tanks are needed on deep wells than on shallow wells or cisterns.

COMMON SIZES OF COMPRESSION TANKS FOR FARM SERVICE.

Diameter in inches.	Length in feet.	Full Capacity Imperial Gals.	Working Capacity ⅔ full.
13	1½	11	7
12	2½	15	10
16	4	42	28
18	4	53	35
18	5	66	44
24	4	100	66
24	5	120	90
30	6	220	146
36	6	315	210

NOTE:—1 Imperial gallon equals1⅕ U.S.A. gallons.

LOCATION.

They should be located close to the pump if possible, but always in a frost-proof, dry and well ventilated room, and convenient for observation of the gauges on the tank as they indicate how the system is working.

A Typical Shallow Well Electric Pressure System.

In certain rural districts the shallow well is the mainstay for water supply. When the farmer gets electric power he may wish to put a little pressure system in his cellar to provide his house automatically with running water. In Fig. 23 are illustrated the main features or details of such an installation.

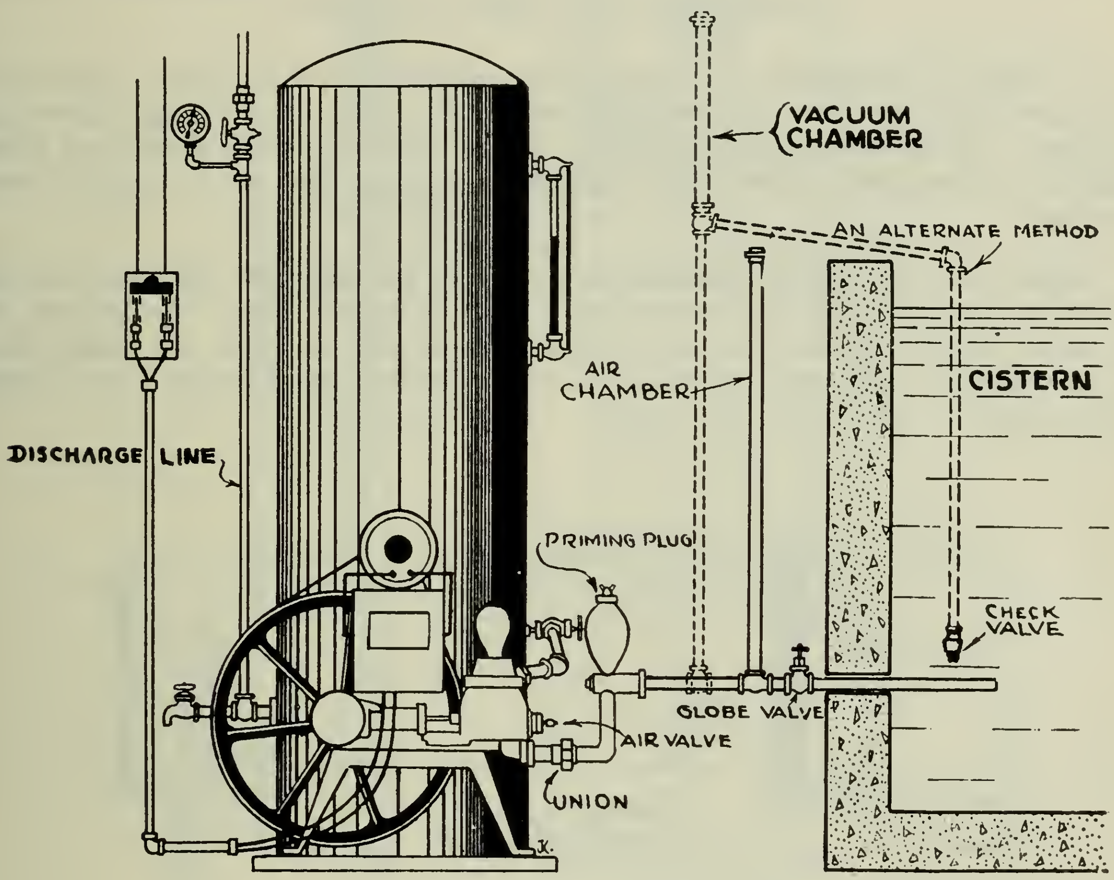


Fig. 23.—Details of two layouts of water system connected to cistern.

When can this Layout be Used?

This installation is possible when the difference of elevation between the cellar floor and the lowest water level of the well is always less than 20 ft., and when the flow into the well is strong enough to maitain the water at this level even under heavy pumping.

Cistern Installation.

It is quite a common practice to install a pressure system on the cistern. In this case the water level in the cistern is above the pump level or there is a head of water on the pump. The pump will work best when this head is kept as low as possible and if the pump cannot be kept high enough to reduce this head considerably it is a distinct advantage to put a globe valve and an air chamber in the suction line between the cistern and pump as shown in Fig. 23.

The purpose of the air chamber is to cushion the water on each stroke and prevent water hammer in the pipe. If the chamber should become water-logged close the valve and remove plugs on top of air-chambers. After the water has drained out replace plugs and open valve to a point where the pump works best.

To replenish the air in storage tank remove the cap from the air inlet valve until enough air has gone into tank to restore the water in the tank to the proper level. Should the valve not work or suck air well, close the globe valve until it does, and after the air is restored in the tank open valve again.

Other Shallow Well Layouts.

In Fig. 21 is shown an installation suitable for the case where the pump and also the tank is best located at the edge of a fresh water lake or stream. This covers the particular situation where the source of water supply is a long way from the house and may be on a much lower elevation.

Again in Fig. 22 is illustrated a somewhat similar case to the preceding one except that the source of supply is quite near the house, but the water level is more than 22 ft. lower than the level of the cellar floor. In this case the tank may, without any particular disadvantage, be located in the cellar, as shown in Fig. 22.

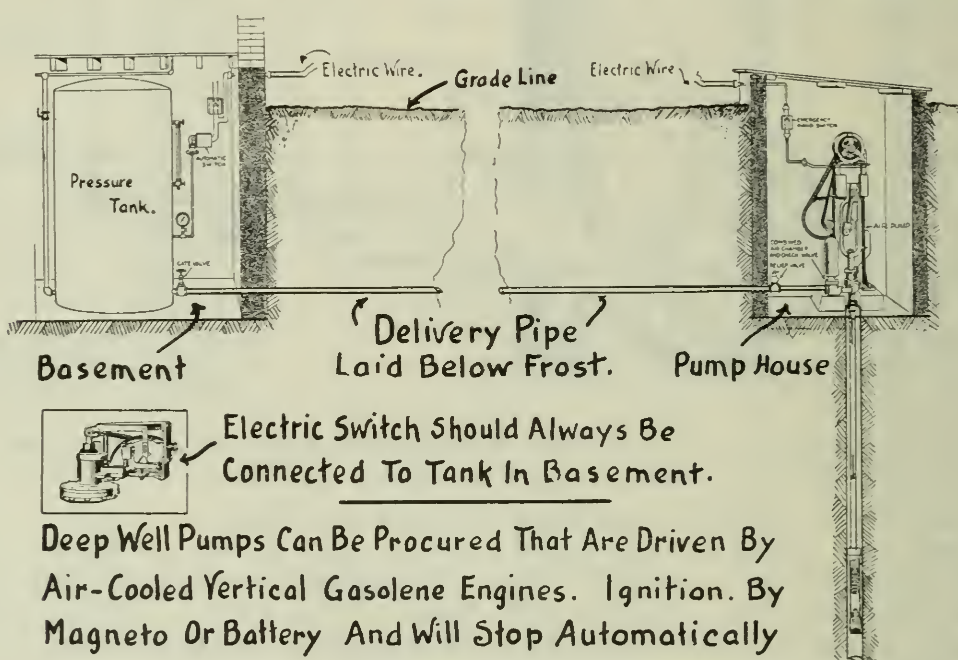


Fig. 24.—Deep well pneumatic water system with tank in house.

A Typical Deep Well Installation Electrically Operated.

In cases of wells where the water level is more than 20 or 22 ft. below the level of the cellar floor, it is necessary to place the pump directly above the well and lower the cylinder into the water. This layout is called a Deep Well installation. If the pump be operated by an electric motor it is absolutely necessary to enclose the pump from the weather or make a pump house or shelter. This may be entirely above ground but the best method is to use a pit below the ground, as illustrated in Fig. 24. If the well is only a few feet from the house this pit may be entered through a passage-way connecting the cellar with the pit, otherwise it has to be entered through a manhole in the top. Pump pits should always be ventilated for the sake of the electric motor.

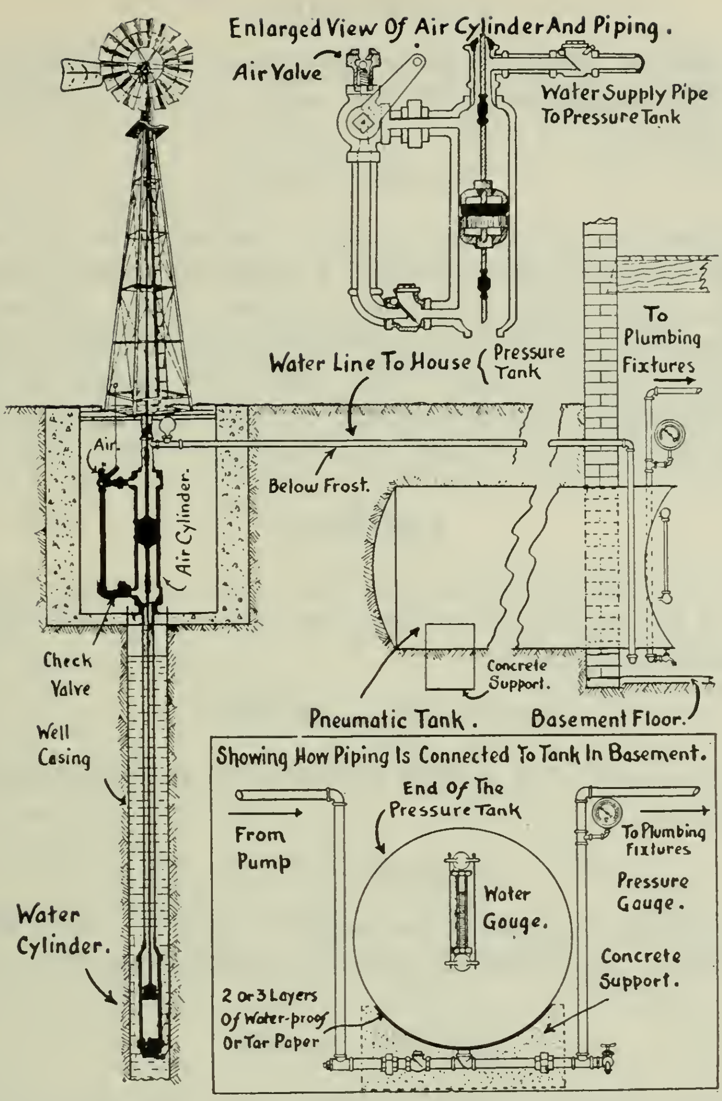


Fig. 25.—Wind engine driven pneumatic water system.

POINTERS REGARDING INSTALLATION AND OPERATION OF PUMPING SYSTEMS.

Space will not permit a full discussion of all the features that arise, but a few of the most important ones should be mentioned. Our best dealers in pumps and water systems publish catalogues and manuals that illustrate and discuss very fully how to install their systems, and how to care for them. These are free and should be carefully read and studied before an installation is made.

MAIN FEATURES.

Water Supply.

1. Be sure that there is plenty of water in the well.

Location.

2. Put the pump and the tank as close as possible to the source, both as to vertical height or elevation and horizontal distance. They should be located in a clean, light, warm and dry place.

Suction Head.

3. In the case of shallow wells the pump must not be more than 20 ft. higher than the water level; in the case of deep wells put the cylinder well into the water.

Suction Line.

4. The suction line is all important; it should be as short as possible, direct, free from sharp bends, laid on a uniform grade of not less than 6 inches in 100 ft., the higher end being at the pump. The joints must be absolutely tight and the pipe line otherwise free of leaks. There should be a foot valve on the suction pipe. The pipe line should be laid well below the frost line. The size of pipe should be at least the size for which the pump is tapped, for 100 ft. or less, and one size larger for each additional 100 ft.

Strainer.

5. A filter or strainer in the suction line is worth while to protect valves. Most of the electric systems are provided with this feature. It should be cleaned occasionally.

Foundation of Pump.

6. The pump should be bolted securely to a solid base or foundation to prevent vibration.

Size of Pump.

7. It is a mistake to install too small a pump. It is better to err on the side of oversize. See page 29 for statement regarding proper sizes to use.

Testing Valves.

8. Sometimes valves in new pumps, and in pumps that have been idle for a while become stuck fast, and will not function until released. Also valve seats may become dirty or corroded and cause trouble. It is an easy matter to inspect the valves to see that they are in good working condition before starting the pump.

To Test Suction Line and Pump for Air Leaks.

9. Close the valve between pump and tank, remove the safety valve and put a ½-inch hose faucet in its place, attach the base to it and put the other end of the hose under water in a pail, then start the pump, if, air bubbles appear in the pail the suction line or pump is drawing air. Go over the joints in the suction line carefully and tighten up valve caps, priming plug, etc., on pumps, until air ceases to appear.

It is very important to have an air-tight suction line and the proper time to test it is when the pump is installed and before the trench is filled up.

To Test Compression Tank for Air Leaks.

10. Pump up the tank to maximum pressure, close the valve between pump and tank and the valve on the discharge line, note the pressure on gauge and leave the tank over night or for a few hours at least. If the tank is leaking air the pressure gauge will show it. If it leaks, test the plug in top of tank, the water gauge fittings, and the seam in the wall of the tank with oil, and repair the leaks.

To Remedy a Water-logged Tank.

11. The quickest way is to drain the tank of water and start all over again. To do this "plug out" the water, fasten hose to the drain at the bottom of the tank, and loosen the plug in the top of the tank. This will empty the tank in a few minutes. Then "plug in" and start the pump and fill the tank afresh.

A Precaution in Case of very Small Tank Systems.

12. Where an automatic system with a very small tank is used, a safety valve should be installed on the pipe line between the range boiler and the heating coil in the case of a furnace, or between the range boiler and the water front in the kitchen range where it is used as the heater. This is necessary as these systems are more easily water-logged than is the case with larger compression tanks.

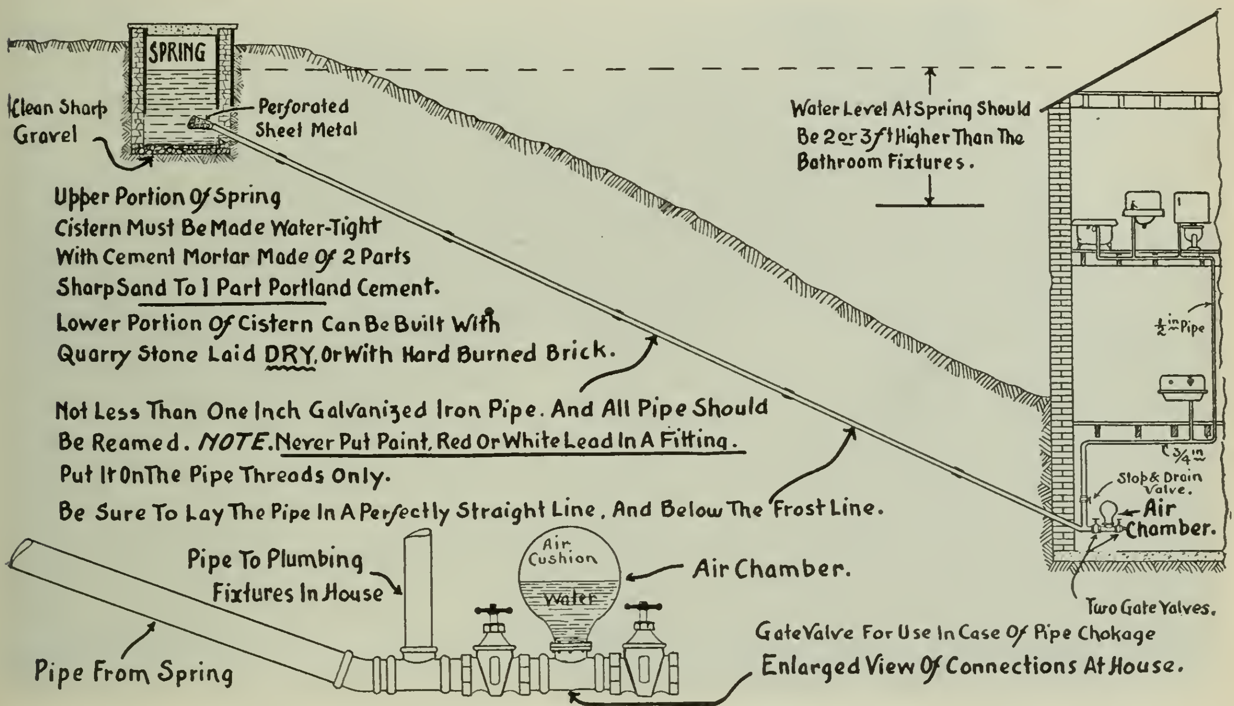


Fig. 26.—Spring Water Piped to the House.

GRAVITY SUPPLY FROM SPRINGS, STREAMS AND LAKES.

Springs, streams and lakes are frequently the source of water supply for various purposes. If the point of use is lower down than the source then a pipe may be laid and the water allowed to flow down by gravity, care being taken that the pipes are placed deep enough underground to escape frost. In this plan, trouble is occasionally experienced, the water running for a time, but gradually stopping. Usually this is due to the lodgment of air somewhere in the pipe. This air comes from the water little by little. We have all seen a glass of cold water set in a warm room and later found the inside of the glass coated with innumerable small bubbles of air that had come out of the water as the temperature increased. Under certain conditions the same thing occurs in the water pipes, and by and by numbers of these small bubbles joining together form larger bubbles, and because of their lightness the large air bubbles try to flow back up the pipe toward the source. When they grow large enough and sufficient in number, the back pressure may entirely stop the water. And if there are any irregularities in grade the air tends to collect in the high spots from both directions. The slower the grade or the smaller the pipe the greater the danger from this source, because then the velocity of the water in the pipe is not sufficient to brush off the small bubbles and carry them along toward the outlet. If the trouble occurs in a pipe on a uniform grade it may be relieved by tapping standpipes into the waterline at intervals, or on an uneven grade, at the high spots. Generally it is not wise to use smaller than inch pipe for gravity systems. The end of the pipe in the source must be provided with a screen to keep back small stones, sticks or anything that might tend to choke the pipe line. The line should be laid as straight as possible, the joints in it well leaded and screwed up close so as to cover all the threaded portions of the pipes. This system is quite rare because very few places have the source of water supply high enough to make its adoption practicable. Fig. 26 shows details of such system.

Fig. 27.—A Farm Spring being piped to the Farm Buildings. The actual Spring is shown in Fig. 9.

The Gravity System.

In some instances the farm water supply comes by gravity from an elevated spring, as shown in Fig. 27, or it may be that the spring water is piped to a trough in the cow pasture. The main details are emphasized in Fig. 27.

How to Estimate the Size of Pipe Required.

In the first place find out how much higher the spring is than the highest outlet for the water, or the head of water, then measure the distance the water has to be piped, and having some rough idea of how big a flow is needed, it is an easy matter to find the proper size of pipe to use, by reference to the friction table, page 24. Take an example. Suppose discharge equals 5 gals. per minute, length of pipeline is 1200 ft., and head of water is 18 ft. In table referred to find 5 in first column and guess that 1-inch pipe would do, then run finger from figure 5 straight across the sheet to column 1-inch pipe. Here is found the number 2.32. This equals the loss of head due to friction for 100 ft. of pipe, for 1200 ft. it would be 2.32 x 12 = 27.84 ft. The actual head due to difference of elevation equals only 18 ft., and since the opposing head due to friction is 27.84 the size of pipe chosen is too small. It is quite evident that a 1¼-inch pipe would be large enough.

Installing the Pipe Line.

The pipe should be laid on a uniform grade and at a depth safe from frost. There should be no upward bends in the line, as air is apt to collect at high points in the line and stop the flow of water. The joints should be made air-tight, and the entrance to the pipe line should be covered with a screen to prevent any rubbish that might get into the spring from entering the pipe. The spring itself should be cribbed up and covered, as shown in Fig. 26.

WATER SYSTEMS FOR THE FARM STABLES.

By this time farmers are fully aware of the value of a wholesome supply of water for their livestock. It is a fact that dairy cattle will produce more milk if they get all the pure water they need, and all classes of animals will be healthier if they have plenty of pure water to drink.

It is important to have a good method of supplying the water. It will insure a constant supply for the stock at all times and save much time and labour at chore time.

Features of a Good System.

A water system for the stable should be simple in construction, easily kept clean and sanitary, not subject to clogging or getting out of order, reasonably cheap and reliable and not requiring much attention.

As to systems of supply, all agree that the water should be supplied in some manner at the mangers so that the cattle need not be let out-of-doors to get a drink. The following are different ways of doing this.

The Individual Basin System.

The most common method in our best stables is the individual drinking basins connected up to a regulating basin supplied with water from a storage tank at the ceiling or in the hayloft. See Fig. 28.

The Common Trough System.

Another system consists of a common watering trough in front of the cattle ,the water being let in as required by a faucet at one end of the trough, and drained by a plug at the lower end when cleaning out is necessary. The trough is made of metal and is placed about three feet above the floor and right against the manger side of the stanchions. This position does not interfere with the cattle when eating out of the mangers, or when standing at ease. This system is best adapted to the fixed type of manger. Disease may be easily spread by this system, and for this reason it is neither popular nor desirable.

The Manger System.

Still another system is that of using the feed manger as the watering trough. In this case the water supply is piped to the higher end of the manger and let in by a faucet, the drain plug being at the other end. After the feeding is over, both night and morning, the mangers are thoroughly cleaned out and the water let in and left until the cattle have had their fill. Both of these last two systems, just described, have been in use a the College stables for some time, the former in the beef stable, the latter in the dairy. The herdsmen find them very satisfactory.

The Compression System for House and Barn.

Since the introduction of the compression water system for homes, many farm stables are being supplied with water under pressure from a common pressure tank for both house and barn. See Fig. 28. In such installations a frost-proof hydrant is put in the lawn or at some convenient point outside, as shown in the illustration.

The Windmill Operating a Dual System.

The reader is referred at this point to Fig. 25, illustrating the use of the windmill for pumping water into a compression tank in the basement

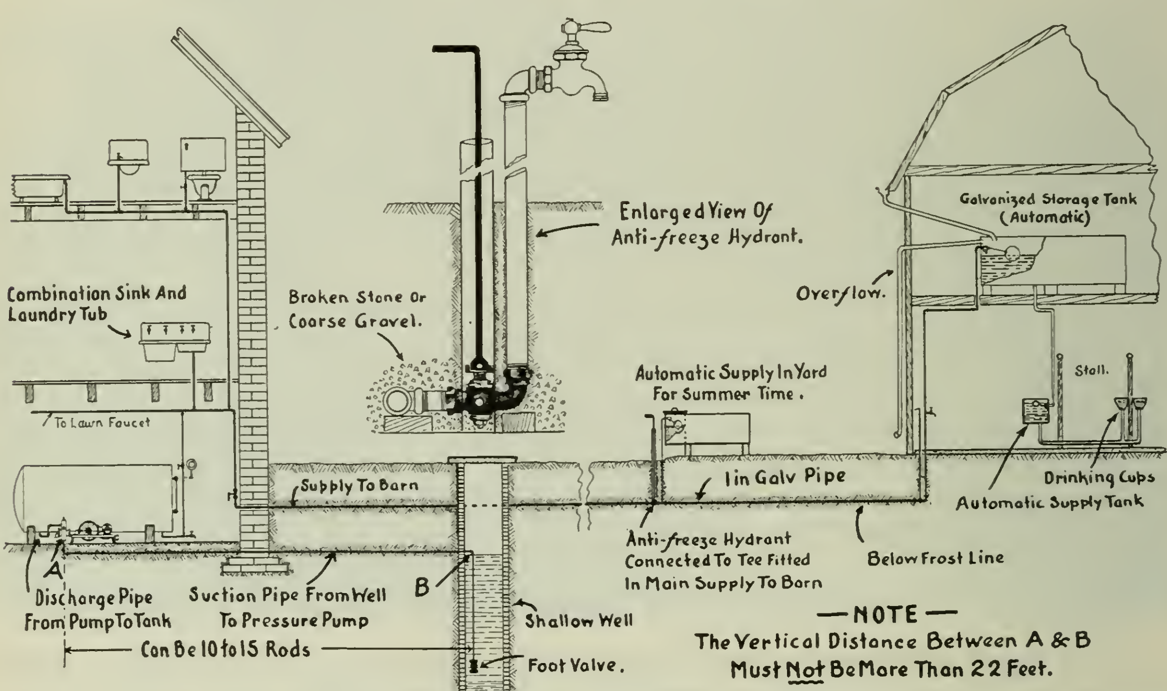


Fig. 28.—Barn supplied with water from house pressure tank and from barn roof.

of the house for domestic use, and into an open tank in the barn for serving the stable with water. In this case the operation is automatic, the wheel being pulled into the wind when pressure goes down to about twenty pounds, and out when it rises to forty. Farmers with good windmills in use now for pumping water into the stables or maybe only in troughs in the yard might be interested to know that they can have water service in the house also by installing a pressure tank and some accessories to the pump.

The Hydraulic Ram Pumping Water for House and Barn.

In Fig. 31 is illustrated how the barn storage may be kept supplied by hydraulic ram. If hydraulic ram is used for supplying barn only the over-head tank may be done away with and the water allowed to flow constantly through a trough in front of the cattle. This makes a very simple, cheap and sanitary system.

WATER BASINS.

One prominent feature of present-day stable equipment is automatic water supply through water basins placed in front of the stock. There are different styles of basins, in some the water level is controlled by a regulating tank connected up with the basins, and there is only a very simple check valve in the bottom of basin, in others there is a spring valve in basin and animal gets supply by pressing its nose on a disc that opens the valve. Again some basins are single, others double. If these basins are given the required attention to keep them clean and sanitary, and the vital parts kept in good working order, they will be found on the whole to be satisfactory for farm stables. Some are easily taken apart for purposes of cleaning.

WATER TANKS.

There are various styles of tanks for this purpose,—wood, steel and concrete made up in round, oval, square and rectangular forms. In some instances the concrete construction is preferable, but to-day a good many steel tanks are being installed. The round end steel form may be strapped to the ceiling of the stable if desired, the other types are more adapted for placing in the hayloft. The size depends on amount of stock kept and the type of water system used. If windmill is used for pumping, the tank should be large enough to hold about one week's supply of water, in order to have plenty during calm days. A tank 6 by 5 by 5 feet will hold enough to supply forty head of stock about three days. The same is true to some extent for pumping water by gasoline engine. However, if automatic pumps are used, there is no reason for a large tank except to provide against lack of water during a breakdown. Water tanks need some protection against frost when located outside or above the stable itself.

WATER TANKS—SIZES AND CAPACITIES.

Style of Tank.	Dimensions.			Capacity.
	Diameter.	Height.	Length.	
Round Steel Tanks	4 ft.	4 ft.	....	297
	4 ft.	5 ft.	....	372
	5 ft.	5 ft.	....	587
	5 ft.	6 ft.	....	695
Round End Steel Tanks	2 ft.	2 ft.	4 ft.	78
	2 ft.	2 ft.	6 ft.	122
	2½ ft.	2 ft.	8 ft.	206
	3 ft.	2 ft.	10 ft.	317
Round Wood Tanks	4 ft. (bottom)	....	4 ft.	285
	4 ft.	....	5 ft.	360
	5 ft.	....	5 ft.	570
	5 ft.	....	6 ft.	675
	Length.	Width.	Depth.	
Square and Rectangular Tanks	5 ft.	4 ft.	3 ft.	375
	4 ft.	4 ft.	4 ft.	400
	6 ft.	4 ft.	4 ft.	600
	6 ft.	5 ft.	4 ft.	750
	6 ft.	5 ft.	5 ft.	937

NOTE.—1 cubic foot=6¼ Imperial gallons, or 7½ U.S.A. gallons.

Regulating Valves for Open Tanks.

When open tanks are filled by automatically controlled pumps, it is necessary to equip the tanks with a good pressure float valve.

5. THE HYDRAULIC RAM.

Merriman in his "Treatise on Hydraulics" describes the hydraulic ram as follows: "It is an apparatus which employs the dynamic pressure produced by stopping a column of moving water to raise a part of this water to a higher level. The principle of its action was first recognized by Whitehurst in 1772, but the credit of perfecting the machine is due to Montgolfer, who in 1796 built the self-acting ram."

The chief purpose of the hydraulic ram is to lift spring water for domestic purposes on farms and large estates. Under special conditions it may be used on a large scale to supply water for irrigation, railroad watering stations, etc.

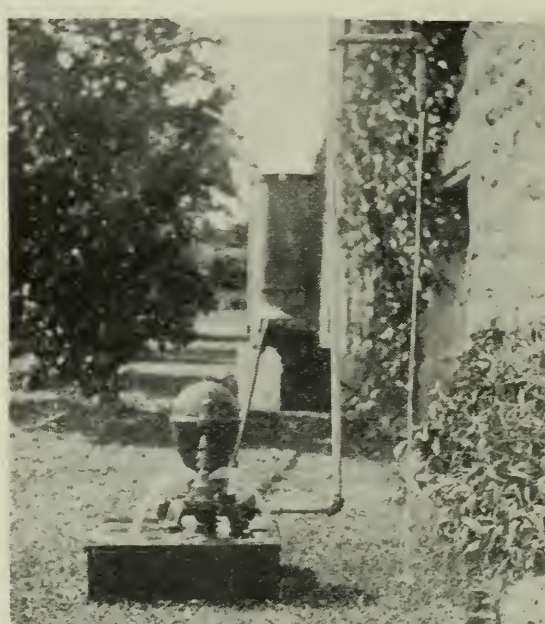


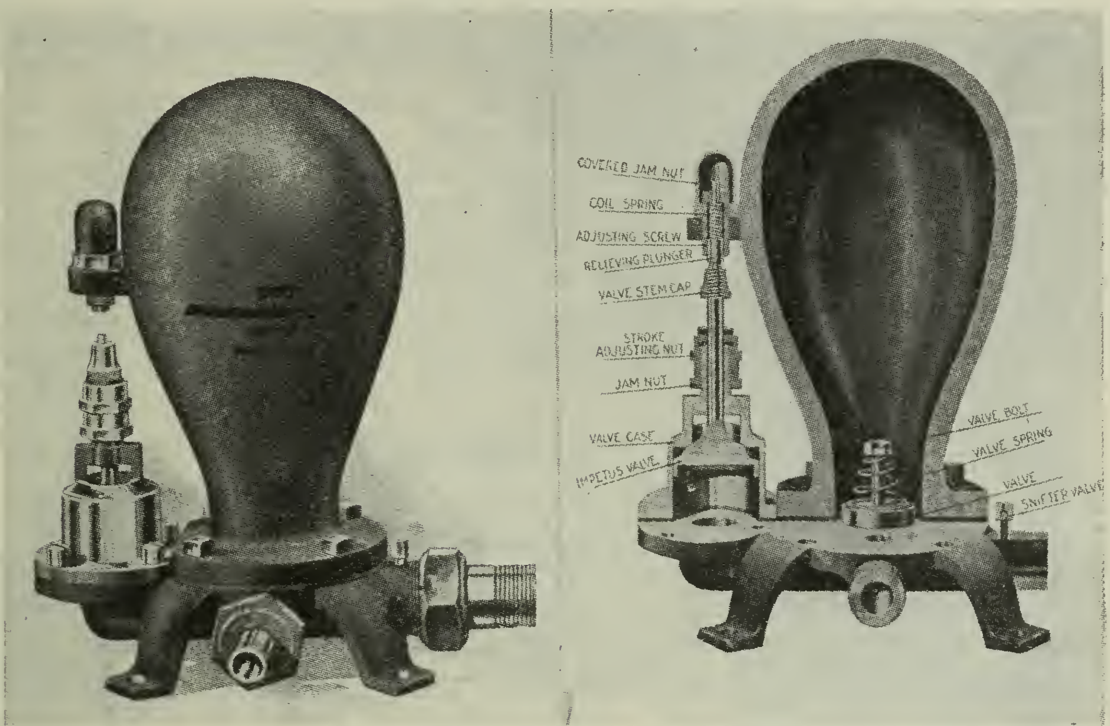
Fig. 29.—Hydraulic ram on test at O.A.C. Guelph.

It has many advantages, chief of which are that it is automatic in operation, requires practically no attention, needs no oiling, does not depend upon the wind, has little cost of maintenance, and it will last indefinitely with reasonable care.

The Construction of the Hydraulic Ram.

For those who are not familiar with the hydraulic ram, a few words regarding its construction may be appreciated. The particular design described herein is commonly known as the standard hydraulic ram, being the one to which our Department has given special study both in the laboratory and in actual service on many farms. There are, however, other types which give equally good service.

The design and construction of the ram itself may be clearly understood from a study of Figs. 30 and 31. The parts are the base comprising the inlet and discharge pipes, the two valve parts, and the four feet; the air dome with relief plunger attached, the waste valve or the cone-shaped part above the lower end of the drive-pipe, the valve at the base of the air dome and the air or snifter valve. The various parts of the waste valve are clearly shown in Fig. 30 (*b*). In Fig. 29 the ram is shown in action, and in drawing, Fig. 31, the details regarding the actual installation are outlined.



a b

Fig. 30.—(a) The standard hydraulic ram in perspective. (b) Vertical section of same.

The Principle, or How the Ram Works.

Keeping Fig. 32 in mind, the principle may be clearly understood by the following description:

When the water flows down the drive pipe it finds the valve C closed and W open on account of their own weight, consequently it begins to escape through the open waste valve. As soon as the velocity of the water is great enough to counterbalance the weight of the valve W, the latter

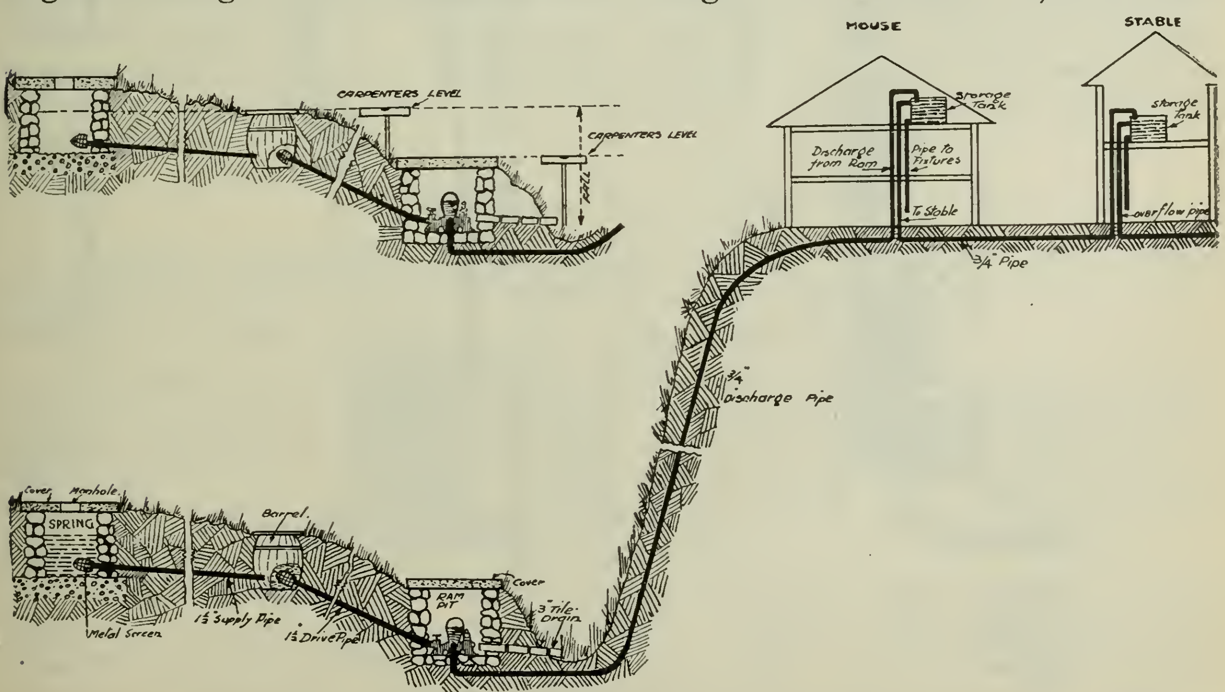


Fig. 31.—A typical hydraulic ram installation.

closes, and very suddenly, too. If the drive-pipe D is 1½ inches in diameter and fifty feet long, which is a length frequently used, the weight of water in the pipe is thirty-eight pounds, and this is moving rapidly down the pipe. When the waste valve closes suddenly the thirty-eight pounds of water strikes a blow on the inside of the pipe, including the valve C.

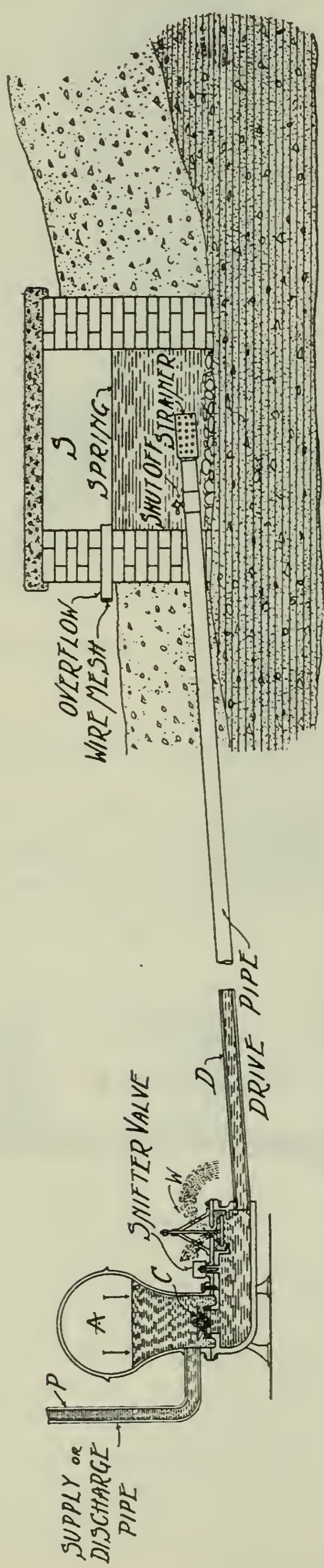


Fig. 32.—Sectional diagram of hydraulic ram installation.

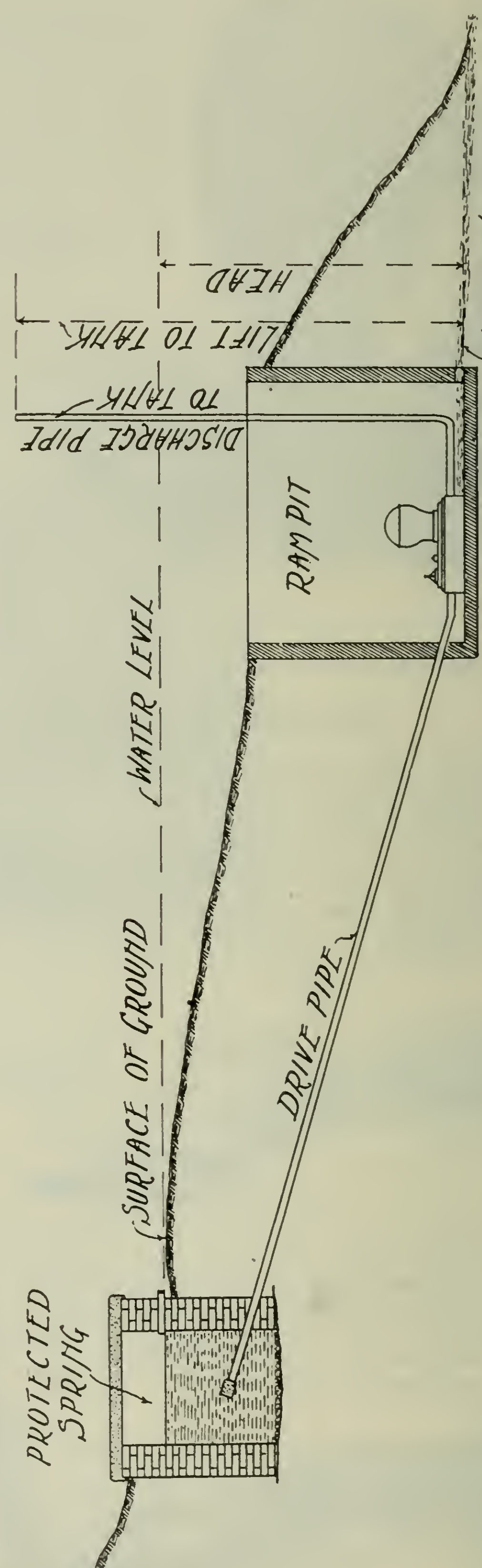


Fig. 33.—The hydraulic ram installation under ordinary conditions, ram close to spring.

Think of the blow a thirty-eight-pound hammer would strike, and you have some idea of the blow delivered by the water. The impulse opens the valve C and the water rushes suddenly and rapidly into the air dome A. By and by, however, it comes to rest on account of the back pressure of the air. Immediately this happens the air begins to expand and starts the water backward up the drive pipe. This lasts only an instant, just long enough for the check valve to close, but this small recoil is a very important factor in the working of the ram. When the check valve closes, the movement of the water backward in the pipe creates a suction on the waste valve, which, along with its own weight, opens the valve. Meantime, the air in A continues expanding and drives the water at a steady rate up the supply pipe toward the buildings. While this is taking place the water is wasting through W, and as soon as the velocity is great enough, W is closed again and another blow is struck, and thus the whole cycle is repeated over and over again.

The Purpose of the Air-Dome.

The air-dome is absolutely essential to the working of the ram. In the supply pipe leading away from the ram up to the buildings there is a large weight of water, and even the blow from the thirty-eight-pound hammer in the drive pipe couldn't set all that water in motion so suddenly. But in the dome is a cushion of air, and when the blow comes that cushion is easily and quickly compressed, allowing a volume of water to rush in suddenly, irrespective of the water in the supply pipe. However, since air is soluble in water, the quantity in the dome gradually disappears and when nearly all exhausted the ram will stop working, and the only way to start it again is to put fresh air into the dome. To do this it may be necessary to remove and empty it. Some drill a hole in it and put in an air valve similar to those used in bicycle or automobile tires, and then by means of a hand-pump force fresh air into the dome from time to time. However, it is possible to have air taken in automatically. It has already been pointed out that immediately after the valve C closes, a suction is created in the drive-pipe. If a small hole is drilled in it, preferably on the top side, and essentially close to the ram, then at each suction a few bubbles of air will be drawn in, and this will keep the air in the dome constantly replenished. During the pressure portion of the stroke, some water will waste through this hole, and consequently, in new rams a check valve is fitted into it to prevent loss of water but admitting air. This is sometimes called a snifting, snifter, or sniff valve.

Making a Ram Survey.

Anyone considering the installation of the hydraulic ram should familiarize himself with the conditions under which it can be used successfully, or make a survey. They are as follows:

1. Supply of Water. It varies with size of ram used, the smallest size, No. 2, using at least 2 gallons per minute; No. 4, the commonest size, eight or ten gallons per minute. It is necessary first of all to measure the flow from the spring in order to make sure there is water enough. Do not guess at it, but actually measure the overflow of the spring by noting how long it takes to fill a pail of a known capacity.

2. Fall or Head. The water operating the ram must have a fall into the ram. It will operate under a head as low as eighteen inches, but usually much more than this is required to lift the water to the desired elevation. The lift is ten feet for every foot fall, so that five or six feet, at

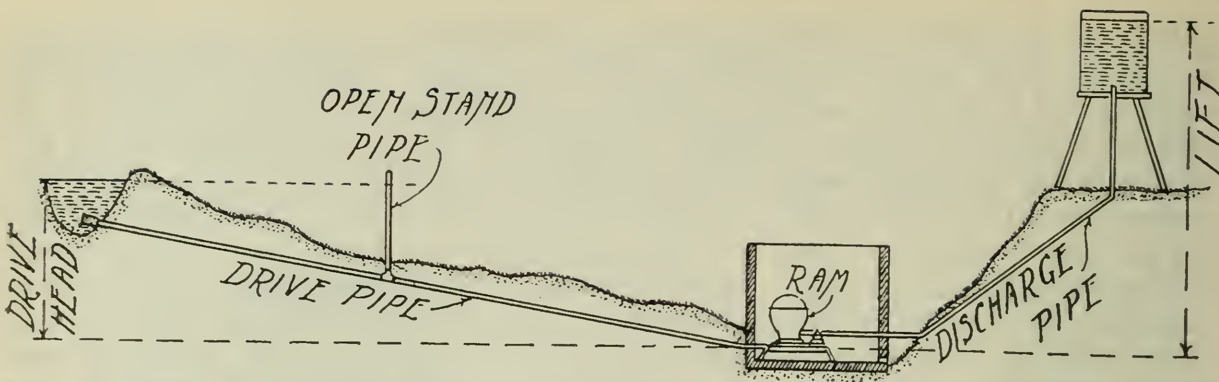


Fig. 34.—When the ram is at considerable distance from the spring, an open stand-pipe or reservoir must be provided within 35 to 50 ft. from the ram.

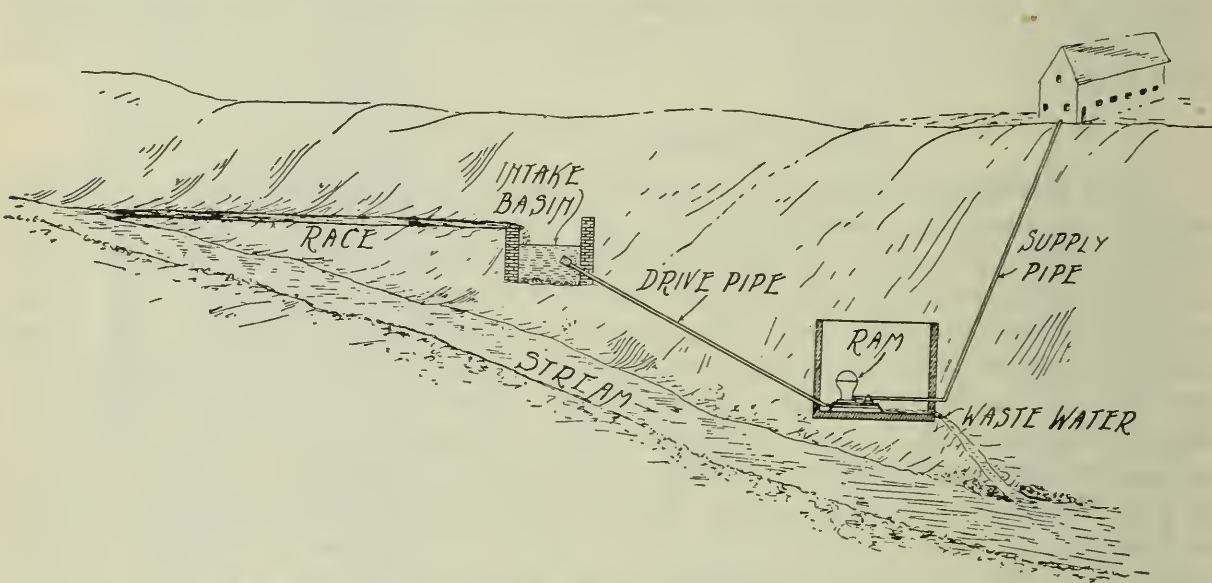


Fig. 35.—Obtaining head for ram along a river bank.

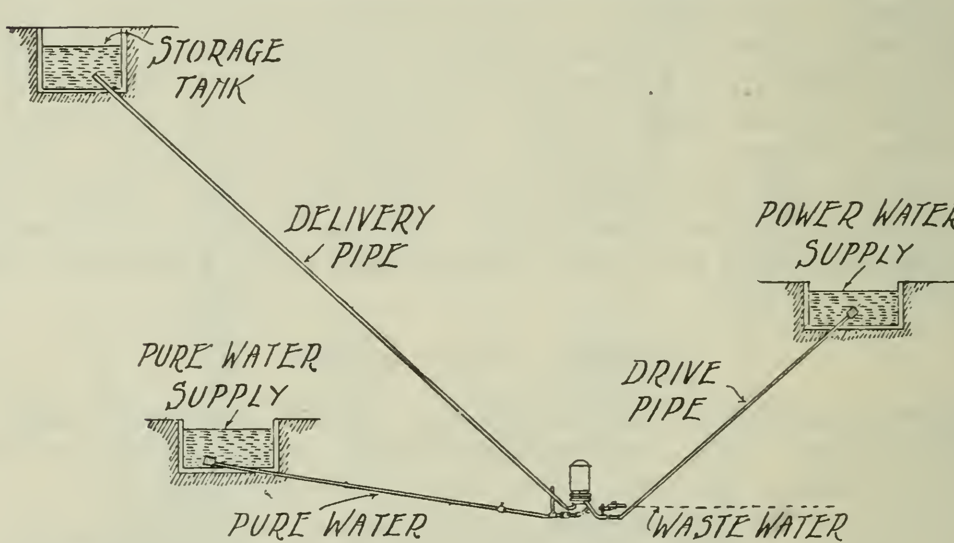


Fig. 36.—Double acting ram using impure water supply to drive pure water to the buildings.

least, are required, sometimes more. The actual fall may be determined by use of the carpenter's level, as shown in Fig. 31. The head may be increased by damming back the source or sinking ram pit or both.

3. Drainage. A great deal of water wastes from the valve, as indicated in Fig. 32, and as flooding would stop the ram it is necessary to have good drainage from the bottom of the ram pit, and in placing the ram this fact must be kept in mind and proper drainage provided for. See Figs. 31 and 33.

4. *The Pipe Lines.* The drive-pipe should be laid on a uniform grade and without any turns or sharp angles. In fact, it should follow a direct course between the spring and the ram. Angles in the discharge pipe are not so objectionable. The length of the drive-pipe should be not less than five or six times the amount of fall or less than three-quarters of the lift. It may be more, however, but if length exceeds 100 feet or so an open stand-pipe should be attached to the drive-pipe about fifty feet from the ram, and extending upwards slightly higher than the source, as shown in Fig. 34. Fifty or seventy-five feet is a very satisfactory length of drive-pipe.

5. *Housing the Machine.* In cold climates the ram should be put in a pit two or three feet deep, and all pipes laid below the frost line in order to avoid any possibility of freezing.

6. *Constant Head.* The ram works rather better if the head of water or fall is kept constant, and this can be done by installing a barrel or some sort of a tank with an overflow a little way below the spring, piping the water to it and connecting the drive-pipe of the ram to this tank instead of to the spring directly, as illustrated in Fig. 31. There should be a depth of at least twelve inches of water over the entrance to the drive-pipe to prevent air entering the pipe and stopping the machine. (See Appendix I.) page 84.

AMOUNT OF WATER THE RAM WILL DELIVER AND HOW TO CALCULATE IT.

Where conditions are suitable for a ram it is without question the cheapest and most satisfactory method of pumping water. It has one drawback—it wastes far more water than it pumps to the buildings, and hence can only be installed where the supply is from five to twenty times as great as required at the buildings. The efficiency of the ram is from sixty-five to ninety per cent., i.e., it uses sixty-five to ninety per cent. of the energy of the falling water. Suppose the spring supplies ten gallons per minute and the fall from the spring to the ram is five feet. Multiply these together and then take sixty-five per cent. of the product, and we have the energy available for driving water to the buildings each minute.

$$\text{Energy in this case} = \frac{65}{100} \times 10 \times 5 \text{ foot-gallons.}$$
$$= 32.5 \text{ foot-gallons.}$$

Now divide this by the height of the buildings above the ram and we have the number of gallons the ram will deliver per minute at the buildings. If, for example, the height is 32.5 feet, then

$$\text{Number of gallons delivered per minute} = \frac{32.5}{32.5} = 1 \text{ gallon which is } 1/10 \text{ of}$$

the water supplied by the supposed spring. In ordinary usage about one-seventh of the water is lifted.

Therefore number of gallons per day$=60 \times 24 = 1{,}440$ gallons=about twenty-nine barrels. Consequently with 5 feet of head and 32.5 feet of lift the ram will deliver at the buildings one-tenth of the water in the spring. The quantity that will be delivered with other heads, lifts and spring flows may be calculated in a similar way.

General Formula.

$$Q = \frac{S \times H}{L} \times E$$

where Q=gallons pumped per minute.
S=supply in gallons per minute.
H=head or fall in feet.
L=lift above the ram in feet.
E=efficiency, average value being 65%.

If E=50% then $Q = \frac{S \times H,}{2L}$ which will give approximate result.

Note.—To get amount pumped per day multiply result by 60 and 24.

Special Types of Installation.

No. 1.—The Ordinary Type. This is illustrated in Fig. 33 below, or where the conditions are such as to allow of building a ram pit within thirty-five to fifty feet of the spring, low enough to give sufficient fall in the drive-pipe, and at the same time affording ample escape for the waste water. Note method of protecting the spring.

No. 2.—Ram far away from spring. Sometimes the ram pit must be built a considerable distance from the spring—say 200 feet. With such a long drive-pipe the ram will not work satisfactorily unless fitted with an open stand-pipe about thirty-five to fifty feet from the ram, as shown in Fig. 34. Sometimes a reservoir is used instead of the stand-pipe, e.g., a barrel sunk in the ground. A long drive-pipe is a detriment, for two reasons; first, friction is so great in it that it takes considerable time for the water to get up sufficient velocity to close the waste valve; secondly, the air expansion in the dome would have to start all the water in 200 feet backward up the pipe before any recoil and suction could take place to aid in reopening the waste valve. The stand-pipe overcomes both these difficulties—during the recoil the water in the lower section of the line recoils up the stand-pipe while above it the water still keeps flowing down the line and raising the level in the stand-pipe. When the waste valve opens again the supply and head in the stand-pipe enables the water in the lower section to develop velocity quickly independent of that in the upper section. Thus the water level in the stand-pipe pulsates up and down.

No. 3.—Ram installed alongside a stream serving as source. On a stream where head is not available under existing conditions, it is sometimes possible to lead a portion of the water by a ditch or tile along the bank at a slower grade than the stream itself, and so obtain the necessary head. This is illustrated in Fig. 35.

No. 4.—Double-acting hydraulic ram. Sometimes a small pure spring which does not supply sufficient water to operate a ram is situated near another source of water unfit for domestic use, as a pond, lake or stream. When the levels are such that the two supplies can be led together at a lower point, a double-acting ram may be used. This is so constructed that the impure water operates the ram and delivers all the spring water at the buildings. Fig. 36 shows this installation.

Further particulars regarding this particular type of installation will be given on application if required.

How to Maintain Successful Operation of the Hydraulic Ram.

1. *Keep air-chamber well supplied with air.* Air is absorbed by the water, or it may escape through a tiny hole in the chamber. See that the air-valve, designated snifter valve in Fig. 30, does not become clogged. A water-logged air-chamber is one of the main causes for ram ceasing to operate.

2. *The valves should be kept in good repair.* Broken or worn valves will cause ram to stop. Foreign matter may lodge in the valves and prevent proper seating of the valves, a leak resulting. A strainer on inlet to drive-pipe will help to keep out dirt, leaves, sticks, etc.

To test the waste valve pull it up tightly and hold it for a moment. If on releasing it the valve remains closed and does not leak, one may rest assured that the valve is all right.

To test the valve in the air-chamber, shut the water off the drive-pipe by closing the gate-valve near the ram, and hold the waste valve open. If delivery valve is leaking water will come out at the waste valve.

3. *Adjust length of stroke of waste or dash valve to suit supply of water.* The larger the stroke, the greater is the capacity of the ram. Therefore, if supply increases lengthen the stroke and vice versa in order to keep the machine working at its greatest efficiency. See Fig. 30 (*b*) for position of adjusting nut.

Storage Tank.

Since the ram pumps very slowly, it is necessary to have a reservoir or storage tank of some kind at or in the buildings so that plenty of water will be on hand at all times. If water is used for both house and barns, the best method is to have a storage tank in the attic of the house and pump directly into it, allowing the overflow to go to another tank in the barns or into troughs in the stables or sheds, as illustrated in Fig. 31 above.

The Cost of Installing an Hydraulic Ram.

As the installations vary considerably in size, no stated cost can be given, but by reference to the subjoined table the cost of any particular outfit can be easily calculated.

THE STANDARD HYDRAULIC RAM.

Table of Capacities, Prices, etc.

Sizes	Minimum amount of water in gals. per min. to operate Ram.	Length of drive pipe.	Diameter of pipes.				Price of Ram.
			Drive.		Discharge.		
2	2	not less than	¾ in.	$9 66	½ in.	$8 03	$19 50
3	4	5 to 6 the	1 in.	13 87	½ in.	....	19 50
4	8	fall or head.	1½ in.	18 77	¾ in.	....	24 60
5	14		2 in.	30 20	1 in.	....	30 60
6	25		2½ in.	47 75	1¼ in.	17 07	49 20

Note.—Prices of black pipe are about 25 per cent. less than galvanized.

Cost of a Typical Installation.

Size 4 ram is the most common one in use, and to install it complete with fifty feet of drive-pipe and 100 feet delivery pipe costs about $65.00, this total being made up about as follows:

Details of Cost.

1 ram, No. 4	$24 60
50 ft. 1½-inch drive-pipe (galvanized)	9 38
100 ft. ¾-inch discharge pipe (galvanized)	9 66
One 1½-inch gate-valve	5 00
Trenching, laying pipe and refilling trenches	6 00
Ram-pit	5 00
Cribbing spring, etc.	5 00
	$64 64

Each additional 100 feet of discharge pipe installed would cost about $14.00.

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6. PLUMBING.

When one is going about to install a complete plumbing system in his home, there are a few general principles that he should consider carefully before he proceeds with the work.

Selecting the Bathroom.

In a two-storey house the bathroom should be directly, or as nearly as possible, above the kitchen, and if there is a laundry room in the basement it should be directly below the kitchen again. This arrangement provides for the simplest, most compact, cheapest and most efficient system. If possible, the whole system should be next to the warmest side of the house, the south preferably, as it will be less liable to freeze, the rooms will get more sun and be more sanitary, and besides, the septic tank to which the system leads should be on the warmest side if possible. The bathroom should have at least one good window facing the morning sun and fitted for convenient ventilation. In summer the window should have a good sized screen. The size need not be large, about sixty square feet, the exact dimensions depending on how the fixtures are arranged in the room, where the window and door are located, also position of the stack. If all three fixtures are placed along one side and a five-foot bathtub is used, it will require a room 9′ x 6′. If the bathtub (5½′ in length) and the closet bowl and tank are placed along one wall and the lavatory or washbasin on the opposite side or at one end, the size will need to be about 8½′ x 7′. See Figs. 37 and 38 for suggestions in laying out bathrooms. The closet should be close as possible to the stack and the nearer the other fixtures are to the stack the better the layout. In one-storey houses, or in any case where bathroom is on the same floor as the kitchen, the two rooms should be as near to each other as convenient.

The General Layout and Principle of a Plumbing System.

As will be seen by examining Figs. 38 and 39, a plumbing system consists of the four-inch cast-iron stack extending from the basement to a point about two feet beyond the roof, and always ten feet away from dormer window, waste pipes and traps connecting the various fixtures to the stack, hot and cold water pipers, one thirty-gallon range boiler for hot water and the bathroom, kitchen and laundry fixtures. Its function is to supply the house with pure running water, hot and cold, and to remove all waste matter from the sinks and other fixtures and dispose of them in a sanitary manner in the sewer or septic tank as the case may be.

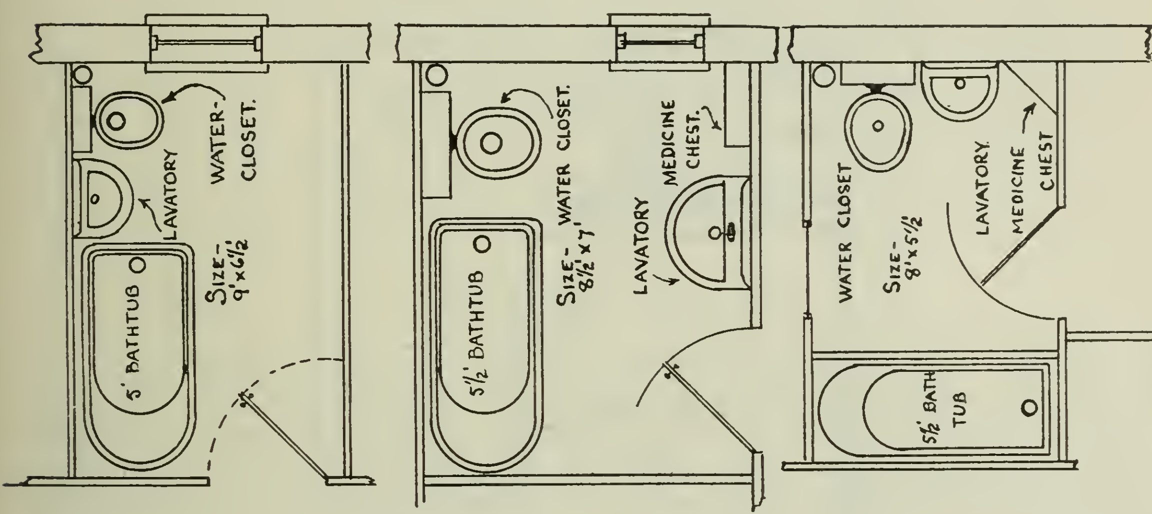


Fig. 37.—Suggested Lay-outs of Bathrooms.

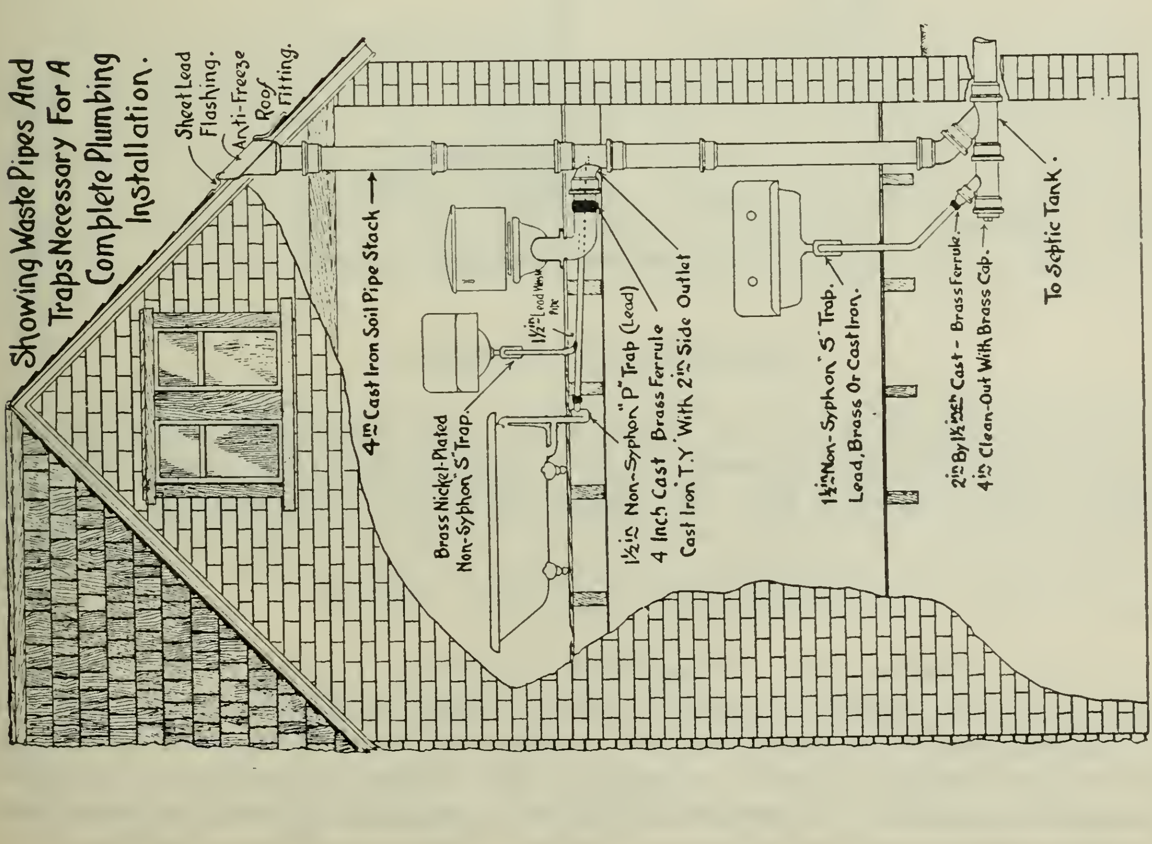


Fig. 38.

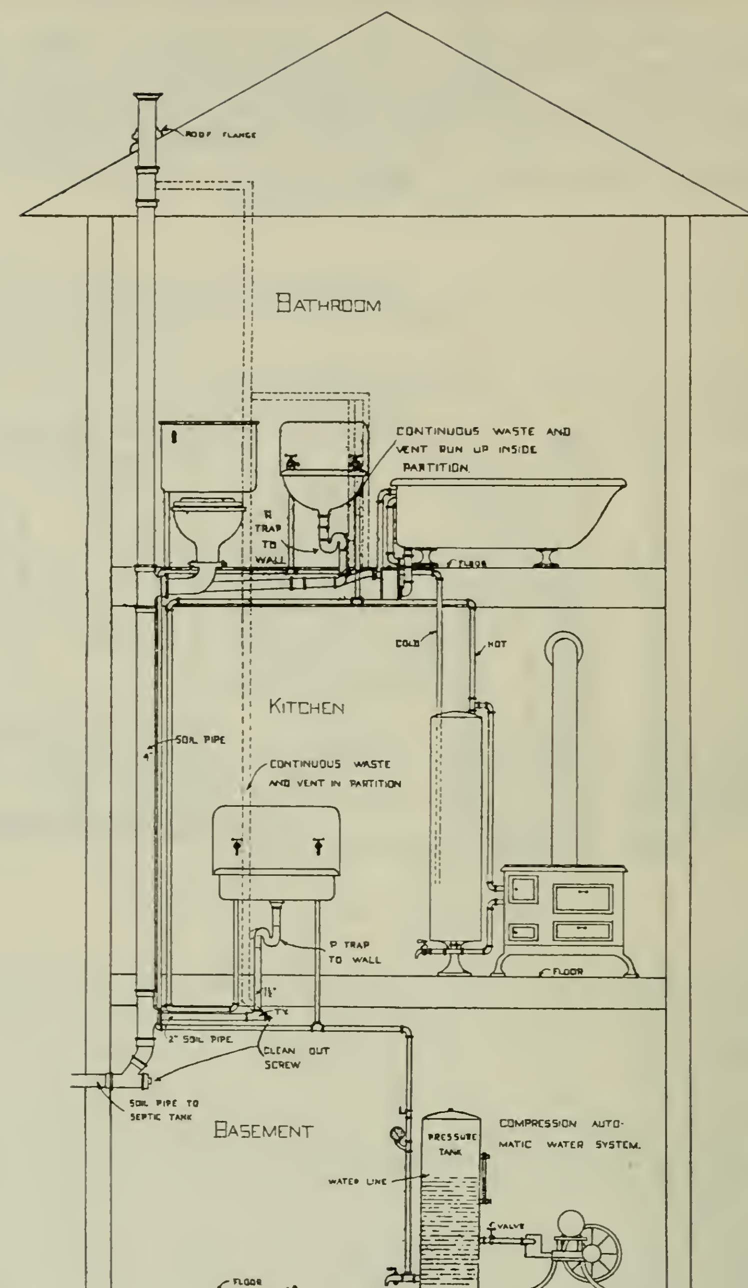


Fig. 39.—A Complete Plumbing System.

"Roughing-in" Material.

This consists of soil pipe, water pipe, lead pipe, traps and pipe fittings and connections necessary to join up the different parts into one system. The plumber's first job, after laying the system, is to assemble all this material, and this he describes by the term "roughing-in." Afterwards the work is completed by connecting up the fixtures to the waste pipes, and the water service to the faucets.

All the material that is used for plumbing should be of standard quality and good in every respect. The quantity required and the cost for any job cannot be stated definitely except by an experienced mechanic, after he has made a careful estimate. The following information, however, may be useful to anyone who wishes to acquaint himself as to nature, and approximate amount of material needed for an ordinary dwelling.

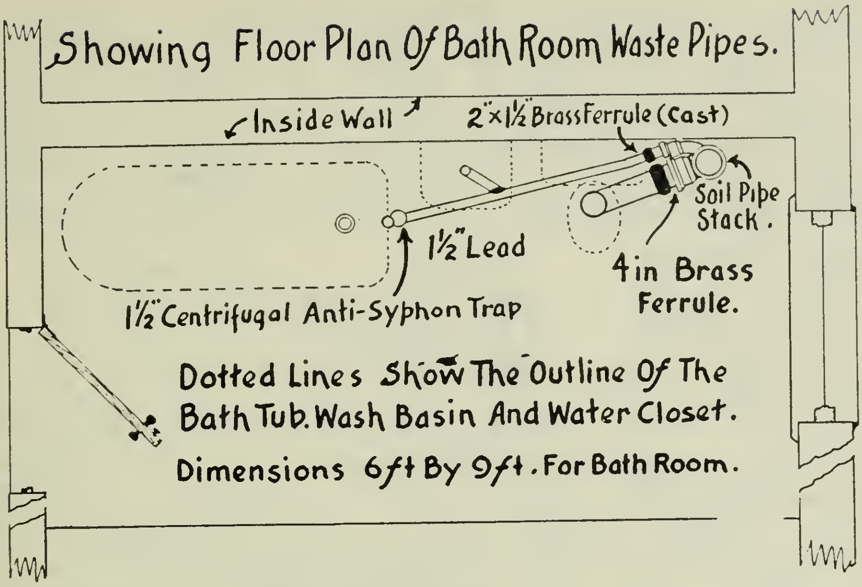


Fig. 40.

Cast-iron Soil Pipe.

The quality of soil pipe used for dwellings is designated medium weight, or 45 lbs. per 5-ft. length. It is made in five-foot lengths, either single or double hub, and in various diameters, but for ordinary jobs only two sizes are used: four-inch for stack and two-inch for waste pipes and vents. It takes about forty feet of four-inch for the stack and run to septic tank close to house, and a quantity of two-inch, hard to estimate for waste pipes probably ten to fifteen feet. In ordering pipe for stack it is economy and a convenience to order a couple of double hub lengths.

Lead Pipe.

The standard lead pipe used for branch soil waste, vent or flush pipes shall not weigh less than 8 lbs. per linear yard for 1½-inch, the common size It is the best material and most commonly used for waste pipes from the bathtub and lavatory. Galvanized wrought-iron and cast-iron soil pipe may be used with very good results and is cheaper and easier to install. The amount of waste pipe varies considerably, amounting to probably eight to ten feet. A brass ferrule is always used to join the lead waste pipes to the stack.

Galvanized Iron Pipe.

For the ordinary job it requires about 150 feet of half-inch pipe to supply hot and cold water to all fixtures, and a small quantity of three-quarter-inchbetween range boiler and coil in furnace or waterfront in kitchen range, the amount depending on distance between boiler and furnace.

Water Pipe Galvanized Fittings.

(Note Fig. 43.)

The following statement is an approximation of the water pipe fittings needed for an ordinary house job: 3 dozen ½-inch elbows, 2 dozen ½-inch nipples (assorted), 1 dozen ½-inch tees, 2 or 3 ½-inch unions, 2 or 3 ¾-inch unions, 2 boiler unions, 4 1 x ¾-inch elbows, 1 ½-inch drain faucet for boiler (brass), 1 ½-inch shut-off for range boiler (brass), 6 to 8 ¾-inch

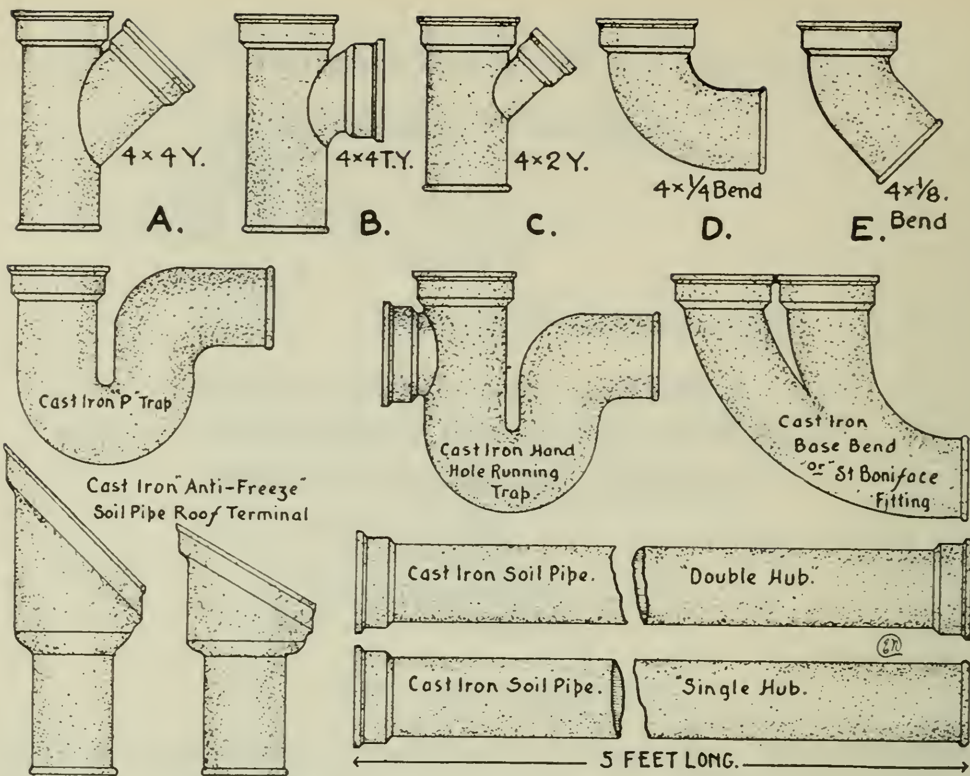


Fig. 41.—Cast iron soil pipe and fittings.

elbows for boiler connections, ½ dozen ¾-inch nipples, and 4 or 5 feet of 1-inch pipe and a return bend for coil in furnace, 2 or 3 stop and waste cocks, one for main shut-off of water supply, the others for shut-off on lawn service pipes, 2 or 3 bibbs for lawn service.

Soil Pipe Fittings.

(See Fig. 41.)

The following named cast-iron fittings are required for roughing-in plumbing system for house: one 4 x 4 x 2 special T-Y with either right or left side inlet. This one fitting provides for 4-inch opening for closet and a 2-inch opening for bath and basin. This is a very useful fitting and is highly recommended. One 4 x 2 T-Y for connecting sink waste to stack; one 4-inch T-Y or Y for connecting sink waste to stack; one 4-inch T-Y with clean-out screw for joining base of stack to horizontal pipe through cellar wall or instead one Y with ⅛ bend; one 4-inch lead bend with lead and iron or brass ferrule for joining closet bowl to special fitting. It may be had in 12-inch, 16 or 18-inch lengths as required. One or two 4-inch soil pipe bends to provide for angles in the soil pipe if necessary; one or two 2-inch soil pipe bends in case of altering direction of waste pipe for kitchen drain, etc.; one 4-inch offset may be needed in case any bend is necessary in the stack; one roof flashing for securing water-tight joint between stack and roof of any approved design, the Ballard type being adjustable to any pitch of roof; 10 lbs. of oakum and about 50 lbs. of caulking lead for soil pipe, and about 10 lbs. of wiping solder for wiped joints.

Traps.

Traps or water seals serve a very important part in a plumbing system in preventing the return of sewer gas or obnoxious odours into the house by way of the waste pipes and fixtures. Every fixture should have a separate trap with a water seal not less than two inches. Traps should be placed as close as possible to the outlets of the fixtures and never more than twelve inches away. There are many different styles of traps. Fig. 42 illustrates the most common types. Traps (*a*), (*b*) and (*c*) are particularly suitable for kitchen sink and laundry tubs, (*c*) and (*d*) for washbasin in bathroom and (*e*) and (*f*) for bathubs or (*b*) if vented and (*c*) in "P" trap. Nickel plated centrifugal anti-siphon traps are always used on lavatory in bathroom on the best jobs and often in the kitchen as well.

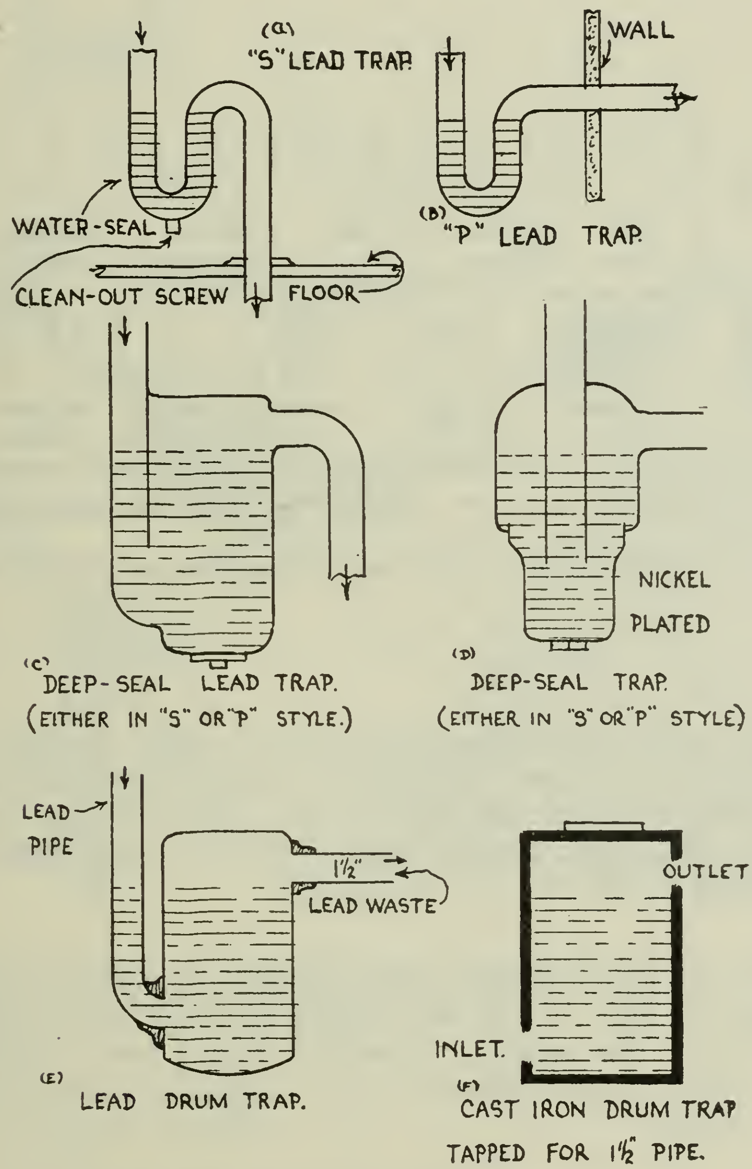


Fig. 42.—Common Styles of Traps.

The anti-siphon or the more expensive ones are recommended highly because they are less liable to lose their water seal, and therefore, are more sanitary and efficient.

Venting.

Venting consists of giving all waste pipes a clear circulation of air and thereby preventing any possibility of siphoning of the traps. It is required by regulation in most of the cities to-day but not in the country. See Fig. 39 for layout of the venting in a plumbing system.

Fixtures.

In regard to the plumbing fixtures for bathrooms and kitchens, there are designs and prices to suit all tastes and purses. In putting in a permanent system of plumbing it is a wise policy to select something pretty good as it is likely to be in style for a long time, it will give good wear, be sanitary and have a good appearance. Built-in bathtubs, pedestal basins, tiled

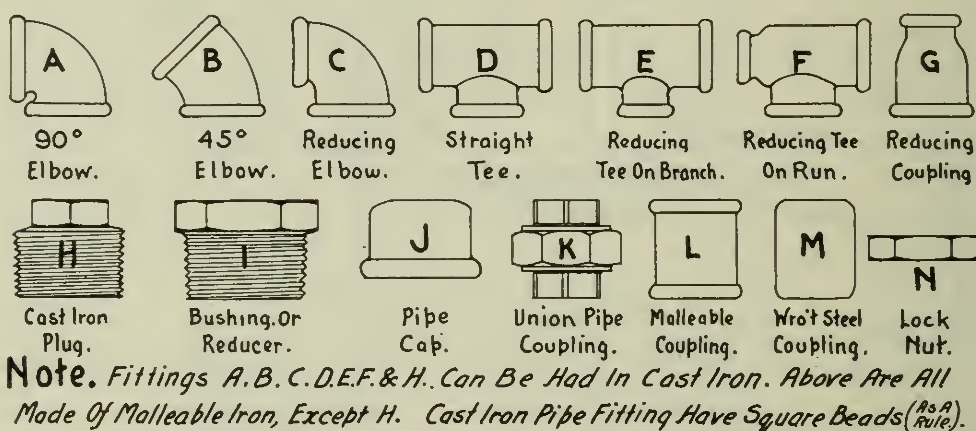


Fig. 43.—Popular pipe fittings used in plumbing and water systems.

floors, etc., are inviting and they certainly are very sanitary and efficient. From the utility standpoint, the quality and wearing ability of the surfaces of the fixtures is the essential thing. The best fixtures are made of cast-iron body with high quality enamel finish, the cheaper one of sheet metal and enamel finish.

Bathtubs.—The two common styles are the ordinary and the built-in. They are made in 4½, 5, 5½ and 6-foot lengths, the five-foot being the most common size. The width is standard at 2½ feet including the rim of three inches. For a few dollars extra a simple shower head may be installed to bathtub.

Washbasins.—There are two main styles, those that hang on the wall and those supported by a pedestal. They vary in size and shape. The common dimensions of the former type are 17″ x 19″ (most common size), 18″ x 20″, 20″ x 22″, 20″ x 24″. Some are square, others are oval, some are flat-back, others are corner basins. The pedestal ones are somewhat larger in dimensions and are built in different shapes.

The Water Closet.—There is some variation in the style and manufacture of the bowl and tank. The tank mechanism needs to be reliable in operation and well built, otherwise considerable annoyance and repair will result. The tank occupies twenty-four inches on the wall, and the distance from wall to outer edge of seat is twenty-six to twenty-eight inches.

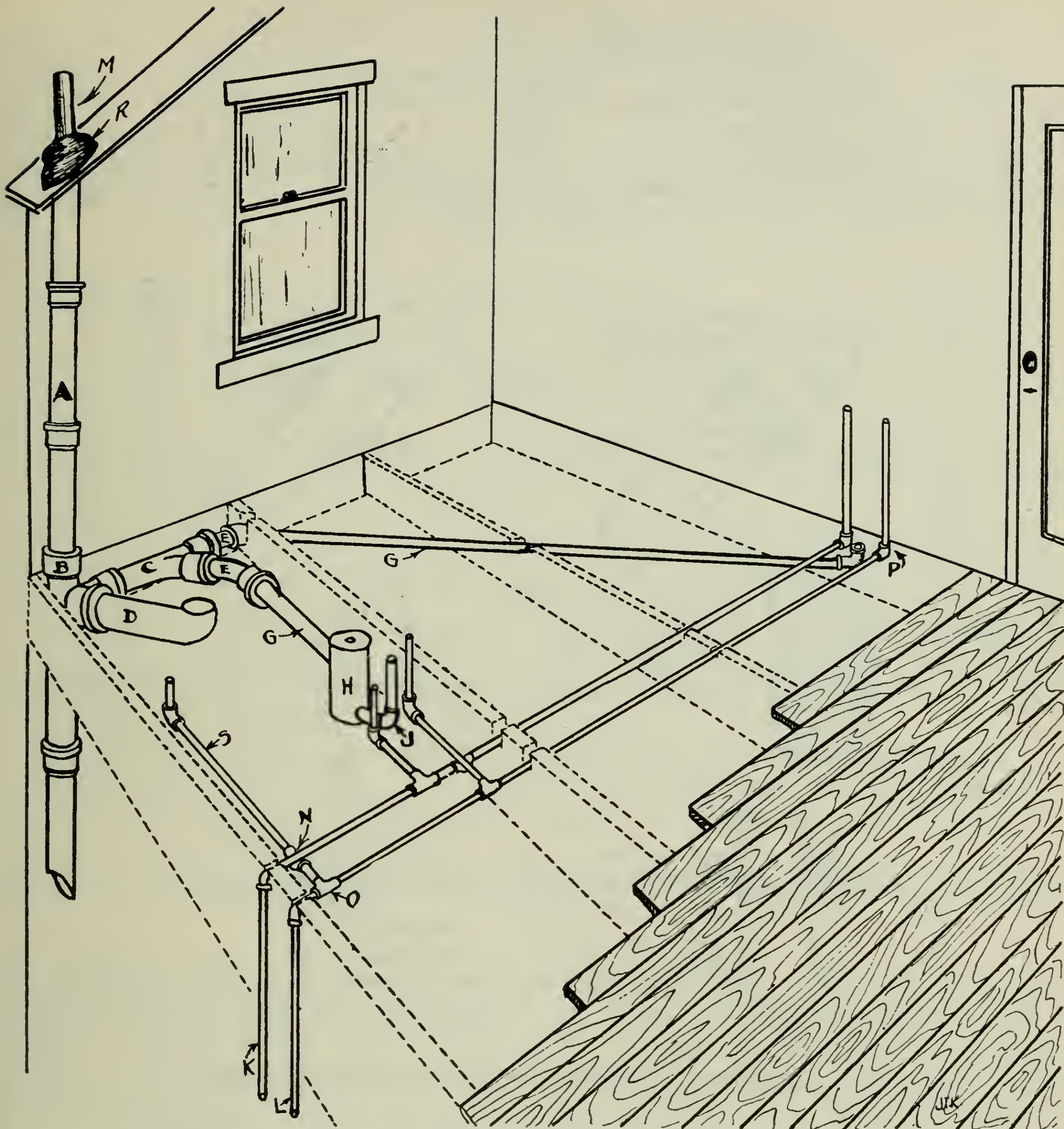


Fig. 44.—A detailed layout of bathroom pipes, using wrought iron pipe for waste pipes and thereby eliminating the use of wiped joints.

A—4-inch cast-iron soil pipe.
B—4 x 4TY cast-iron fitting.
C—2 x 2Y fitting.
D—Lead bend waste pipe with iron ferrule inserted.
E—2 x ⅛ bend.
G—2-inch wrought iron pipe.
H—Cast-iron drum trap.
J—Trap connection to waste pipe for toilet.
K—½-inch hot water pipe.
L—½-inch cold water pipe.
M—Stack pipe.
N—½-inch cross-over.
O—½-inch tee.
P—½-inch elbow.
R—Roof flange for stack pipe.
S—Pipe to closet tank.

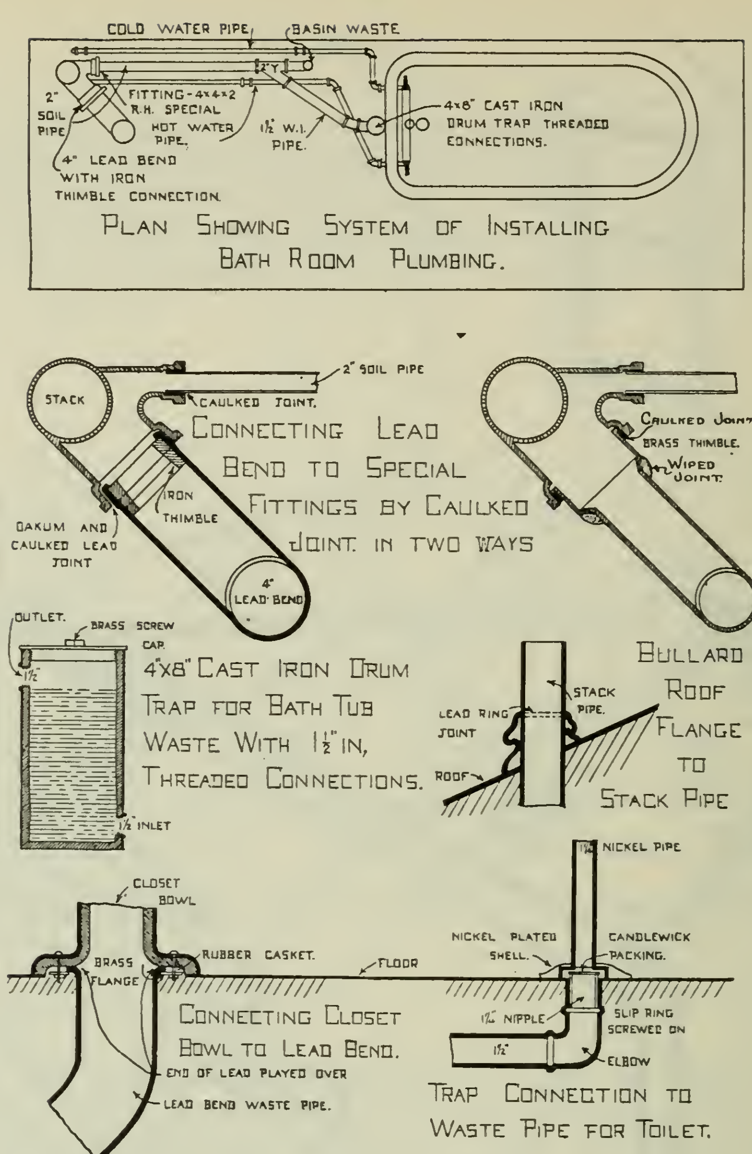


Fig. 45.—Special Connections of a Plumbing System.

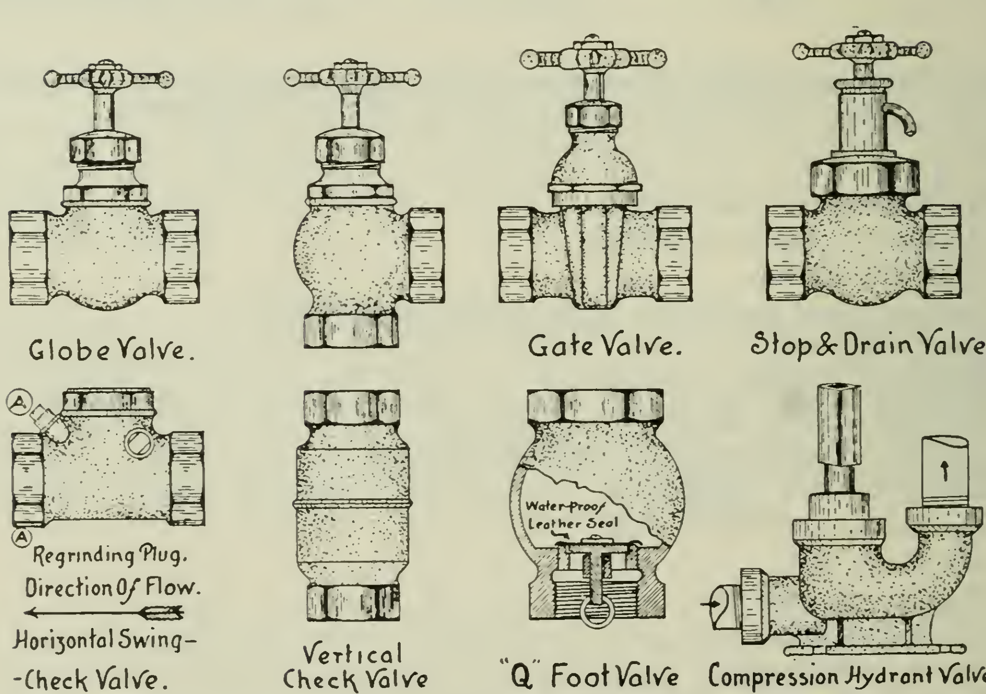


Fig. 46.—Globe, angle and gate valves, horizontal and vertical check valves, stop and drain valve, foot valve and compression hydrant valve.

The Kitchen Sink.—The kitchen sink gets a great deal of use, and therefore should be built to stand up well. It should have two drainboards if possible, either wood or metal; it should be high enough, about thirty-six inches off the floor, to prevent the woman stooping too much when using it; it should be in a bright, cheerful place and yet convenient to the stove and cupboards; the sink and the back should be in one piece to make it sanitary and easily kept clean. The common size is 18″ x 30″.

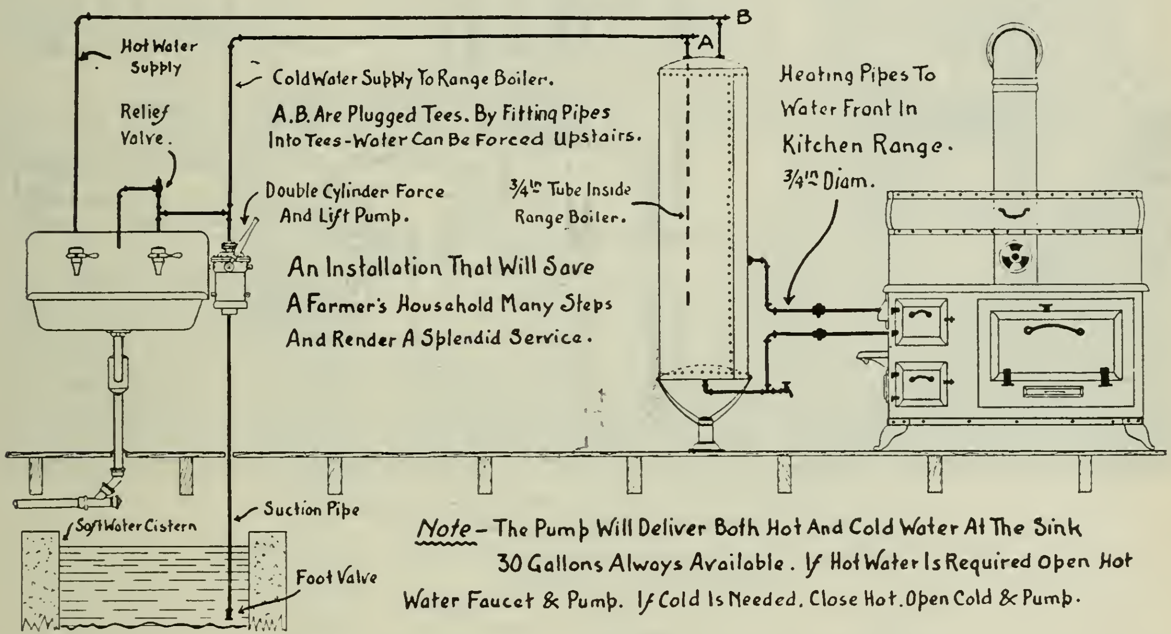


Fig. 47.—A simple hot water system—cistern pump connected to kitchen range boiler.

For washing dishes it is a convenience to have the screen over the outlet provided with some sort of shutter or plug. The combination sink and laundry tub is a very good arrangement in case the kitchen is used for a laundry, the washtub section being covered up by a tap or drainboard when it is not required. This is the very type of fixture for the farm home, as it is not always possible to get drainage from a tub installed in the basement.

Plumbing Tools.

A set of plumbing tools is made up chiefly of the following items: 1 fire pot; 1 metal pot for lead, 4 inches in diameter with handle; 1 ladle for pouring lead into joints; 1 asbestos rope for use in pouring horizontal joints; 1 set of caulking irons, 4 different types; 2 pipe wrenches, 10″ and 14″ sizes, 1 pipe cutter, 1 stock and dies, ¼″ to 1¼″, 1 pipe vise. This set will cost about $40.00.

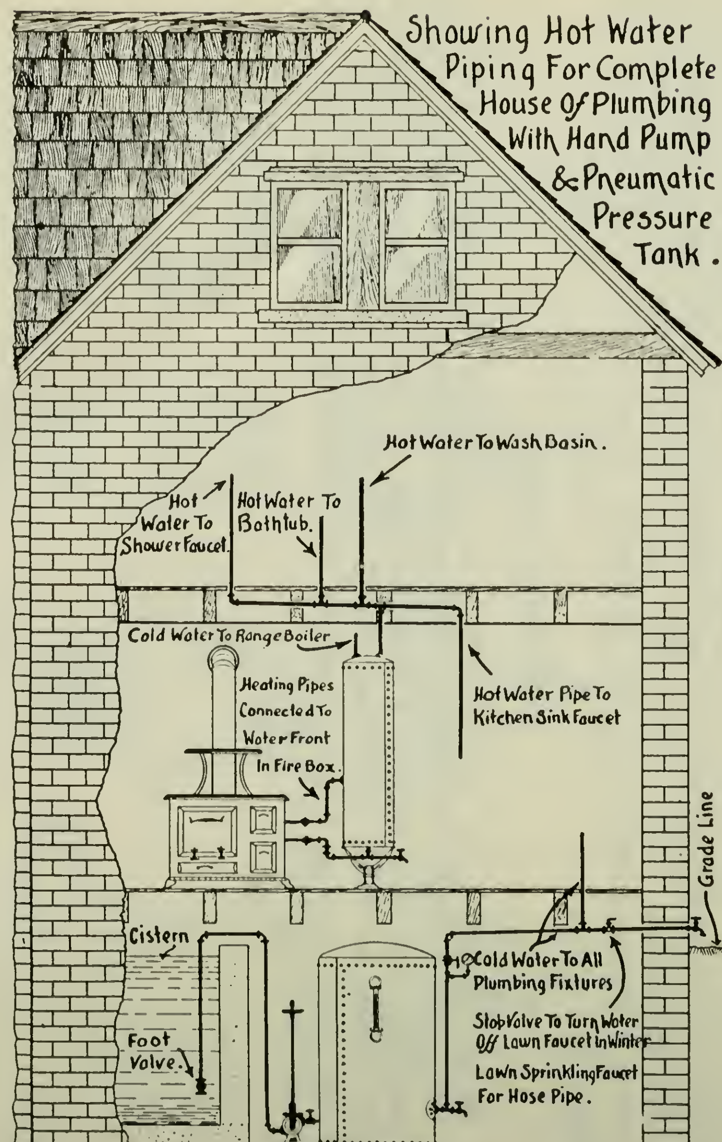

Showing Hot Water Piping For Complete House Of Plumbing With Hand Pump & Pneumatic Pressure Tank.
Hot Water To Wash Basin.
Hot Water To Shower Faucet.
Hot Water To Bathtub.
Cold Water To Range Boiler
Heating Pipes Connected To Water Front In Fire Box.
Hot Water Pipe To Kitchen Sink Faucet
Grade Line
Cistern
Foot Valve.
Cold Water To All Plumbing Fixtures
Stop Valve To Turn Water Off Lawn Faucet In Winter
Lawn Sprinkling Faucet For Hose Pipe.

Fig. 48.

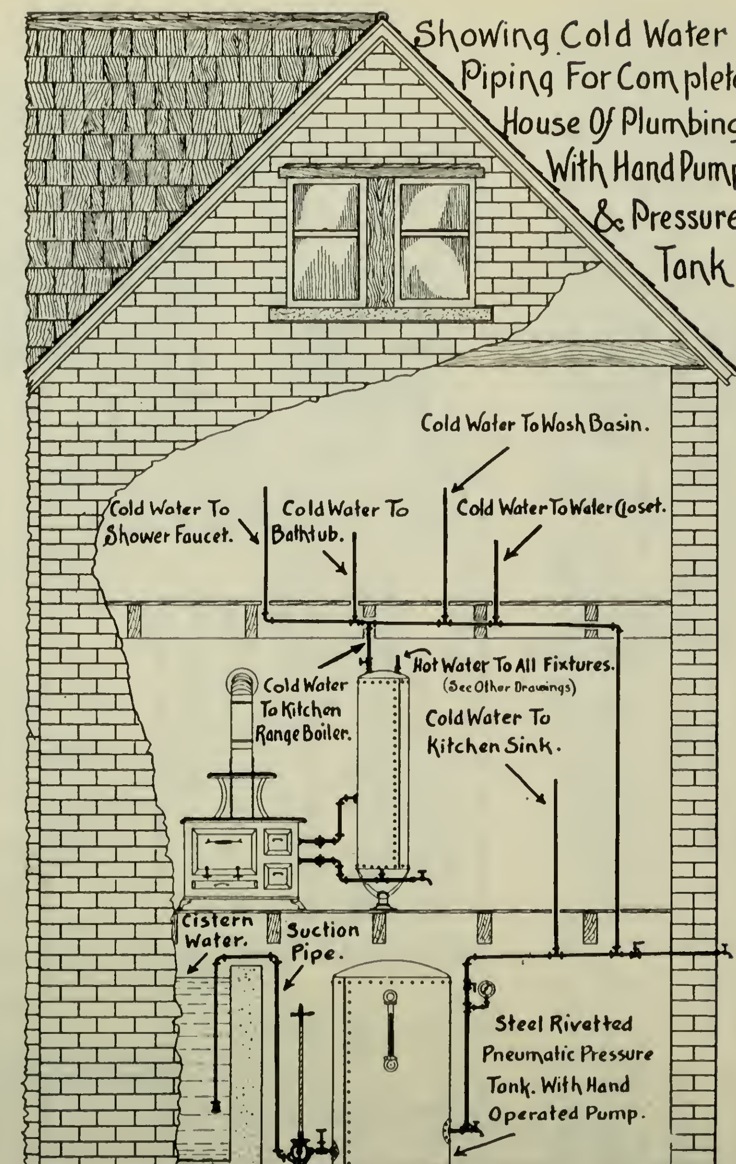

Showing Cold Water Piping For Complete House Of Plumbing. With Hand Pump & Pressure Tank.
Cold Water To Wash Basin.
Cold Water To Shower Faucet.
Cold Water To Bathtub.
Cold Water To Water Closet.
Cold Water To Kitchen Range Boiler.
Hot Water To All Fixtures.
(See Other Drawings)
Cold Water To Kitchen Sink.
Cistern Water.
Suction Pipe.
Steel Rivetted Pneumatic Pressure Tank. With Hand Operated Pump.

Fig. 49.

7. SYSTEMS OF SEWAGE DISPOSAL.

The Septic Tank.

When the farm home is equipped with running water and a complete plumbing system, it is necessary to provide for a sewage disposal system. The approved method is the septic tank. There are various types of septic tanks but the two most common systems are the double-chamber with siphon and the single-chamber without siphon, both of which are described and illustrated herewith.

The septic tank is recognized by all Provincial Boards of Health and sanitary engineers as the best system for disposing of sewage from rural, village and suburban homes.

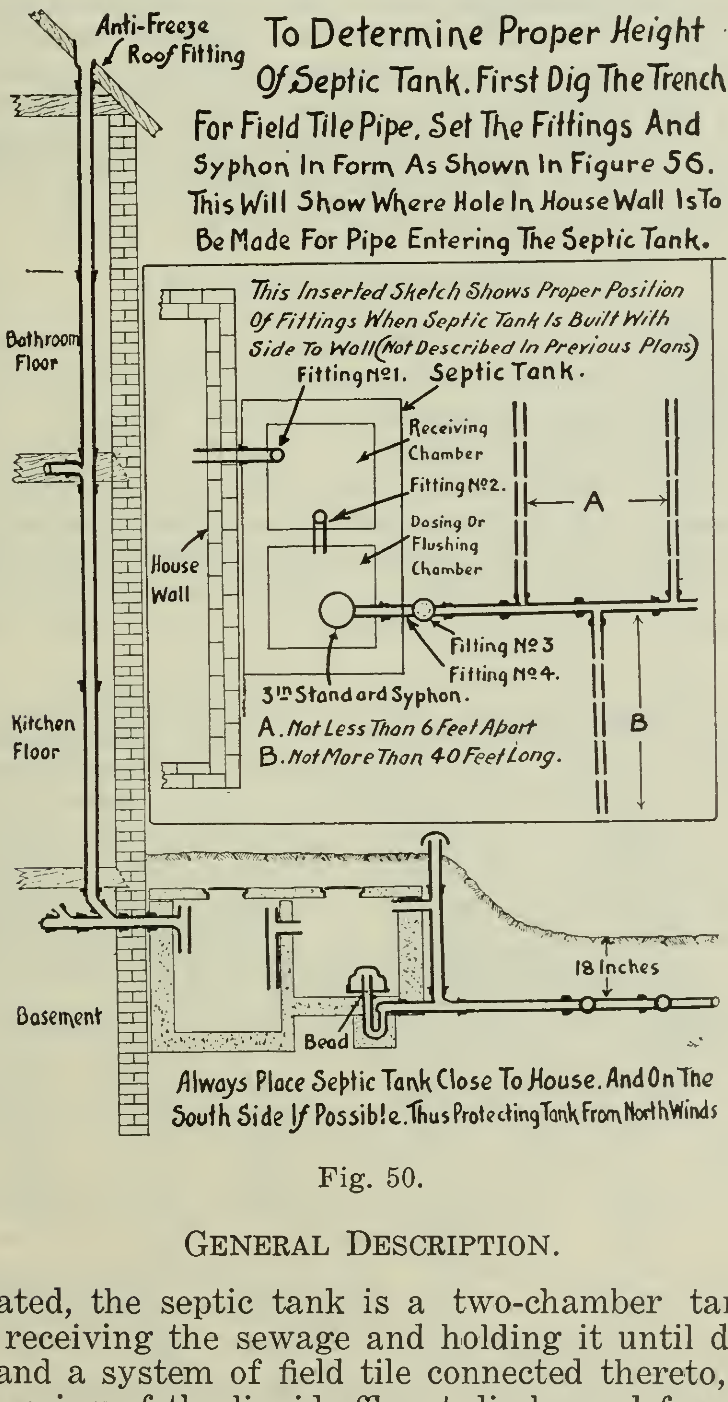


Fig. 50.

General Description.

Briefly stated, the septic tank is a two-chamber tank or a single receptacle for receiving the sewage and holding it until digested by sewage bacteria; and a system of field tile connected thereto, and laid underground for disposing of the liquid effluent discharged from the tank from time to time. For the most part the sewage is destroyed in the receiving chamber; however, there is some bacterial action in the other chamber, and in the soil as well. The chief products of the bacterial action in the tanks are gases and water. Disease germs may survive the action in the tank, but ultimately they succumb in the soil. See on page 70 further description of the septic tank action under heading:

Bacterial action in the septic tank sewage disposal.

(a) The Two-Chamber System with Siphon.

The function of the first or receiving chamber is to retain the sewage until it is digested by bacteria, that of the second or dosing chamber is to collect the overflow from the first chamber and discharge it at intervals into the tile system. The second chamber, therefore, is part of the distributing system. The intermittent discharge from the second chamber is made possible by an automatic siphon located in the bottom of this chamber. This system is particularly well adapted to medium and large installations such as large homes with more than 12 people, schools, hospitals and other public institutions in unseweraged districts, but for farm homes the second chamber and the siphon are not absolute necessities as the effluent can usually be disposed of satisfactorily without a siphon. See Figs 52 and 53 for details of construction.

Construction of the Tank.

As a rule it is of concrete construction, a 1 to 6 mixture being used. The plans (Fig. 51) and the subjoined table supply the necessary information as to dimensions, thickness of walls, amounts of gravel and cement, etc. The forms are simple and easy to build, and outer ones are not necessary except above the surface. The forms should be made true, and be well braced. The fittings should be placed in the forms at positions indicated in Fig. 52 and before the concrete is run into the forms. The U-part of the siphon should be placed vertical and near the outer end of the chamber, and with the bead on a level with the finished sur-

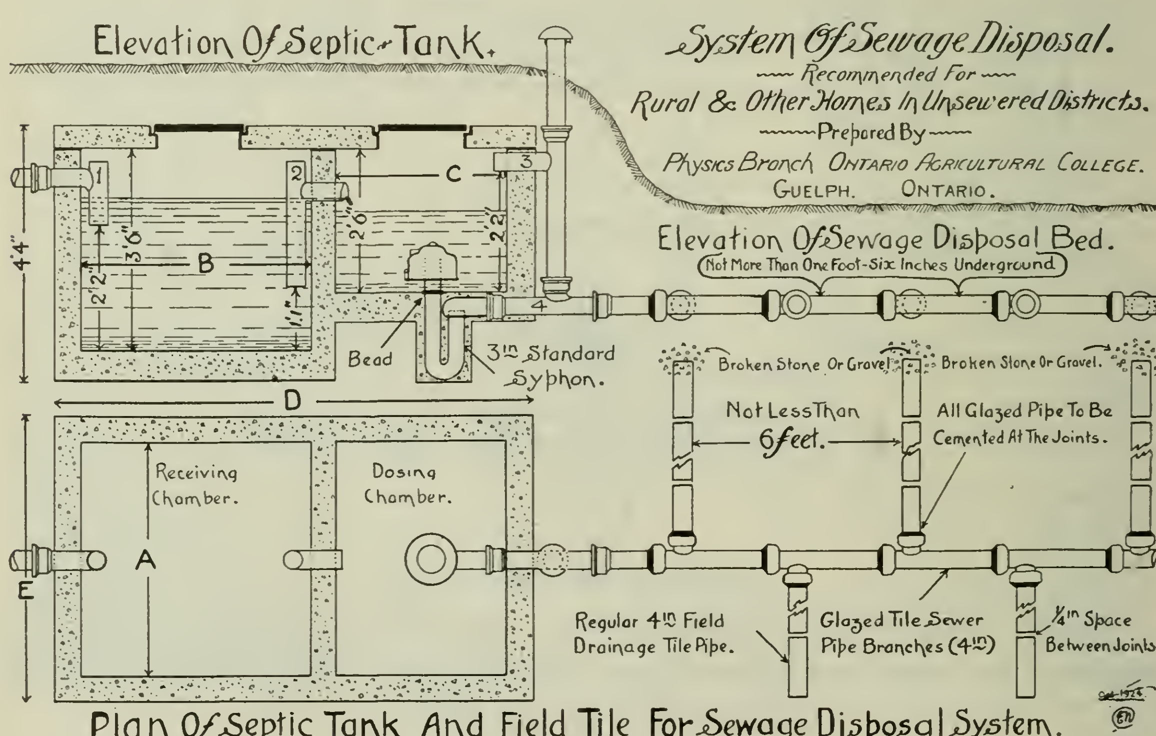
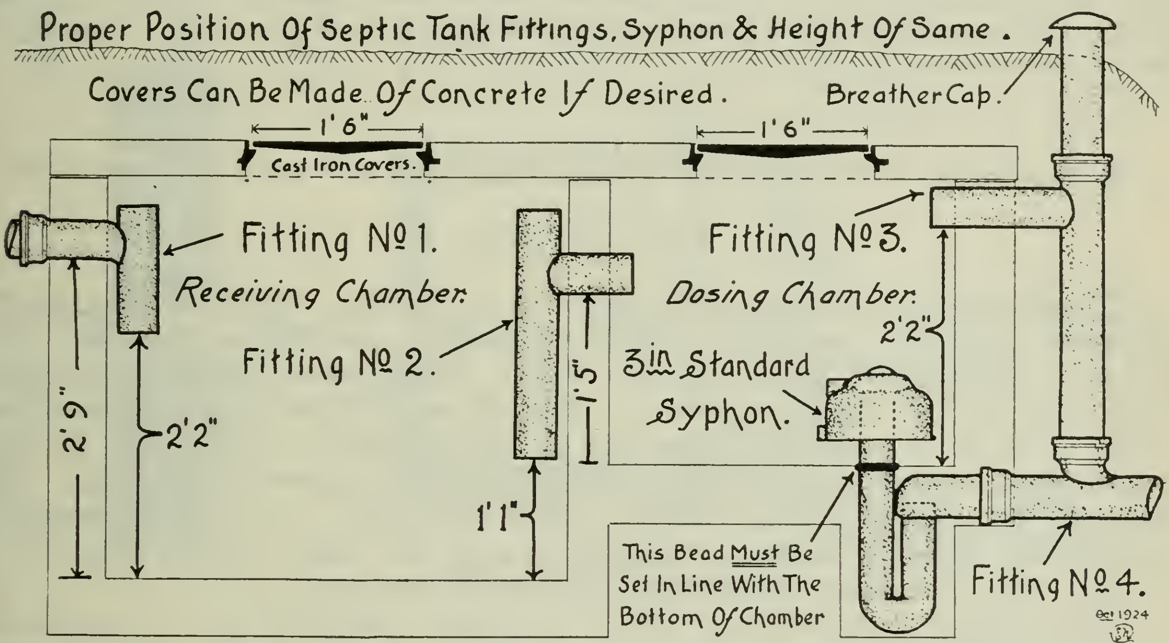


Fig. 51.

face of the floor. The entrance to the vertical tube of the siphon should be plugged to keep objects from falling into it during the construction of the system. After the forms have been removed, the interior surfaces should be plastered with rich cement mixture (one to one) to make tank water-tight. After this the top or cover is constructed with accommodation for two manholes. In the top of the partition wall there should be two or three openings to permit of air passing from one chamber to the other unless standard fittings as shown in Fig. 52 are used, when openings may be omitted.



Showing Exact Position Of Standard Septic Tank Syphon And Fittings Nos 1.2.3. And 4. Irrespective Of The Size Of Septic Tank — All These Fittings Are 4in Cast Iron Soil Pipe Size.

Fig. 52.

Construction of the Absorption Bed.

An area of ground about 25 feet by 50 feet is required for the bed or system of tile for the average-sized home. If the soil be very heavy or apt to become water-logged it should be tile-drained first by putting two parallel rows of three or four-inch tile at a depth of two and a half feet and joining them to a good outlet. The main line of tile of the absorption bed may run through the centre of the area or along one side. The branches should be four or six feet apart and not more than forty feet long, and the joints left about one-quarter inch open. The whole system should be practically level and not deeper than eighteen inches. The joints in the main should be well caulked with *oakum* but not cemented. Vitrified sewer pipe is used for the main, and four-inch field drainage tile for the branches. In heavy soil it will help to put a few inches of cinders, gravel or broken stone around the tile to assist drainage, as illustrated in Fig. 53, and always put plenty of small stones at ends of laterals.

The system of tile may be laid in terraced or sloping ground if necessary, but it is not a common occurrence. Diagrams for such a layout may be obtained upon application, if required.

Data Regarding Size and Construction of Double-Chamber System.

Number of Persons to Occupy House	A ft.	A in.	B ft.	B in.	C ft.	C in.	D ft.	D in.	E ft.	E in.	Lineal feet Field Tile 4 in.	Materials required using 1-2.4 Mixture: Sacks of Cement	Loads of Gravel
Four	3	6	4	0	3	0	8	4	4	6	150	16	3
Six	4	0	5	0	5	0	11	2	5	0	285	22	5
Eight	4	0	6	0	6	6	13	10	5	0	375	26	6
Ten	5	6	5	6	6	0	13	4	7	0	470	35	8
Twelve	6	6	6	6	6	6	14	10	8	0	605	58	12

Note.—Six-inch walls for the first three tanks and 8-inch walls for the last two.

Tank Fittings.

These parts comprise the siphon, the inlet, the overflow in the partition wall, and the ventilation pipe, all clearly shown in Fig. 52. The siphon is commonly known as the Miller design, and may be purchased from plumbers or hardware men. The other fittings may be assembled on the spot from pieces of four-inch cast-iron pipes, or they may be purchased as standard tank fittings similar to those shown in Fig. 52. The complete set, including the siphon, costs about $35. It is very essential to have all fittings correctly installed, and for this reason Fig. 52 is shown with all details and measurements emphasized.

The siphon empties the second chamber automatically when liquid gets about sixteen inches deep. It helps in keeping the tile system flushed out and ventilated and thereby making conditions in the soil more favourable for bacterial action. The U-part of the siphon should be filled with water, or primed, before the bell is set on. The breather shown in Fig. 52 may be omitted, a 90° elbow being used instead of a "T" in tting marked No. 3, Fig. 52, at the point where vertical pipe turns into tank.

Location.

The tank should be placed near the house, and preferably on the south or warm side. If convenient, it may be placed tight to the foundation wall, either endwise or sidewise, as shown in Fig. 50. If the system be properly installed there should be no odour from the tank. The tank should be easily accessible for the purpose of opening up or cleaning out when necessary. The top should be kept covered with about six inches of soil or turf.

The absorption bed may be laid under the flower or vegetable garden, the lawn or any convenient place near by. It should be kept away as far as possible from the water supply and roots of bushes and trees, and at least 15 to 20 ft. from the house.

Where to Begin in Laying Out the System.

The purpose of Fig. 50 is to show the connection of the system to the soil pipe in the house, on the one hand, and the lay of the land about the house, on the other. According to it, the depth of the trenches for the tile should be determined first of all; then the bottom of the excavation of the siphon chamber should be fixed a few inches higher; then if the fittings are placed at their proper positions, as shown in Fig. 52, the point where the soil pipe passes through the foundation wall is automatically determined. If the land is quite level, the tank when finished will project some above the ground level; if so, it will be necessary to bank it up and cover.

(b) The Single-Chamber Tank.

This system has only one chamber but usually there is a baffle wall or two inside of it to keep the contents of the tank as quiet as possible, thus promoting the sedimentation of the solids. The tank should be at least 4 ft. deep, and have a capacity of about 10 cu. ft. per person in the

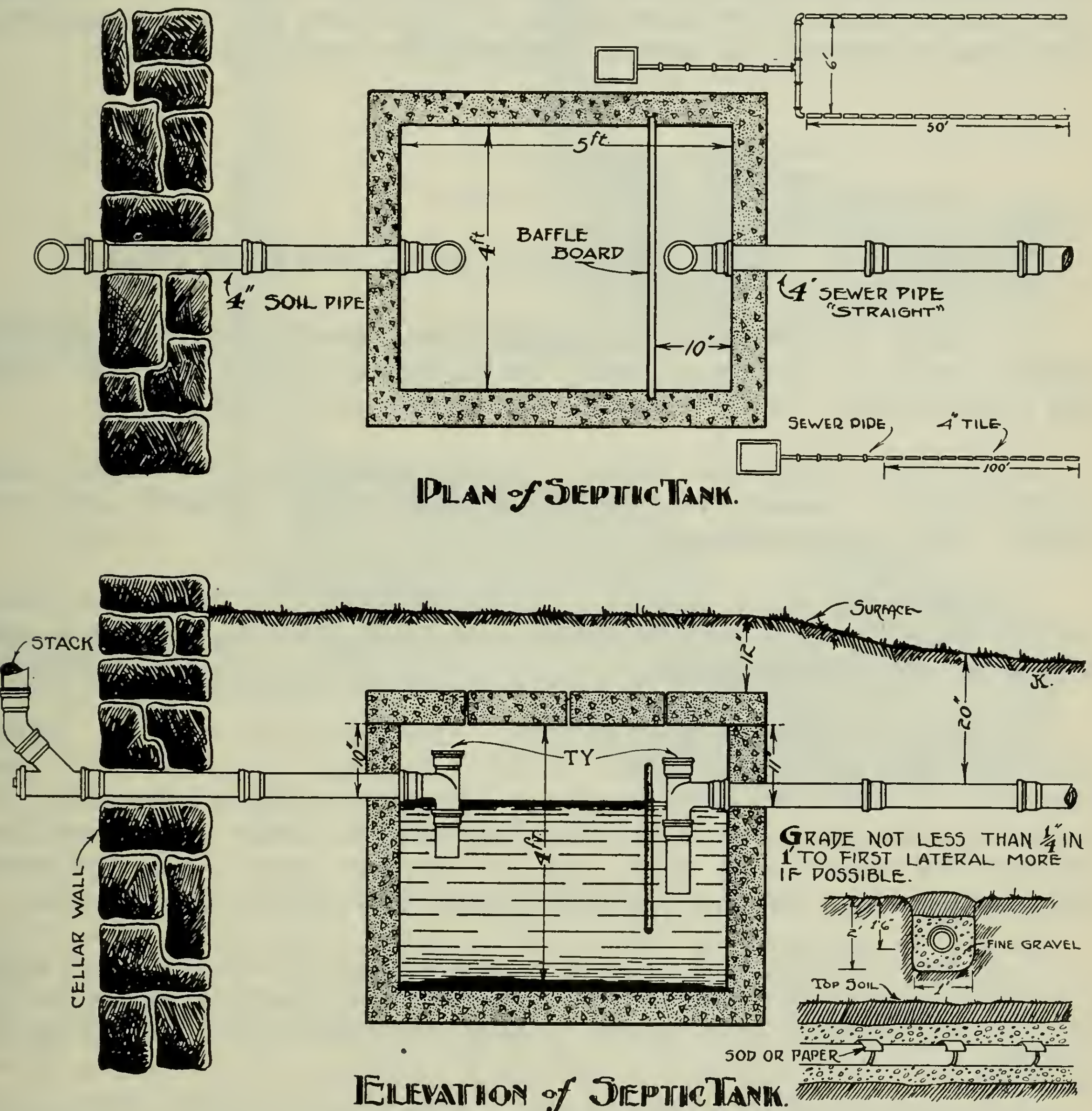


Fig. 53.—A Single-chamber Concrete Septic Tank.

home. Oblong is the best shape, and the length should be about 1½ times the width. The most durable and satisfactory construction is concrete.

The Department of Agricultural Engineering has designed a septic tank of this type for farm service, also built portable wooden forms or molds for building the tank and supplied the same to several of the Agricultural Representatives to lend free of charge to farmers wanting to build this tank. It has also prepared a special circular describing and illustrating the tank, and how to use the form. Each applicant for the form is supplied with this circular. The form can be transported in a motor car. If interested, telephone your Agricultural Representative or write the Department referred to above, at Guelph, Ont.

The advantages of this tank over the two-chamber one are that it is much simpler to construct and especially so when the ready-to-use form is available; and it is considerably cheaper. It has also good capacity, enough for 8 or 10 people, and if some care is taken to lay the tile in plenty of fine gravel or some porous material (See Fig. 53) the distribution of the overflow will be quite satisfactory. It is not claimed that the distribution is as good as in the siphon system, and in medium and large septic tanks where the effluent has to be distributed over a comparatively large area of ground, the siphon system is the proper one to use.

HOW TO AVOID TROUBLES WITH SEPTIC TANKS.

1. *Follow instructions and plans very carefully.* We have frequently found on inspecting septic tanks that they were not built right, and some trouble was the result of the neglect or oversight.

2. *Do not empty the laundry waste water into the septic tank.* Strong alkalies hinder the activity of the sewage bacteria and even destroy them in some cases.

3. *Build tank large enough.* It is safer to err on the side of building too large than too small a tank. Overloading a tank will soon cause a clogged system throughout.

4. *Proper design of tank fittings.* The inlet and overflow fittings should be designed and installed, as shown in Figs. 51 and 53. It is very important to have the inlet discharge below the surface, otherwise the contents of the tank are churned and agitated so badly that proper bacterial action cannot take place, and an overflow heavy with undigested material goes out into the tile system, and soon fills it up completely.

5. *Avoid placing field tile too close together at the joints.* Usually one-eighth inch is recommended, but a little more space is advisable. The joints need covering with paper to keep out the earth when filling the trenches.

6. *Lay tile in gravel.* In medium and heavy soils this is necessary, and the method is illustrated in Fig. 54.

7. *Lay tile at shallow depth*—not more than 16 or 18 inches.

8. *Use toilet disinfectants sparingly.* These chemicals are very injurious to sewage bacteria, and bad results are sure to follow a too lavish use of them. Use as little as possible, scatter in the bowl before retiring, scrub out in morning and flush out 2 or 3 times with water.

GREASE TRAPS FOR KITCHEN AND LAUNDRY WASTE WATER.

In farm kitchens there are large quantities of waste water to be disposed of daily in some way or another. In homes equipped with septic tank or cesspool these wastes may be discharged into them, although there is some objection to this practice, in the case of the wash water for the reason that it contains much strong alkali material which is injuri-

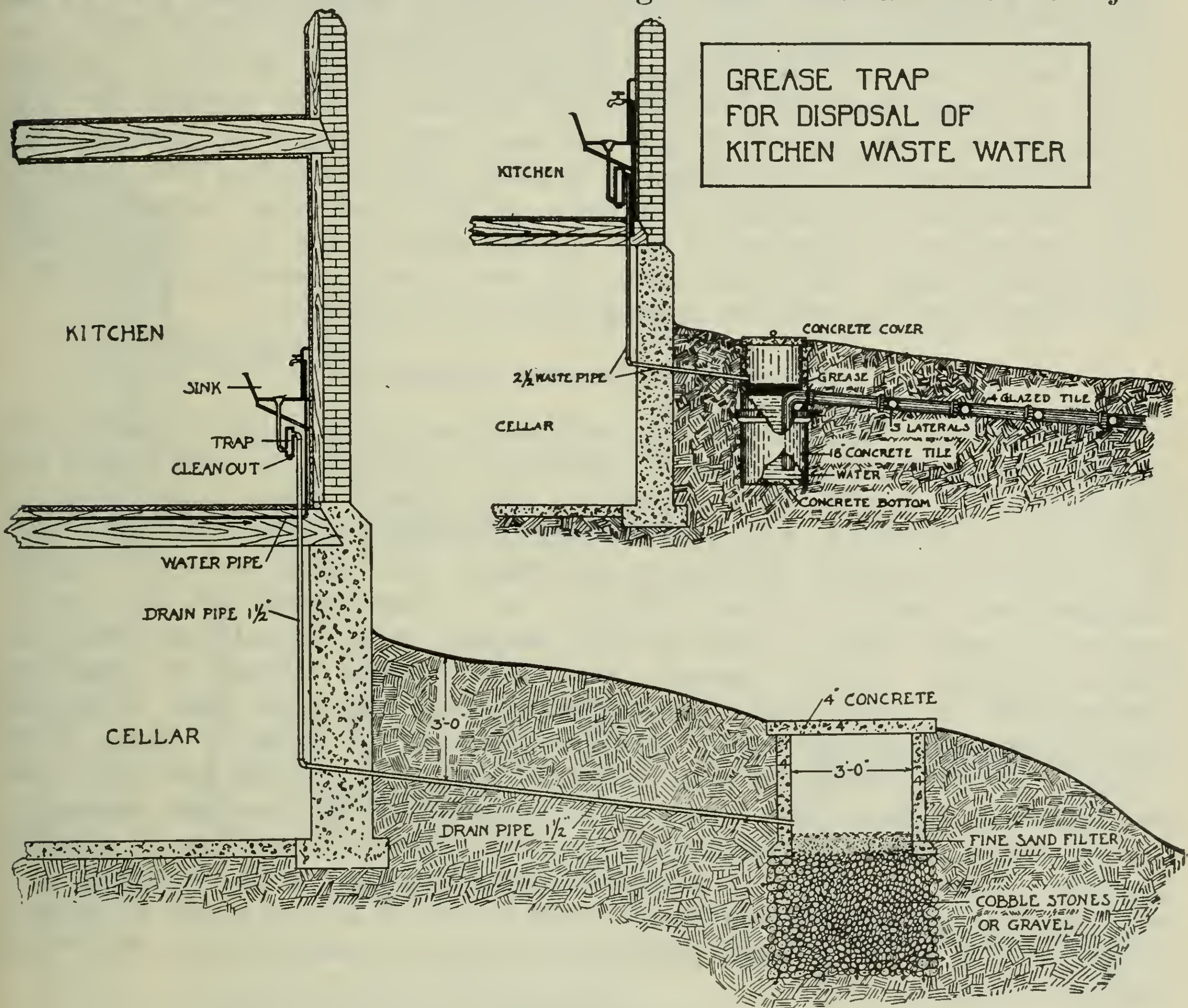


Fig. 54.—Two types of grease trap for disposal of kitchen waste water.

ous to the sewage bacteria both in the tanks and in the soil. For homes without septic tanks these forms of waste may be disposed of in a convenient and sanitary manner in a grease trap or miniature cesspool, two types of which are illustrated in Fig. 54. The upper type is best adapted to heavy soils, and it will be necessary in this case to install a small absorption bed of thirty or forty three-inch or four-inch drain tile on the same principle as for a septic tank. The trap may be located close to the cellar wall and the tile ten or more feet away. The lower type is adapted to light, gravelly soil or any soil with a very porous subsoil well drained. It should be built fifteen or twenty feet away from the house. The top of the trap in either case should be strong, tight fitting and removable in order that the trap may be readily accessible at any time for cleaning out the accumulation of grease and sediment whenever necessary. Neither one of these types is difficult or expensive to construct and their installation at any farm home not having sewage disposal systems would aid materially in making conditions tidy and sanitary about the back door.

THE CESSPOOL.

Before the advent of the septic tank the cesspool was the only method of sewage disposal for farm homes equipped with plumbing fixtures. In its original and simplest form it was a hole in the ground eight to ten feet deep and four to six feet in diameter, lined up with field stone and safely covered with timbers, plank and earth. Into this pit the sewage was discharged through the inlet pipe and partly decomposed, and in the liquid form slowly seeped away in the surrounding soil. As it was a frequent occurrence for this form of cesspool to overflow, the idea was conceived of improving it by building an enclosed trough around the edge of the pit near the top of the ground and connecting it to rows of field tile, radiating out like the spokes of a wheel, and the liquid was conveyed from the pit to this trough by a three or four-inch pipe between them and turning down a foot or so into the contents of the pit. This is some improvement upon the older form, but not much unless the pit itself is made water-tight to prevent seepage into the soil below.

Objections to the Cesspool.

One serious objection to the cesspool has already been referred to, namely, its overflowing. This condition may be due to a very heavy and poorly drained subsoil, or too small a pit, or both. The installation of tile already referred to will prevent this trouble for a while, but they soon fill up by the constant dribbling into them of liquid and fine solids. Another bad feature is that well may be contaminated by the underground seepage from it, and as this seepage may be carried great distances through small channels and the various forms of passages through the soil and rocks below the surface there is ever a lurking danger not only to the water supplies near-by but even to those more remote. If the subsoil be very gravelly and well drained and one could be absolutely certain that there was no chance of the seepage endangering the water supply or reappearing somewhere at the surface as a public nuisance, there could be no serious objection taken to the building of a cesspool, but as the possibilities of trouble with it are so great we cannot recommend it to the general public as a safe and satisfactory method of sewage disposal.

CHEMICAL CLOSETS.

Where there is no running water in the house, and an inside closet is desired, the chemical closet in some form must be used. The two common types are illustrated in Fig. 55 (*a*) and (*b*) Briefly described the chemical closet consists of a receptacle of metal or wood to hold the sewage and a chemical added from time to time to destroy the sewage. The small type shown in Fig. 55 (*b*) is a very simple affair, as may be seen by the figure, and is adaptable for setting up in any convenient place in the home where a vent pipe to the outside can be accommodated. It needs frequent emptying and charging with chemicals, say about once a week, if satisfactory results are to be realized. This kind is quite cheap, about $10 to $15, the price depending upon the size and design.

The design shown in Fig. 56 (*a*) is newer somewhat, more elaborate and costly, but it is very efficient. It is made in a great range of sizes, from that suitable for a private home to large institutions like schools, hospitals, camps, etc. It consists of a metal tank, a nicely designed closet bowl, drop tube and ventilating pipe, and usually an agitator in the tank for mixing up the sewage and chemical. For a house of average size, the tank has a capacity of 125 gallons, and the cost of the complete outfit is in the neighbourhood of $100. This type does not need much attention, the regular thirty-pound charge of chemical being sufficient to sterilize 125 gallons of sewage. Occasionally the sludge has to be removed from the tank.

The Department of Agricultural Engineering will be glad to supply further information regarding chemical closets, particularly in regard to different makes, names of firms selling them, etc.

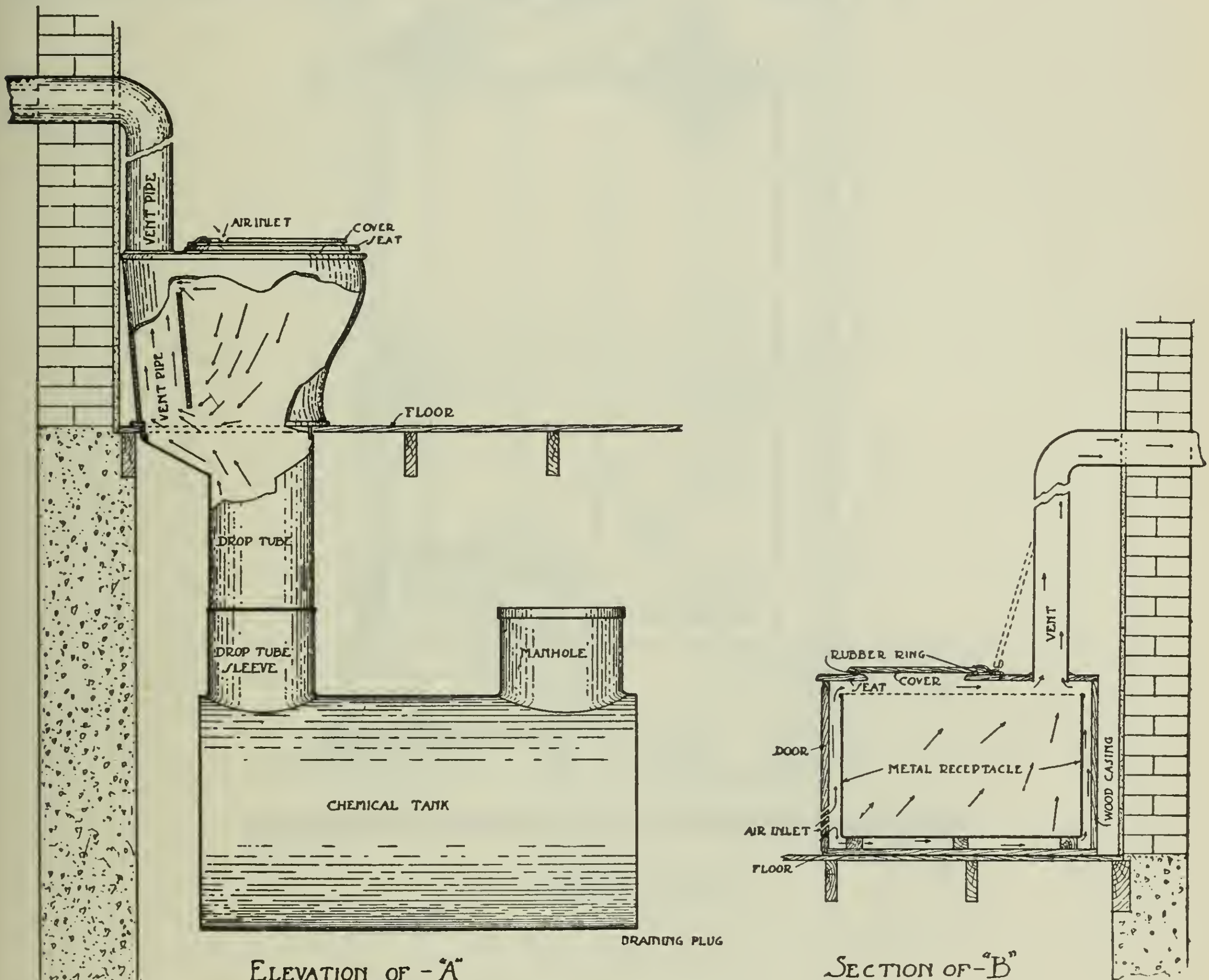


Fig. 55.—Two types of chemical closets.

TYPES OF OUTSIDE PRIVIES.

The two most satisfactory types of outside privies are illustrated in Figs. 56 and 57. The chief difference between them is in the kind of receptacle used; in the former it is a pail or box, while the latter an underground watertight vault. These designs are recommended by the Provincial Board of Health, Parliament Buildings, Toronto, and a full treatment of the subject is given in their circular No. 9, entitled "Rural and Semi-Urban Sanitation," which may be had on application to them. As the accompanying figures give all the details and measurements no further description is necessary.

In order to make these privies as sanitary as possible they should be built fly-proof and screens put in the door and on opposite sides, as shown in the drawings, for purpose of ventilation. The receptacles should be cleaned out often and they should be disinfected each time with chloride of lime, and dry ashes may be used regularly on the contents of the receptacle or vault with good results. If the privy is built and attended to as herein specified it may be located quite close to the house, preferably inside or

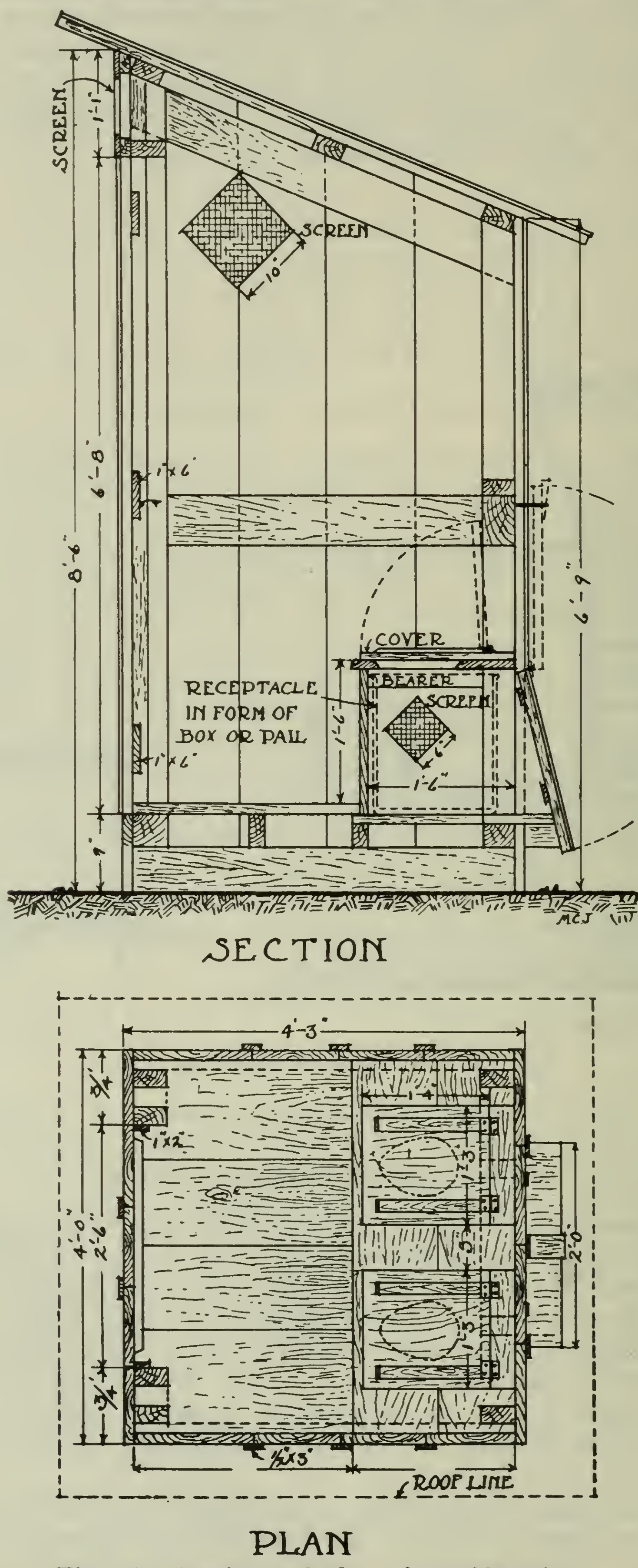


Fig. 56.—Section and plan of outside privy.

attached to the woodshed to avoid undue weather exposure to those using it. The purposes of the waterproof underground vault are threefold: to prevent the seepage of contamination underground to the well, to increase the storage capacity for sewage and make less frequent cleaning possible, and, lastly, to keep out flies.

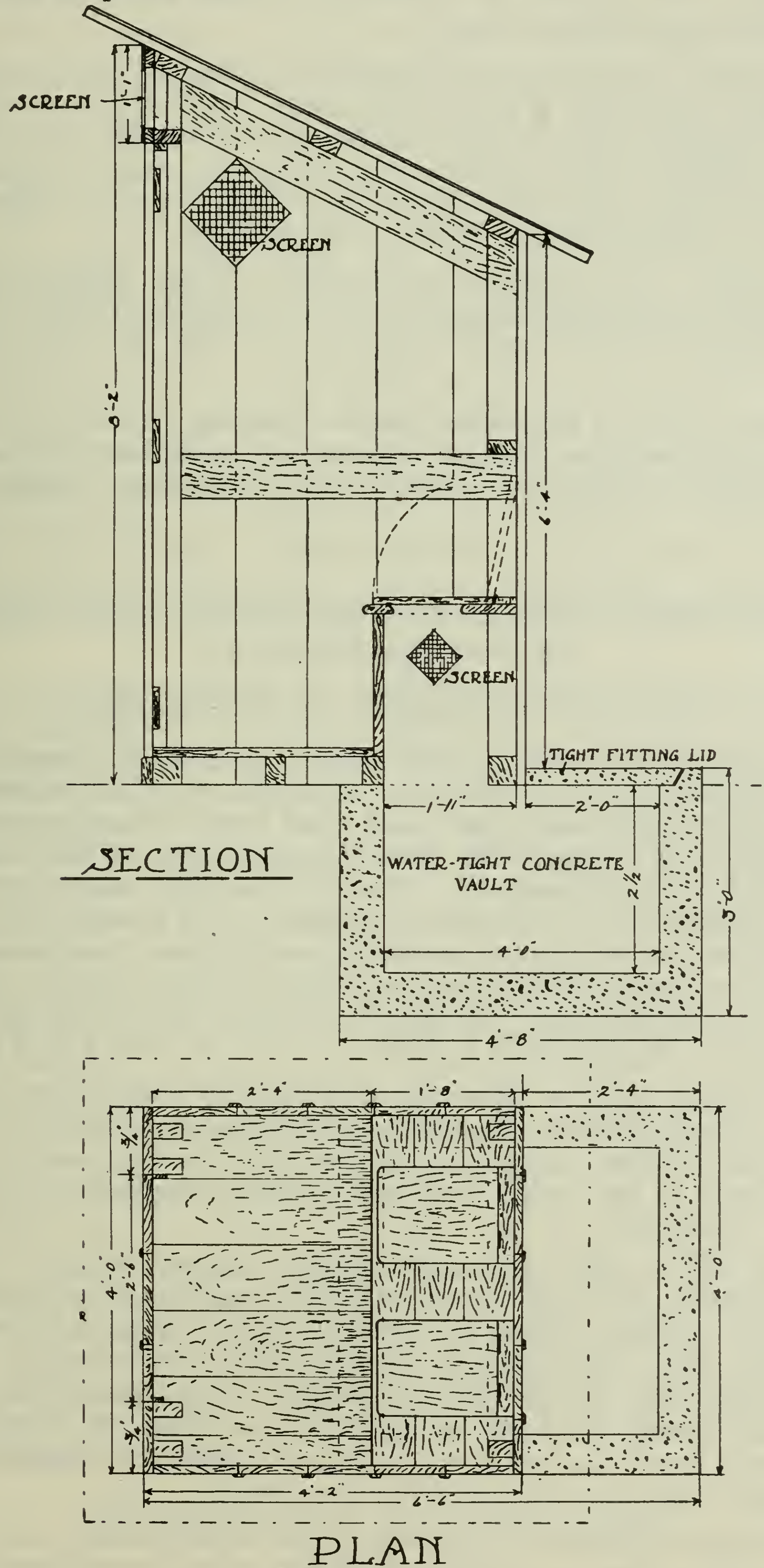


Fig. 57.—Section and plan of outside privy.

SEWAGE DISPOSAL IN RELATION TO PUBLIC WATER SUPPLY.

Those who intend to install sewage systems should bear in mind carefully the fact that our water supplies are protected by law against sewage contamination. The articles in The Public Health Act that pertain to this case are given herewith as follows:

"*Article 90.*—The Provincial Board shall have the general supervision of all springs, wells, ponds, lakes, streams or rivers used as a source for a public water supply with reference to their purity together with the waters feeding the same, and shall examine the same from time to time when the necessity for such examination arises, and inquire what, if any, pollution exists and the causes thereof. 2 Geo. V, c. 58, s. 90.

"*Article 91.*—(1) No garbage, excreta, manure, vegetable or animal matter or filth shall be discharged into or be deposited in any of the lakes, rivers, streams or other waters in Ontario or on the shores or banks thereof."

Therefore it is the duty of all parties putting in any form of sewage disposal systems to strictly guard against any possibility of them directly or indirectly contaminating the sources of public water supply.

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8. BACTERIAL ACTION IN THE SEPTIC TANK SYSTEM OF SEWAGE DISPOSAL.

D. H. JONES, PROFESSOR OF BACTERIOLOGY.

The private house septic tank system of sewage disposal may be considered to consist of four sections. First, there is the collecting system composed of the toilet basin, bath and wash basins (laundry water should not be allowed in) ; second, the first compartment of the septic tank, known as the settling chamber; third, the second compartment of the septic tank, known as the discharge chamber, and fourth, the sub-irrigation tile system into which the sewage from the tank is discharged. Bacterial action in these various sections differs to some extent and is very marked in all but the first. To gain an idea of what bacteria are, their nature, size, etc., the reader is referred to Fig. 58, Nos. 1, 2, 3 and 4.

Crude sewage consists of water, plus organic and mineral solids, both in suspension and solution. Purification of the sewage implies the removal or destruction of these organic and mineral substances, leaving an effluent of pure water. In the septic tank system this purification is induced by the bacteria present.

Sewage has a very rich and complex bacterial flora. It contains millions of bacteria in every cubic centimeter, and many species are represented in this number. When the action of these bacteria is properly controlled, it results in the complete purification of the sewage. The septic tank system has been devised for the purpose of adequately controlling the action of the sewage bacteria to the end, first, that the sewage may be purified, and, second, that as much manurial value as is possible under the circumstances may be obtained from the sewage.

The bacteria responsible for this purification process may be divided into three main groups, according to their oxygen requirements: First, the anaerobic bacteria; second, the aerobic; and, third, the faculative bacteria. The anaerobic bacteria are those species which are active only in the absence of oxygen; the aerobic bacteria are those which are active only when oxygen is present, and the facultative bacteria are those species which are active either in the presence or absence of oxygen.

The settling chamber of the septic tank remains always full. As the sewage enters this chamber at one end the heavier solids settle to the bottom and the excess liquid from the tank passes over into the discharge chamber at the other end. The bacterial action which takes place in the settling chamber is mostly due to the action of the anaerobic species of bacteria which find favourable conditions for their work in the lower depths of the sewage, where free oxygen is not present. Here they accumulate in large numbers and their work consists mostly in reducing or partially breaking down or digesting, by extraction of oxygen, the complex organic matter present in the solids, changing it to simpler and soluble substances which are then ready to pass over in liquid form into the discharge chamber. In this action, gases such as carbon dioxide and hydrogen sulphide are produced, which bubble up through the liquid. In the surface layers of this chamber the aerobic and faculative species of bacteria are also active, to some extent, as oxygen is there available. Their action results in a digestive process, mostly by oxidation of the organic materials present. As a result of their activities in the surface layers using up the oxygen that is present, they ensure strict absence of air in the lower depths, thus making ideal conditions for the anaerobic bacteria.

In the discharge chamber the bacterial action is not so decided as in the settling chamber, for the simple reason that the oxygen requirements are not at the maximum and the contents of this chamber are discharged once or twice daily. Nevertheless, bacterial action is progressing constantly in the sewage of this tank as it slowly increases in volume to the time when it is discharged. The classes most prominent in this chamber are the aerobic and facultative bacteria. Their action is a further breaking down or digesting by oxidation of the organic material still present in the sewage, both in soluble condition and also solids in suspension.

As soon as the contents of the tank are discharged into the sub-irritation tile system, the liquid is slowly absorbed by the soil around the tiles and by capillary action a film of the liquid covers the individual soil particles, and through this thin film the oxygen of the soil air is readily available to the bacteria in the film, enabling them to complete their action in breaking down the complex organic substances still remaining. Then, the nitrifying bacteria and others, some of which are in the sewage, but more of which are in the soil, recombine the elements and simple comuounds thus formed into fresh compounds, as nitrates, which may then be utilized by growing plants. In this way much of the manurial value of the sewage is reclaimed in the soil and the drainage water from such soil, if there is any, should be relatively, if not absolutely, pure, providing the system is working properly. Needless to say the tile system should not be allowed to clog up and the soil surrounding it should be more or less porous and not heavy clay.

Bacterial Action in the Dry Closet.

The satisfactory disposal of human excreta is frequently a troublesome problem both in individual houses in the country and in dense town or city communities. The excreta contains considerable manurial value, as it is composed almost entirely of organic material in process of decay. It contains millions of bacteria to the ounce and it is the activities of these bacteria that are responsible for its putrefaction and decay. If allowed to accumulate as in dry closets or outhouses, it becomes a decided nuisance with objectionable odours and serves as a breeding place for flies and other insects. If these closets were kept clean, the contents being removed weekly and buried six inches to a foot beneath the surface of the soil in field or garden, the nuisance would not occur. When the excrement is allowed to accumulate, the action of the various anaerobic species of bacteria within the mass results in the production of the strong smelling gasses, whereas if it is not allowed to accumulate but is buried in small quantities just beneath the surface of the soil, the aerobic species of bacteria bring about its decay without the production of the strong odours and its manurial value is recovered in the soil.

Bacterial Action in Cesspools.

In the cesspool, sewage is not thoroughly purified, as the bacterial action is incomplete, being mostly anaerobic and very similar to that in the settling chamber of the septic tank. As the walls of the cesspool are permeable to water, the sewage soaks away directly into the surrounding subsoil. When this becomes water-logged the sewage rises more or less to the surface, thus becoming a nuisance, giving foul odours and bogginess. As the bacterial action in the cesspool is mostly, if not altogether anaerobic, the decomposition of the sewage is only partial. If the surrounding soil is fairly porous and does not become waterlogged, there will be some aerobic bacterial action in the upper layers of the soil which will tend to purify the sewage should it reach those upper layers. But this action cannot be regulated or depended on and the drainage water from such soil is liable to be heavily contaminated with undesirable sewage bacteria with sewage only partially purified. Hence wells should never be located near a cesspool.

Description of Fig. 58.

1. *Bacillus fluorescens,* fairly common in well water.
2. *Bacillus subtilis* (hay bacillus), common on hay and in the soil; occasionally found in well water.
3. *Bacillus coli,* common in sewage and in polluted water; the danger signal in water examination.
4. *Bacillus typhosus*—showing flagella. Cause of typhoid fever.
5. Flask of culture media, test-tube cultures, inoculating needles, petri dish cultures, high power microscope. (Edwards.)

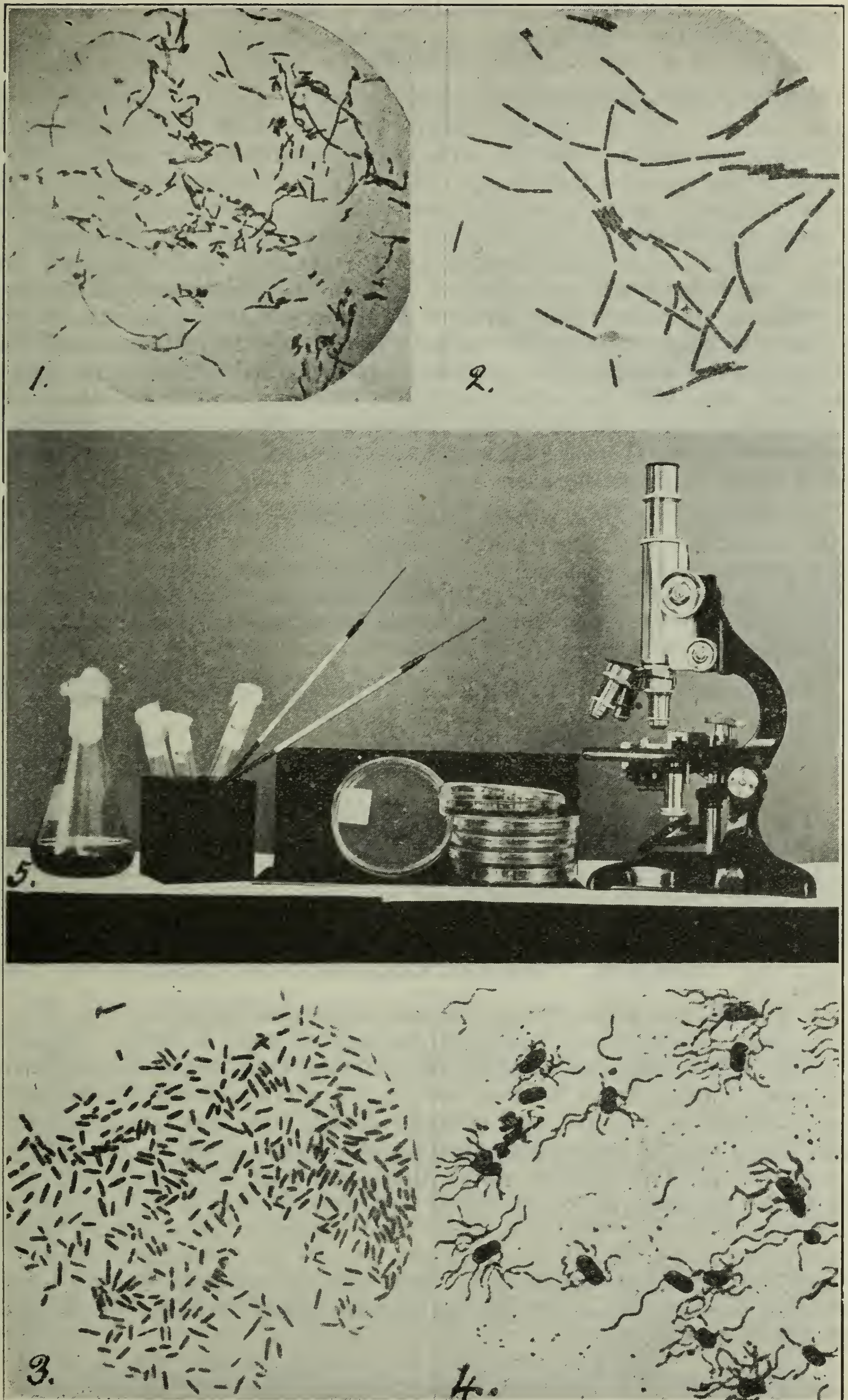

Fig. 58.

BACTERIA AND THE WATER SUPPLY.

D. H. Jones.

Bacteria are microscopical plants. They are the smallest living things known. They average about 1/5,000 of an inch in length and 1/15,000 of an inch in breadth. They are invisible except when viewed through a high power microscope, hence the term microscopical. They are very simple in structure, being unincellular. In shape some are spherical, some are straight rods, and some are spiral. See Fig. 58, Nos. 1, 2, 3 and 4. Under favourable conditions for growth they multiply very rapidly. One bacterium may have a progeny of from ten millions to fifteen millions in twenty-four hours. They occur in large numbers wherever man, animal or plant life exists. There are many species of them, the majority of which are beneficial, but some species, however, are injurious. Amongst the latter are those which cause most of the infectious diseases of man and animals. Sometimes these injurious species get into the water supply and as a result an epidemic of infectious disease, as typhoid fever, is liable to occur.

All natural drinking waters, such as rivers, ponds, lakes, wells, etc., usually contain many species of bacteria. Other micro-organisms, such as algæ, diatoms and crustacea are also likely to be present. Some of the bacteria may be harmful to health, being liable to cause disease, but many of them are not. It is the presence of these dangerous species in the water supply that has to be guarded against.

The species of bacteria found in drinking waters are divided into three more or less distinct groups, as follows:

Group I. Natural Water Bacteria.

This group includes a number of species of bacteria which are not harmful to health. They are liable to develop and multiply in water in which there is a minimum of organic matter, but as they cannot cause disease their presence is not sufficient to condemn the water for drinking purposes.

Group II. Soil Bacteria Found in Water.

In the soil there are many different species of bacteria. See Fig. 58, Nos. 1 and 2. One ounce of soil will contain millions of them. These find their way into rivers, lakes, wells, etc., during rains, particularly at flood time, being washed from the soil both in the surface and drainage waters. These bacteria do not live and multiply in the water to any great extent unless there is a considerable amount of organic matter present in it. They do not produce disease, hence their presence alone in water is not sufficient to condemn it for drinking purposes, though if they are present in any quantity they indicate either that there is considerable organic matter present, or that there is danger of the water being polluted from soil surface washings, which may have been contaminated with disease-producing bacteria coming from infected persons. Neither of these conditions is desirable.

Group III. Intestinal Bacteria Found in Water.

In the intestines of man and animals there are certain species of bacteria, particularly *Bacillus coli,* normally present in very large numbers. See Fig. 58, No. 3. These are passed out by the million in the bowel discharges, so that when the water supply becomes contaminated with sewage from cesspools, drains, or seepage, there will be many contaminating bacteria present in the water. These bacteria do not multiply to any great extent in natural waters as the food and temperature conditions of the water are not usually suitable for their multiplication.

Thus, when *Bacillus coli* or any other species of intestinal bacteria is found in water, it is an indication that the water has been recently polluted and may be dangerous. *Bacillus coli* itself is not, except under certain conditions, a disease-producing bacillus, but wherever it is found in water there is danger of *Bacillus typhosus* (Fig. 58, No. 4), which causes typhoid fever, being present. Many outbreaks of typhoid fever are due to the water supply being polluted with the discharges from either a typhoid patient or typhoid "carrier." A typhoid carrier is one who has had typhoid fever and has got better, but has not got rid of the typhoid bacteria from his system. Within his system the bacteria are constantly developing and being discharged in the urine and fæces. Water, milk, or any kind of food that becomes contaminated from such discharges is liable to establish typhoid fever in those consuming the food. Hence, great care is necessary to prevent water and foods from being so contaminated.

Shallow or dug wells are very liable to such contamination unless they are properly located and constructed. They should be so located that surface drainage cannot find entrance and the upper ten or twelve feet of the wall should be impervious to water, thereby forcing all water that enters the well to filter through soil to a depth of at least ten or twelve feet, a process which aids in purifying it.

When wells have become polluted from unsanitary seepage or drainage the cause should be found and removed and preventive measures taken so that the trouble should not recur.

The water so polluted should be sterilized, that is, should have all the bacteria killed before being used for drinking purposes. Sterilization may be accomplished either by boiling the water or by the addition of a suitable disinfectant. The disinfectant most suitable for this purpose is a hypochlorite solution. This hypochlorite solution may be prepared and applied as follows:

Stock Hypochlorite for Water Purification.

1. Mix ½ pound of chloride of lime (33 per cent. available chlorine) with 1 pint of water.

2. Then add sufficient water to make 1 gallon.

3. Dissolve 13 oz. of sal soda crystals in 2 quarts of lukewarm water.

4. Add sufficient water to make 1 gallon.

5. Mix these two solutions in a barrel or crock and allow the milky solution to settle over night.

6. Pour off the clear liquid from the white sediment into a jug and fill into bottles, well stoppered, and keep cool in a dark place. This "stock hypochlorite" will contain approximately the equivalent of three per cent. of chloride of lime or one per cent. of available chlorine.

Application. Mix one ounce of this stock solution to five gallons of water that is to be used for drinking purposes. After mixing, allow to stand for half an hour before use.

The solution may be added in small quantities to water after it has been drawn from the well or the quantity of water may be estimated and the necessary amount of solution poured direct into the well and stirred in.

Free Bacteriological Tests Made.

Farm well waters suspected of being polluted will be tested upon application to the Bacteriological Laboratory, Ontario Agricultural College.

Taking a Sample of Well Water for Bacterial Analysis.

In procuring samples of water for bacterial analysis great care must be taken that they be not contaminated by bacteria from the hand, clothing, etc. To this end full directions for sampling are given in Appendix 4, and they should be followed in every detail. Also full information about the well should accompany the sample. Forms as outlined in Appendix 3 will be supplied on application to the Department of Agricultural Engineering, O.A.C., Guelph.

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9. CHEMISTRY OF THE FARM WATER SUPPLY.

H. L. Fulmer, Associate Professor of Chemistry.

Water is a thing with which we are all very familiar, it being one of the most widely found and used of naturally occurring substances. It exists everywhere—in the air; in the soil; in animals and plants where it makes up, on the average, three quarters of the total weight; in milk, which is composed of eighty-seven per cent. of water; and, of course, it is best known as the liquid found flowing in our streams and found filling our lakes and oceans. We know it as the fluid which falls as rain and dew; as the solid which in cold weather locks up our ponds, lakes and rivers and blocks our roads and highways; as the vapour which composes fogs, mists and clouds, and which issues from the tea kettle and the steam engine in the form of what we call steam. It ordinarily exists as a fluid but at temperatures below 32° Fah. (0° C.) it occurs solid as ice, hail, sleet or snow, and at temperatures above 212° Fah. (100° C.) it is found in the form of vapour (steam). It is one of the most useful of Nature's gifts and at the same time one of the most destructive.

Chemically, water is composed of a combination of the two gases, Oxygen and Hydrogen. The former makes up 22 per cent. of our atmosphere and is the supporter of the life of plants and animals, of fire and decay; the latter is not found uncombined in nature but can be easily liberated from some of its combinations and is then used for filling balloons, dirigibles and such like because of its extreme lightness, and for producing high temperatures by burning. Hydrogen easily takes fire, and when mixed with air forms an extremely high explosive and for these reasons has to be handled very carefully. When these two gases are made to combine chemically, water is the substance we get as the result. Chemists refer to it as H_2O, a symbol which imparts the information that it is composed of the two substances above mentioned, (H)ydrogen and (O)xygen, and in the proportion of two parts of the former to one part of the latter.

It is the liquid form of water with which most of us are chiefly concerned, and it is only this form of it with which we will here deal. The solid form (ice) is important to the cold storage man and others; and the vapour form (steam) to the engineer and men in like industries, but these two states of water are of comparatively minor importance to most of us.

Water is Seldom Pure.

Liquid water, as it occurs under natural conditions is seldom, if ever, pure. It nearly always has various things absorbed in it, either dissolved or suspended, and it is the presence of these "impurities" which lends prime concern to our water supply. For, according to the character of the absorbed substances, water is often rendered unsuitable for use, sometimes for drinking, sometimes for cooking, sometimes for washing and laundry work, sometimes for boiler use, and sometimes also for various other purposes. Often, however, on the other hand, substances are found in water which impart to it desirable qualities or properties which render it of use for special purposes not fulfilled by pure water. An example of the latter are the mineral waters used at the various spas and other similar health resorts.

How Water Becomes Impure.

About the only source of *nearly pure* water we have is that which one can get by catching in a clean vessel rain falling at the end of a heavy shower, or that obtained by melting clean snow or by condensing clean steam in clean containers. Water, the moment it comes into contact with anything whatsoever—air, soil, rocks, containers,—immediately begins to absorb more or less of all those substances which it touches. If it flows over or through limestone rock it becomes heavily charged with dissolved limestone; if it comes into contact with peaty soil, it becomes heavily impregnated with dissolved and suspended dead plant and animal remains (organic matter); if it comes into contact with salt, it becomes salty; if it rambles through oily rocks or soils, it assumes an oily taste and smell; if it gets associated with certain sulphur formations as it moves about it becomes a sulphur water; if it goes through soils rich in soluble sodium and potassium mineral salts, it becomes an "alkali" water; and so on. This is all due to the fact that water is a liquid and thus can move over and through everything at the same or a lower level and that it is a powerful disintegrator and a universal and potent solvent.

Impurities Found in Water.

Impurities, or those constituents found in solution or in suspension in water are of two classes, namely:

(a) Organic impurities.

(b) Inorganic impurities.

(a) Organic impurities, or in other words, the dead remains of plants and animals or their excretions, and the products of the decay of these, are the most dangerous ones with which water can be contaminated. Not only have many of these bodies the power, when taken into the alimentary tract of animals and man, to produce grave digestive and other disorders; but what is probably more important, their presence in water is invariably a sign of the presence of numerous kinds of bacteria which feed upon them.

In addition to the above objections, the presence of organic matter in water very frequently discolours it and gives it a forbidding appearance; or imparts to it a bad odour or nasty taste. This is what happens when large quantities of raw sewage, barnyard drainage, or seepage from peaty swamps get into the water. Furthermore, such water is hard on utensils in which it is stored or boiled; causes frothing, incrustation and corrosion in steam boilers; and attacks destructively all metals with which it comes in contact.

Detection of Organic Matter.—The presence of organic matter is not always made evident by the mere colour or odour or taste of the water —sometimes the clearest and brightest of waters, one that is palatable and sparking, may be dangerously polluted. It is never wise, therefore, to depend upon appearance—a chemical examination should always be made. Such an examination in all its detail is not easy or simple, but useful information can be obtained by the following tests:

1. Pour half a pint of water to be tested into a wide-mouthed bottle or decanter which has been thoroughly washed and scalded with clean, boiling water; close it with the palm of the hand, or better, with a glass stopper, and shake it violently up and down. If an offensive odour is then perceived on immediately removing the hand or stopper, the water is probably contaminated with sewage, or other forms of decaying or decayed organic matter.

2. To a little water in an absolutely clean glass vessel add a drop or two of sulphuric acid, and enough permanganate of potash solution to tinge it to a faint rose colour; cover the vessel with a saucer or glass plate and let stand. If the pink tinge is still visible after a quarter of an hour, the water is probably free of organic matter. If the colour disappears or lessens the water is probably contaminated.

3. Pour a little solution of silver nitrate and a few drops of nitric acid into a carefully cleaned and dry glass. See that it remains clear (if not, the glass is not properly cleaned) ; then pour in some of the water. Should a strong milkiness appear, the water is probably contaminated with sewage. This test is not conclusive in proximity of salt wells or in the vicinity of the ocean where the water may be influenced by spray or seepage from the sea.

The above three tests are only useful for determining whether or not it is advisable to have a more elaborate or costly analysis made by a skilled chemist.

If the water is found to be contaminated with organic matter then an inspection should be made to find, if possible, the source. Most organically impure waters are so because of some preventable factor, such as seepage from barnyard or outhouse, or such like, and if this is located and remedied, the water then becomes pure. It occasionally happens, however, that a water is bad because at some time or other before it reaches the point from which it is drawn by the user, it has to pass through some naturally infested location such as a swamp or some other place possessing a mass of dead and decaying organic matter. In such circumstances it is necessary to locate a source of supply elsewhere.

How to Purify a Water of Organic Matter. If the water is not too badly infected with organic matter it can often be sufficiently purified in small quantities to make it usable. On the large scale, however, it can only be economically handled by large corporations, such as cities, or towns, or other governments.

One of the simplest methods of purification is to boil the water for a short time. This will kill bacteria, drive off bad odours due to any sewage gases that may be present, and render somewhat inert, physiologically, the small amount of partially decayed organic matter.

In case the water is coloured this treatment will not clarify it, if the colour is due entirely to organic matter (or to suspended particles of soil, iron, etc.). Under such circumstances, in addition to being boiled, the water would have to be passed through a filter composed of a considerable depth of alternate layers of good clean, sharp sand, gravel and charcoal. This filter would have to be re-charged frequently with fresh sand, gravel and charcoal, or with some of these that have been previously used and then afterwards thoroughly renovated and cleansed by spreading out in the air and sun or by baking in an oven.

Another method of purification is by the use of chemicals. The most satisfactory one is chloride of lime, provided it is fresh and of good quality (33 per cent. available chlorine) and used in sufficient quantity. The method of using this substance is to be found on page 75 of this bulletin and need not be repeated here. This treatment gives the water an odour of chlorine at first, but this finally passes off on standing or can be largely removed by boiling for a few minutes. It also destroys the colouring in the water (if the latter be due to organic matter and is not present in too large quantities), and thus makes it unnecessary to filter if there is no sediment.

The best plan, however, in cases of organic impurity, is to remove the cause, if it can be found and is removable, or, as before stated, if the cause is not removable, to locate a new water supply.

(b) Inorganic impurities or those derived from the mineral constituents of the soil and rocks, are seldom particularly objectionable or dangerous unless present in large quantity. Sometimes poisonous minerals are to be found in water, such as lead and copper, and even iron, usually because of lead, copper or iron pipes, etc., through which the water has passed; sometimes sufficient mineral is present to give the water a decidedly salty or brackish taste, i.e., salt water and alkali water; but very seldom, under average conditions, does water contain sufficient mineral of any kind to make it unfit or objectionable for drinking purposes by man or beast.

The chief objections to inorganic impurities are that the water is made "hard" by certain of them, most frequently the lime and magnesium salts, and often quite unfit for cleansing where soap is used, cooking some kinds of vegetables, laundry work, or boiler use; also unsatisfactory for many industrial purposes, such as the retting of flax; and sometimes destructive to metal pump connections and other metal parts coming in contact with it for any length of time.

Detection of Hardness. The detection of hardness in water is a simple matter. Hard water does not form a lather readily with soap, but, instead, produces a sticky, curdy substance which adheres to the hands or clothes washed in it with soap. Such water also turns milky when soap is put in it; and furthermore, usually forms a thick incrustation on the bottom and sides of vessels in which it is frequently boiled, such as tea kettles, or the flues of steam boilers. Also, if the water is very hard, it is found that some kinds of vegetables, such as beans and peas do not soften properly, but rather become harder and tougher and hence less easily digested, when cooked in such water.

Removal of Hardness. Hard water, on a small scale, often can be somewhat remedied for domestic use by various treatments. To do this intelligently one should understand that hardness of water is of two kinds, namely:

(1) Temporary hardness.

(2) Permanent hardness.

Temporary hardness is caused mainly by the bicarbonates of calcium, magnesium and iron. This is the kind of hardness which causes a water to form a whitish scum on top, or which produces a sediment on the bottom, or on the sides, of a vessel after boiling for a short period, particularly noticeable after standing till cold.

This kind of hardness, can, fortunately, be easily remedied. If a gallon of water be boiled until about a quart of it has boiled away, it will usually be found that it has lost all its temporary hardness; and if a water so treated had nothing but temporary hardness in it originally, straining now to remove the scum and sediment will give a water almost perfectly "soft."

Permanent hardness is a kind of hardness which is caused principally by the dissolved chlorides, nitrates and sulphates of calcium, magnesium and iron and can only be easily detected after the temporary hardness has been removed by boiling. If the water is still hard after boiling and straining, it is quite safe to conclude that it contains permanent hardness. Or, if a water is hard, and on test is found not to contain temporary hardness, it is then safe to assume that its hardness is of the permanent variety.

There is no simple physical method for removing permanent hardness. The only way to get rid of it is to treat the water with some kind of chemical, such as washing soda or phosphate of sodium, and the amount of these chemicals to use can only be determined by chemical analysis. However, boiling for a short time, after the addition of a spoonful of either of these to four or five gallons of the water, will probably be about the average amount to use to take away the permanent hardness more or less completely from most waters. After this treatment straining will give a water practically soft.

Most hard waters have both kinds of hardness, particularly waters to be found in limestone formations or districts, or in districts containing rocks with considerable calcium in their makeup. Usually, in these cases, the hardness is about equally divided between the two classes, sometimes one predominating, sometimes the other. Under such circumstances, a combination of the boiling and chemical treatment will completely soften the water.

A very simple and efficient method of quite recent invention for softening water is to percolate the hard water slowly through a suitable depth of a substance called "Zeolite" or "Permutit." This brings about a chemical change whereby all the hardness is removed and the water issues from the outlet practically soft. After a time this softener loses its power to remove further hardness but its ability to do so can be fully recovered by washing it thoroughly with strong brine for a short time. It can then, after washing out the excess brine, be used over again. This can be repeated indefinitely.

Many elaborate methods have been worked out and put into operation for softening water on the large scale. But these are only available to large industrial concerns or municipalities, chiefly because of cost and intricacy, which can employ a chemist or other expert to oversee the work or to act in an advisory capacity. The farmer needing much soft water should aim at providing means for catching rain water and storing it in sufficient amount to supply his needs.

Chemical Analysis Offered.

Anyone desiring chemical analysis of his water supply will be willingly aided in every way possible, through analysis, advice and otherwise, by application to the Department of Chemistry of the Ontario Agricultural College. Directions for taking, describing and shipping samples of water to this laboratory will be found in Appendixes III and V, pages 85 and 86. Forms of Appendix III will be supplied on application to the Department of Chemistry, O.A.C., Guelph, as a convenience in describing the water and its source, to those who desire them.

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10. THE SEPTIC TANK METHOD OF DISPOSING OF CHEESE FACTORY AND CREAMERY WASTE WATER.

By Frank Herns, Chief Dairy Instructor, London, Ontario.

The disposal of cheese factory and creamery wash water by the septic tank system presents, because of the special kind of solid content, greater

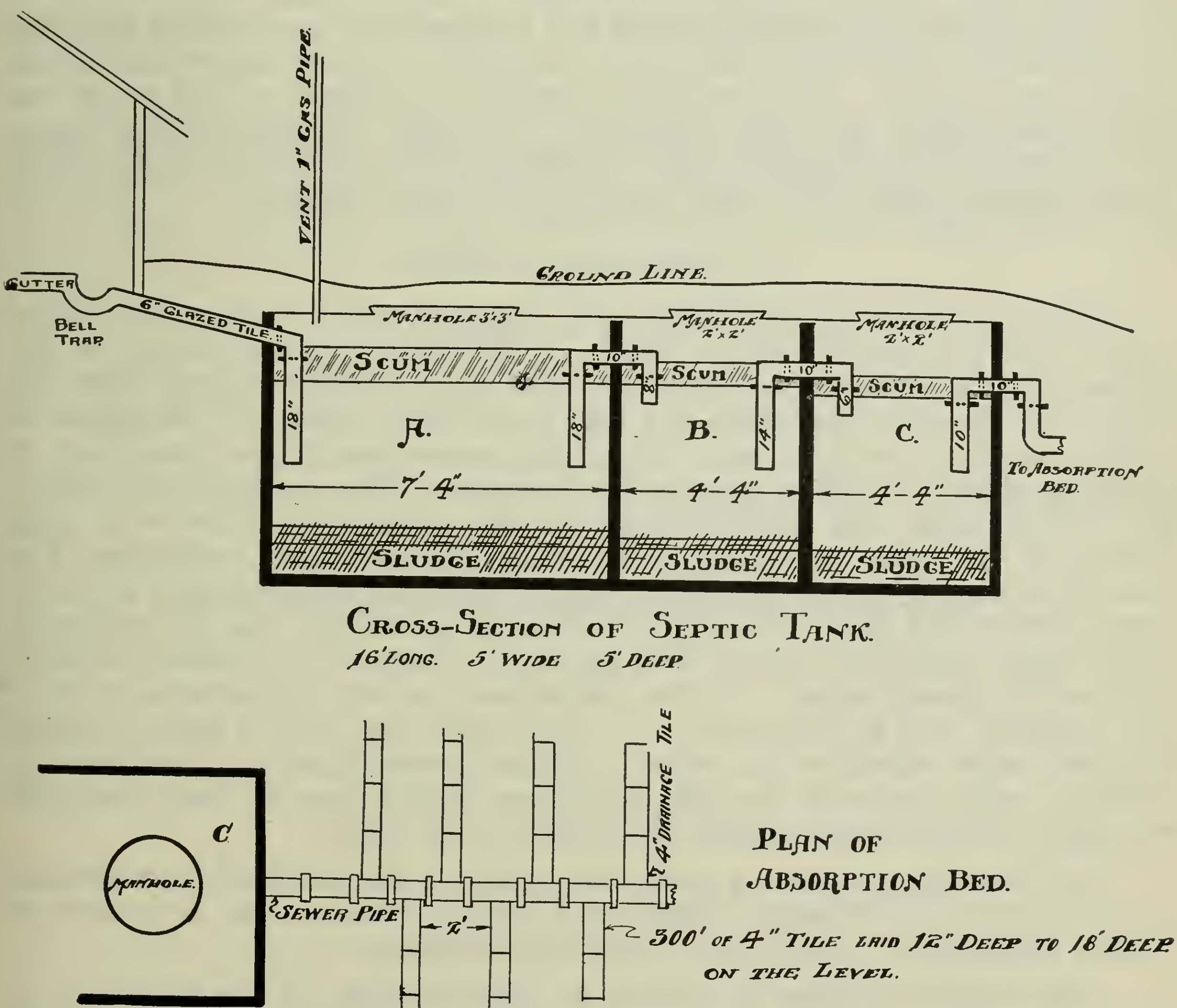


Fig. 59.—System or taking care of Cheese Factory and Creamery Waste.

difficulties than does the handling of house sewage. The fatty solids especially (which do not readily decompose) must be prevented from entering and clogging the tile.

The tank should have at least three compartments through which the waste water must pass on the way to final absorption by the soil. With hard soil, a filter bed is necessary which may require special drainage, since an outlet for the surplus water not absorbed by the soil or taken up through evaporation must be provided.

The cement tank is so constructed as to retain most of the sediment and floating material in the first compartment. The additional chambers retain most of the organic matter and sediment which may pass over from the first section and thus prevent so far as possible anything but water from leaving the last compartment. Decomposition of the organic matter is encouraged through retention in the tank for as long a time as possible.

In the settling chambers, any material which will float rises to the top in the form of scum, while sand and some other sediment falls to the bottom. The tank must, therefore, be cleaned about once each season. The organic solids slowly decompose through bacterial action and since most of this material remains in the first section of the tank, it must be large enough to provide for an accumulation.

Size of Tank.

The larger the tank the longer the sewage may be retained and the greater will be the decomposition of the organic matter before the liquid passes into the tile. There should be capacity sufficient to hold all of one day's washings in the small section C. A double partition cement tank, 16 feet long, 5 feet deep and 6 feet wide with 5-inch walls and 4-inch partitions, should be about the right size for the average factory.

Construction of Tank.

Six-inch glazed tile, carefully laid, may be used to conduct the waste water from the factory to the tank. A bell trap is placed either in the factory gutter or near the factory to shut off the odour coming from the drain. At the point at which the water enters the tank it is desirable to attach an elbow with an arm (about 18 inches long), the lower end of which is always in the water below the scum. This prevents the breaking of the scum and undue mixing of the incoming sewage with that already in the tank—a matter of importance in successful operation. The tank should be covered with six or eight inches of soil and kept air-tight except where the vent (which may consist of a two-inch gas pipe properly stayed and extending beyond the top of the factory) is placed to carry off the foul gases caused by the decomposition of the material within. An air inlet may be required at the discharge end of the tank to make the vent more effective. In order to afford communication of sections A, B and C with the vent, the two partitions should have at least one inch of space between the top and the cover of the tank.

For cleaning purposes a man-hole is left in the cover of each section, or the cover is so arranged that the different sections may be gotten at easily, especially the first and largest compartment.

The discharge pipes are placed at opposite ends of the partitions in the tank and may consist of special four-inch sewer fittings or be made of four-inch iron pipe with four-inch elbows.

The tank plan indicates the length of the discharge pipes required for withdrawing the water from section A and discharging into section B; from section B into section C and from section C into the tiles or drain. The discharge pipes in the partition between section B and C are placed four inches lower than those in the partition between section A and B, and similarly the discharge pipes from section C into the tile are placed four inches lower than those in the partition between section B and C.

For creameries it is well to lay one-and-a-half inch gas pipe over the tank through which the pure water from the cream cooler and cream vats may be discharged directly into the drain. This water requires no purification and if conducted through the tank would necessitate one of too large dimensions and the large amount of cold water running into the tank might cool the contents too much for a rapid decomposition of the solids.

The Receiving Tile and Absorption Bed.

Four-inch tiles are laid level under twelve to eighteen inches of soil in rows two feet apart to receive the treated sewage from the tank and thus distribute it evenly over the ground area. The joints are left slightly apart and may be covered with pieces of tile or tar paper to prevent soil from falling into the joints. It will require about 300 tile to dispose of the water, although the number will depend on the amount of water that has to be disposed of and the condition of the ground. Sandy or gravelly soil will readily absorb water. Four-inch field tile will hold approximately one-half gallon each. Therefore 300 tile will be sufficient for about 150 gallons of water.

If the soil is stiff clay or not porous it will not readily absorb the water, in which case it will be necessary to construct a filter bed of sand and gravel to the depth of twelve to eighteen inches through which the tile is laid. An outlet through under-drainage of the filter bed for the surplus water will be necessary.

A Few Points to be Remembered.

(a) Tank of sufficient capacity. For large factories increase the size of tank and absorption bed twenty-five per cent.

(b) At least three compartments.

(c) Prevention of fatty solids from leaving the tank and entering the tile.

(d) Sufficient tile, properly laid to dispose of the water.

(e) Under-drainage of clay soil and filter bed constructed.

APPENDIXES

Persons desiring information on any of the subjects mentioned below should apply for blank forms of these Appendixes to the Department indicated, and fill them in to the best of their ability and return. *There is no charge.*

APPENDIX I.

(HYDRAULIC RAM).

(Apply to Department of Agricultural Engineering).

1. How many gallons per minute does the source of water supply?..............
   Spring or stream?..Yield?..
2. How much water per day is needed?..
3. How many feet fall can be secured?..
4. How high will the water have to be lifted above the ram?..............................
5. How far approximately between source of ram?..............................
   and ram and buildings?..
6. If ram be put 3 feet below surface, can the waste water be drained off? ....
7. Do you wish water supply for both house and barn?..............................
8. Submit a simple sketch of your premises, showing house, barns, water supply, lay of land, measurements, etc.

APPENDIX II.

WATER SUPPLY SYSTEM.

Apply to Department of Agricultural Engineering).

1. What is your source of water supply?..
2. If well, is it dug or drilled?..............................Is there plenty of water? ....How much lower would the water level be than the basement floor of the house or barn?..............................
   How far is well from house and barn?..............................
3. Will water be required for both house and barn and also for lawn service? ....
   What is the size of your family?..............................How much livestock is kept?..............................Is the house to be equipped with bathroom, kitchen and laundry fixtures?..............................
4. Have you a cistern?..............................What size is it?..............................
   Do you wish both hard and soft water "on tap"?..............................
5. How do you propose to do the pumping?..............................
   If by motor, state voltage A.D. or D.C. used?..............................
6. Describe your present pumping outfit and water system, if any, in order that we may be able to advise you if it can be made any use of in your new layout..
   ....
   ....
   ....
7. Send us a sketch of your buildings, with location of well and any other features that might aid us in laying out a water system for your place
   ....

APPENDIX III.

Information re Wells.

(Apply to Agricultural Engineering Department)

Persons enquiring about wells, either from the standpoint of construction, improvement, bacteriological analysis or chemical analysis, should send the following information on form to be had on application to the proper Department.

Well:

1. Distance to rock.................................. 2. Depth of well......................
3. Nature of soil (gravel, clay, sand or loam)..
4. Whether the well is fed by a spring...
5. The mode of construction of the well, including its wall and covering

....

6. Is the cover tight?..
7. Depth of water in the well...
8. Whether the appearance or depth of the water is affected by heavy rains ....
9. Date of digging........................ 10. Date of last cleaning..................
11. Any indications of pollution, discoloration of sides, etc.........................
12. Amount of water used from well...

Surroundings:

1. Proximity to dwellings, outbuildings, stables, drains, sewers, etc........
2. Drainage of surrounding soil: Is slope towards or away from well?........
3. Is surface drainage from house or barns to or away from well?............
4. Are surroundings clean?..

Water:

1. Has the water been healthful?..
2. Have there been any cases of typhoid fever?...................................
   If so, how many in five years?..

APPENDIX IV.

Directions for Taking a Sample of Well Water for Bacterial Analysis.

(Apply to Bacteriological Department).

1. It is essential that the bottle to contain the sample and also the cork for the same be sterilized by boiling in water 30 minutes.

   Care should be taken not to touch the neck of the bottle nor that part of the cork that goes into the bottle with the hands, or anything that has not been just previously sterilized.

   A small bottle, as a medicine bottle, will hold sufficient for the test.

   Note.—A sterile bottle, in a mailing case, ready for taking the sample, will be forwarded on application to the Bacteriological Department, O.A.C., Guelph.

2. Pump for one or two minutes, or until all local laterals are emptied of water that has been standing in them.

3. In removing the cork from the bottle do not touch the part of the cork that goes into the neck of the bottle against anything, and do not remove cork until ready to take the sample.
4. Do not touch the mouth of the bottle with the hands or anything else.
5. Let the water from the pump run directly into the bottle, then cork tightly with the same cork that is removed from the bottle, place the bottle in the mailing case, stamp the case and mail it immediately to the Bacteriological Department, O.A.C., Guelph.
6. Write a card stating date and time of day the sample was taken.

APPENDIX V.

Directions for Taking a Sample of Water for Chemical Analysis.

(Apply to Chemistry Department).

Container.—A bottle of not less than one quart capacity is to be used, preferably one with a glass stopper. If there is no glass stopper, the bottle must be stopped with a new cork.

Preparation.—The bottle must be thoroughly cleaned, all foreign substances removed, and scaled out with boiling hot water and then allowed to drain until cool.

Taking of Sample.—If the sample is to be taken from a well, the water must be pumped out for about five minutes, or long enough to empty all pump connections before the sample is taken; if from a tap, the water must be allowed to run to waste for about ten minutes, or long enough to empty all local laterals, before sampling. If the sample is to be taken from a lake or stream, it must be taken some distance from the shore, the sampling vessel being plunged a foot and a half below the surface, to avoid the surface scum. Samples are not to be taken immediately after a storm.

From wherever the sample is taken, the bottle must be rinsed out several times with the water to be analysed. The bottle must not be filled quite full, a small space must be left for the expansion of the water. Cork, and tie a piece of cloth over the neck to keep the cork in place. Do not use sealing wax.

Notification.—Send notice by mail stating by what express company you are sending the water, and the date of the shipment. Also give, as fully as possible, the history of the well or source of the water, and remarks on the sanitary surroundings. Address the package to Chemistry Department, Ontario Agricultural College, and prepay express charges on the same.

Bulletin 362 March 1931

ONTARIO DEPARTMENT OF AGRICULTURE

ONTARIO AGRICULTURAL COLLEGE

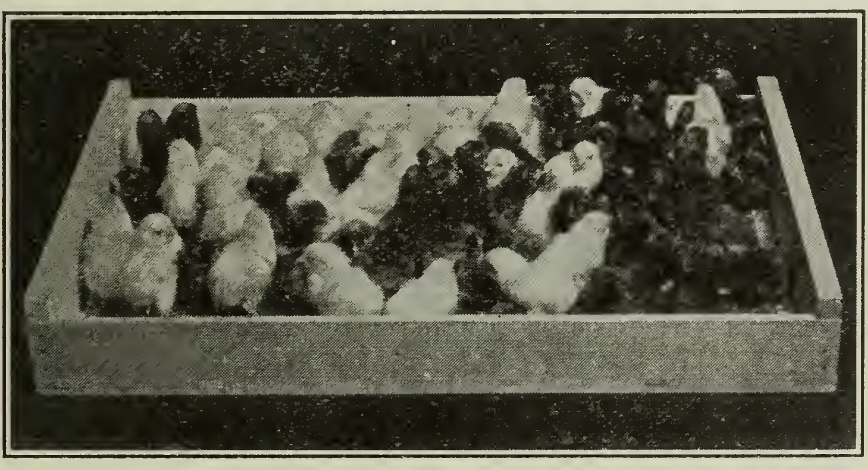
GUELPH, ONTARIO

RESULTS OF A THREE YEARS STUDY OF CERTAIN POULTRY RATIONS AS THEY EFFECT THE HATCHING POWER OF HEN EGGS AS WELL AS THE NUMBER OF EGGS LAID.*

by

W. R. GRAHAM J. B. SMITH W. D. McFARLANE

Department of Poultry Husbandry



Strong, healthy baby chicks as they come from the Incubator

*This project is carried on with the financial co-operation of the Empire Marketing Board, London, England.

RESULTS OF THREE YEARS STUDY OF CERTAIN POULTRY RATIONS AS THEY AFFECT THE HATCHING POWER OF HEN EGGS AS WELL AS THE NUMBER OF EGGS LAID.

The Province of Ontario loses annually many thousands of dollars through poor hatches during incubation. In our modern types of incubators with their controls for temperature, ventilation and moisture, there are still about forty percent. of the eggs set never hatch a chick. Poor hatches are put down to a number of causes. Too often, however, when the hatch is low people are inclined to find fault with the incubator. It seems quite safe to state that the majority of incubators in use today will give reasonably good results, providing the eggs are set from a well managed flock and the operator performs his or her duties faithfully during the period of incubation. Good management is the secret to success. It involves the care of the breeding flock; the selection of the breeding of the birds used, especially that of the males; the feeding methods and kind of rations used; the sanitation as carried out together with such things as the handling of the hatching eggs. It is possible to so manage the flock during the winter months that more eggs may be gathered; such eggs when set to give as many chicks as the same number would if set in July.

It is hoped that the data submitted may be of service to those who wish to produce a good hatchable egg.

Much experimental and research work has been done and is in progress at the present time on the use of the various kinds of proteins, vitamins and minerals, on both the growing chick and the laying hen. Through the use of Cod Liver Oil—a rich source of vitamin D., feeding methods have changed somewhat during the past few years. There is considerable evidence to show the beneficial effect of Cod Liver Oil on hatchability, egg production and the general health of the flock. The diet fed the parent fowl appears to have a very definite effect on egg production and hatchability.

PLAN OF EXPERIMENT

The general plan of the experiment was to study the influence of such animal proteins as Milk, Fish Scrap, Beef Scrap and Tankage as they might affect hatchability and egg production. These materials were used as a sole source of protein in the rations and, in addition, were fed in combination with Milk, with or without Cod Liver Oil. The experiments consider two main points.

1. The effect of certain animal proteins on the hatchability of hens' eggs.
2. The effect of the amount and quality of sunshine on the hatchability of hens' eggs.

It is generally believed that the hatching power of eggs is an inherited character and might very well be considered to be an equally important factor. The birds used in the experimental trial are all of known ancestors and come from the general pedigree pens of the Department. Their ancestors are known for ten years or more together with their record of performance. This information may help materially in the final study of the problem.

The incubator used was a six thousand egg Petersime machine, which makes it possible to set all eggs daily for the entire period. This insures that all eggs are set the day they are laid and that every egg is under the same external conditions during incubation.

Twenty Barred Rock pullets and one male as nearly equal in age and breeding as possible, are used in each pen. All pullets used in the experiment were hatched in late March and early April. It is generally conceded by Ontario poultrymen that April hatched Barred Rocks give a lower hatch than those hatched in February or March. The males are rotated from pen to pen daily. Pullets are used in preference to hens in that their eggs are likely to be a little more difficult to hatch, other things being equal.

In case of a death of a bird, it is immediately replaced by a bird of similar breeding so that the pens are constantly kept up to strength.

It is planned to conduct the trial for five years which would give data on one hundred females on each ration being studied.

The individual pens are twelve feet wide and fourteen feet deep. There are two glass windows three feet by three feet six inches in each pen as well as two movable screens which may be opened on days when the weather permits. The screens are twenty inches square. One is covered with cheese cloth and the other is covered with cel-o-glass. The trapnests, drinking fountains, pans, feed hoppers, are the same size in each pen. There should be little or no difference between the pens.

THE METHOD OF FEEDING AND MANAGEMENT

In view of the many factors that may affect production and also hatchability, a system of feeding and management has been developed to control as many of these as possible on a measurable basis. With this in-mind, the following feed schedule was followed:—

A.M.—A light feed of grain scattered in the litter.

Noon—A portion of the mash for each pen is fed moistened. The Cod Liver Oil is fed in this mash daily.

P.M.—A heavy feed of grain was fed in troughs.

N.B.—No artificial lights were used.

The mash for each pen is fed in hoppers and is available for the bird to eat throughout the entire day.

All birds confined to the pen for the entire eleven months.

RATIONS FOR EXPERIMENTAL PENS

Basal Mash to All Pens

700 lbs. Corn Chop
500 lbs. Wheat Shorts
300 lbs. Oat Chop
10% Alfalfa Meal
2½% Bone Meal
½% Salt

Whole Grain Mixture

50 lbs. Yellow Corn
50 lbs. Wheat
Daily amount to each pen—
A.M.—½ lb. in litter
P.M.—2 lbs. in hopper

To the dry mash, kept in front of the birds all the time, was added the following,—

Pen	Amount and Kind of Protein	Other Additions
2	10% B.M.P. (Buttermilk Powder)	U.V.L. (Irradiation)
4	10% B.M.P.	Cod Liver Oil
6	5% B.M.P. + 7½% Fish Scrap	
8	5% B.M.P. + 7½% Fish Scrap	Cod Liver Oil
10	5% B.M.P. + 10% Beef Scrap	Cod Liver Oil
12	5% B.M.P. + 10% Tankage	Cod Liver Oil
18	20% Beef Scrap	Cod Liver Oil

20	10% B.M.P.	
22	20% Beef Scrap	
24	20% Tankage	
26	15% Fish Scrap	
28	15% Fish Scrap	Cod Liver Oil
30	20% Tankage	Cod Liver Oil
32	37% B.M.P.	Cod Liver Oil

N.B.—U.V.L. (Ultra Violet Light) half hour irradiation daily except Sunday.

C.L.O. (Cod Liver Oil) 20 cc. daily to each pen in moist mash.

In addition to the dry mash, the birds have free access to oyster shell, grit and water at all times. The weighed quantity of grain, 2½ lbs. per pen per day, was fed on an assumed ratio 50-50 mash to grain consumption. By this method any variation in food consumption was measured by the amount of dry mash and oyster shell eaten.

The protein supplements were added on an equivalent basis to the basal mash, with the exception of Milk. Small quantities of the basal mash were weighed out in separate containers weekly and the animal proteins were added to the various groups.

A chemical analysis of each individual source of protein was determined. An equivalent quantity of Fish Scrap, Meat Scrap and Tankage was fed on the basis of their chemical analysis, as stated previously, with the exception of Milk, of which one half of the quantity by weight was used.

The feeding trials for 1929 and 1930 included two pens on a Milk diet; one pen the same as 1928, that is 10% of the mash of Buttermilk Powder and the other pen was given 37% of Buttermilk Powder or enough to equal the animal protein of the pens on Fish Scrap and Meat Meal.

COMPOSITION OF THE RATIONS

In Table 1 is shown the percentage composition of representative samples of each of the protein supplements used in these experiments. Repeated analysis of different samples of the same protein concentrate showed that the composition might vary within fairly wide limits, for instance, the buttermilk consignments analysed varied in crude protein content from 29—35%. It was, therefore, necessary to make protein determinations on each new batch of feed and to increase or decrease the amount of the protein supplement in the ration so that the total protein was kept approximately the same throughout the entire experiment. The percentage composition of the mash fed to each pen is given in Table II and is calculated from the percentage composition of the ingredients of the mash (see Table I). To study the effect of adding Cod Liver Oil or Ultra Violet irradiation to the buttermilk powder rations, the total protein of those rations was kept approximately the same at 13.5% (i.e. pens 2, 4 and 20). The total protein content of the rations planned to compare the different protein supplements with and without Cod Liver Oil (i.e. pens 18, 22, 24, 26, 28, 30 and 32) was approximately 21.%. In comparing the nutritional value of the combinations of these protein supplements (i.e. pens 6, 8, 10 and 12) the total protein of the rations was approximately 18%.

Table I.

PERCENTAGE COMPOSITION OF PROTEIN SUPPLEMENTS

	Meat Scrap	Tankage	Fish Meal	Buttermilk Powder	Semi-solid Buttermilk	Basal Mash
Moisture	3.84	5.89	5.90	7.62	71.25	9.82
Crude Protein (N x 6.25)	55.90	56.70	75.77	34.80	9.90	12.34
Ether Extract	14.58	10.91	3.86	5.31	1.65	4.78
Crude Fibre	1.22	1.79	.23	....	....	7.59
Lactose	....	....	....	37.91	10.90	....
Lactic Acid	....	....	....	5.82	4.60	....
Total Ash	10.51	20.28	17.63	8.47	1.90	4.95

70 lbs. ground Yellow Corn — 10% Alfalfa
50 lbs. Shorts — 2.5% Bone Meal
30 lbs. Ground Oats — 1. % Iodized Salt

Table II.

PERCENTAGE COMPOSITION OF THE MASH

Pen	Ration	Crude Protein (Nx6.25)	Ether Extract	Crude Fibre	Total Ash
2	B.M.P. + Irradiation	13.6	4.7	6.8	5.3
4	10% B.M.P. + C.L.O.	13.5	6.7	6.7	5.2
20	10% B.M.P.	13.6	4.7	6.8	5.3
32	37% B.M.P. + C.L.O.	20.6	6.9	4.6	6.2
18	20% Meat Scrap + C.L.O.	20.8	8.7	6.1	7.8
28	15% Fish Scrap + C.L.O.	21.3	6.4	6.3	6.7
30	20% Tankage + C.L.O.	21.1	8.0	6.7	8.1
26	15% Fish Scrap	20.6	4.2	5.7	6.4
22	20% Meat Scrap	21.0	6.7	6.3	7.9
24	20% Tankage	21.2	6.0	6.4	8.0
10	5% B.M.P. + 10% Beef Scrap + C.L.O.	17.6	7.5	6.4	6.5
8	5% B.M.P. + 7½% Fish + C.L.O.	17.9	6.6	6.5	6.0
12	5% B.M.P. + 10% Tankage + C.L.O.	17.6	7.2	6.5	6.5
6	5% B.M.P. + 7½% Fish Scrap	18.2	4.7	6.7	6.2

** Table III.

MONTH	* HOURS OF SUNSHINE	
February	100.2	
March	126.2	389.8 hours
April	163.	
May	246.1	
June	263.8	823.1 hours
July	313.2	

* Three years average.
** Data supplied by the Engineering Department, O.A.C.

The data in reference to the hatching power of eggs is based only upon the fertile eggs. All the eggs candled out as infertiles during incubation were broken for an examination of the germ inside. A small percentage of the total number of eggs removed at the time of candling as infertile, contained a dead germ of early development.

For some years observations have been made on the amount of sunshine available and its influence on hatchability.

The following table gives the number of hours of sunshine for the winter and summer hatching seasons.

From the above table it will be noticed that the month of July has three times as much sunshine as that for the month of February. There is also a monthly increase in the amount of sunshine from February until July. April has less than two hundred hours of sunshine, while May exceeds this amount by forty-six hours, hence the division into the two periods.

Table IV.

SHOWING THE INFLUENCE OF THE AMOUNT AND QUALITY OF SUNSHINE ON THE PERCENTAGE HATCHABILITY

PERCENT. HATCHABILITY

RATION	Feby.	March	April	May	June	July
Milk	56.3	56.1	59.	71.7	72.8	74.8
Beef Scrap	51.2	47.4	44.6	55.	68.6	63.6
Tankage	10.2	21.7	29.	34.9	48.4	55.

DISCUSSION—

The beneficial influence of the amount and quality of sunshine is clearly shown in Table IV. With over two hundred hours of sunshine the hatch is increased 12.7 percent., 10.4 percent. and 5.9 percent. for Milk, Beef Scrap and Tankage. For all three rations already referred to, the hatching quality of the eggs gathered in May, June and July has been greatly improved over that for those of February, March and April.

The lack of sunshine during the months of February, March and April may be substituted for by such well known substitutes as Cod Liver Oil and Ultra Violet Light.

The following tables contain a summary of three years results from several rations differing largely in the kind of protein used. In each table the results are given for a single protein supplement with and without Cod Liver Oil and also with Milk and Cod Liver Oil added.

Table V.

BEEF SCRAP

PERCENT. HATCHABILITY

RATION	Feb.	Mar.	Apr.	May	June	July	*Egg Production	Lbs. Feed Required to Produce Dozen Eggs	Average Amount of Feed Consumed Per Bird
Beef Scrap	51.2	47.4	44.6	55.	68.6	63.6	138.4	7.05	80.9
Beef, C.L.O.	69.2	67.4	59.9	71.9	70.6	72.	164.2	5.95	77.5
Milk, Beef, C.L.O.	76.9	75.2	60.	59.6	66.5	74.5	165.6	5.87	81.

*Eleven Months Only.

DISCUSSION—

A combination of Milk, Beef Scrap and Cod Liver Oil is a more satisfactory ration than either Beef Scrap or Beef Scrap and Cod Liver Oil. When Milk and Cod Liver Oil were added to Beef Scrap the egg production is increased thirty-seven eggs per hen, the hatching power of the egg was much higher for the winter months and over one pound of feed was saved for every dozen of eggs laid. The beneficial influence of Cod Liver Oil when added to Beef Scrap is shown by the increase in the number of eggs produced, pounds of feed required to produce one dozen eggs and the hatching power of the eggs for all months but more especially for those of the winter season. It is interesting to note that after two hundred hours of sunshine are available, the Beef Scrap pen produced a much higher hatching quality egg. A combination of protein supplements with Cod Liver Oil gave more satisfactory results than a single protein supplement with Cod Liver Oil.

Table VI.

FISH SCRAP

PERCENT. HATCHABILITY

RATION	Feb.	Mar.	Apr.	May	June	July	*Egg Production	Lbs. Feed Required to Produce Dozen Eggs	Average Amount of Feed Consumed Per Bird
Fish	57.4	59.3	53.	56.6	69.4	71.8	165.4	6.18	85.1
Fish, C.L.O.	64.3	60.2	50.3	63.6	66.4	67.5	177.8	5.64	83.6
Fish, Milk, C.L.O.	79.2	74.	58.8	63.3	67.9	67.9	166.6	5.91	82.

*Eleven Months Only

DISCUSSION—

When Cod Liver Oil is added to Fish Scrap the egg production is increased one dozen eggs per hen for eleven months and it required less feed to produce a dozen eggs. Apparently the vitamin content has some influence on the egg production. In hatchability Cod Liver Oil does not improve the hatch for February, March and April when added to Fish to the same extent that it does when added to Milk or Beef Scrap. With Milk and Cod Liver Oil added to the Fish Scrap the hatch is greatly improved for February and March and somewhat higher for April. The egg production was eleven eggs less per hen where Milk was added to the Fish and Cod Liver Oil and it required slightly more feed to produce one dozen eggs.

While the egg production was down eleven eggs on the average for Milk, Fish and Cod Liver Oil as compared with Fish and Cod Liver Oil, the hatching power of the eggs was very much in favour of a combination ration.

Table VII.

TANKAGE

PERCENT HATCHABILITY

RATION	Feb.	Mar.	Apr.	May	June	July	*Egg Production	Lbs. Feed Required to Produce Dozen Eggs	Average Amount of Feed Consumed Per Bird
Tankage	10.2	21.7	29.	34.9	48.4	55.	126.6	7.44	78.5
Tank., C.L.O.	27.9	41.2	28.7	39.4	57.8	57.6	157.2	6.03	79.3
Tank., Milk, C.L.O.	72.	58.6	58.7	42.7	55.6	60.4	151.	6.41	80.7

* Eleven Months Only

DISCUSSION—

Tankage gave a low egg production, eggs of poor hatching power and it required over thirty percent. more feed to produce a dozen eggs than where Fish Scrap was used. Cod Liver Oil added to Tankage increased egg production thirty-one eggs per hen with almost one and one half pounds of feed less required to produce one dozen eggs. The hatching quality of the eggs was improved for all months but still unsatisfactory. A combination of Milk and Cod Liver Oil with Tankage gave a fair hatch, but does not compare with the results from the other combination rations studied. Not only did Cod Liver Oil improve the hatching power of the eggs when added to Tankage but it also increased the egg production materially.

Table VIII

MILK

PERCENT. HATCHABILITY

RATION	Feb.	Mar.	Apr.	May	June	July	*Egg Production	Lbs. Feed Required to Produce Dozen Eggs	Average Amount of Feed Consumed Per Bird
10% Milk	56.3	56.1	59.	71.7	72.8	74.8	143.6	7.05	84.4
10% Milk, C.L.O.....	73.4	69.9	60.6	54.8	64.1	65.1	153.5	6.48	82.8
**37% Milk, C.L.O.....	75.8	75.7	65.8	74.1	80.	73.3	153.7	6.07	77.8
H 10% Milk, Irrad....	74.1	77.2	71.7	74.	79.5	77.1	139.8	7.01	81.7

* Eleven months only.
** Two year results.
H Birds handled every day except Sunday.

Discussion—

With the addition of Cod Liver Oil to Milk the number of eggs produced was increased, hatchability was improved considerably for the winter months and less feed was required to produce a dozen eggs. Again it may be seen that the amount of Vitamin supplied has not only influenced the hatching power of the eggs but also the egg production. By increasing the amount of Milk in the diet to thirty-seven percent. there was no increase in the egg production although a little feed was saved. However, the hatching quality was higher for all months. Irradiation from a Mercury Quartz Lamp would appear to be more efficient in supplying the necessary Vitamin D than Cod Liver Oil when the results are compared. The egg production is low for this pen but in view of the fact that the birds were handled every day, except Sunday, and carried in a crate to the top floor of the Poultry Building, introduces a point of difference in comparing this pen with the other pens. It would seem that when Milk is fed at the same level as Beef Scrap, Fish Scrap or Tankage, there is a possible wastage of this material.

Table IX.

A COMBINATION OF PROTEINS

PERCENT. HATCHABILITY

RATION	Feb.	Mar.	Apr.	May	June	July	*Egg Production	Lbs. Feed Required to Produce Dozen Eggs	Average Amount of Feed Consumed Per Bird
Milk, Fish	58.2	49.1	30.9	42.6	64.5	68.1	141.4	6.78	79.9
Milk, Fish, C.L.O.	79.2	74.	58.8	63.3	67.9	67.4	166.6	5.91	82.
Milk, Beef, C.L.O.	76.9	75.2	60.	59.6	66.5	74.5	165.6	5.87	81.
Milk, Tank., C.L.O.	72.	58.6	58.7	42.7	55.6	60.4	151.	6.41	80.7

* Eleven Months Only

Discussion—

There are many of the opinion that heavy egg production tends to decrease the hatching power of eggs. This does not seem to be the case when the results for the two diets—Milk, Fish Scrap, Cod Liver Oil, and Milk, Beef Scrap, Cod Liver Oil are considered. The average production for eleven months was 165 and 166 respectively while the percent. hatchability would average over seventy percent. for the February, March and April period. When Tankage is used in place of either Fish Scrap or

Beef Scrap, the egg production is down fourteen eggs per bird, more feed is required to produce a dozen eggs and the hatching power of the eggs is decreased considerably. Twenty-five eggs more per hen are recorded when Cod Liver Oil is added to Milk and Fish, almost one pound of feed is saved every time twelve eggs are produced and the hatching quality of the eggs increased very greatly for the more important months to the hatcheryman.

A study of the three years summary shown in Table X seems to justify the following conclusions.

1. Comparing the feeding value, from the standpoint of egg production, Fish Meal, Powdered Buttermilk, Beef Scrap and Tankage, rank in the order named.

2. The addition of Cod Liver Oil to a single protein supplement increased the egg production with all rations tested but much more with Beef and Tankage than with Milk and Fish.

3. A combination of Fish Scrap and Milk failed to increase either the hatching power of the eggs or the number of eggs produced.

4. Cod Liver Oil added to a combination of Milk and Fish Scrap; Milk and Beef Scrap; Milk and Tankage; did increase both the hatching power of the eggs set and the number of eggs produced.

5. It would appear that Tankage fed to poultry alone or in combination is not the most desirable kind of ration.

6. With a grain ration such as used plus alfalfa meal, the addition of direct sunshine or sunshine substitutes (a good grade of Cod Liver Oil or Ultra Violet Light) is the most important factor in producing good hatching eggs for the rations tested.

7. Vitamin D. appears to be a very important factor in hatchability. Birds housed in these feeding trials did not get the necessary amount until there was at least two hundred hours of sunshine per month.

8. Milk in combination with Beef Scrap or Fish Scrap together with Cod Liver Oil appears to be the most satisfactory feed used, in these trials, where hatching power of eggs, number of eggs produced and pounds of feed required to produce one dozen eggs are considered.

Table X.

SUMMARY OF THREE YEARS RESULTS

PERCENT. HATCHABILITY

RATION	Feby.	March	April	May	June	July	EGG Production 11 Mos.	Lbs. Feed To Produce One Dozen Eggs	Average Feed Consumed Per Bird	Total Eggs Set for Three Years
Milk, Beef, C.L.O.	76.9	75.2	60.	59.6	66.5	74.5	165.6	5.87	81.	5851
Milk, Fish, C.L.O.	79.2	74.	58.8	63.3	67.9	67.4	166.6	5.91	82.	5730
Milk, Irradiation	74.1	77.2	71.7	74.	79.5	77.1	139.8	7.01	81.7	4732
10% Milk, C.L.O.	73.4	69.9	60.6	54.8	64.1	65.4	153.5	6.48	82.8	5430
*37% Milk, C.L.O.	75.8	75.7	65.8	74.1	80.	73.3	153.7	6.07	77.8	3682
Milk, Tank., C.L.O.	72.	58.6	58.7	42.7	55.6	60.4	151.	6.41	80.7	5256
Beef, C.L.O.	69.2	67.4	59.9	71.9	70.6	72.	164.2	5.95	81.3	6103
Fish, C.L.O.	64.3	60.2	50.3	63.6	66.4	67.5	177.8	5.64	83.6	6575
Fish	57.4	59.3	53.	56.6	69.4	71.8	165.4	6.18	85.1	5958
Milk	56.3	56.1	59.	71.7	72.8	74.8	143.6	7.05	84.4	4985
Beef Scrap	51.2	47.4	44.6	55.	68.6	63.6	138.4	7.01	80.9	4683
Milk, Fish Scrap	58.2	49.1	30.9	42.6	64.5	68.1	141.4	6.78	79.9	4630
Tankage, C.L.O.	27.9	41.2	28.7	39.4	57.8	57.6	157.2	6.05	79.3	5890
Tankage	10.2	21.7	29.	34.9	48.4	55.	126.6	7.44	78.5	4523

*Two years.

BULLETIN NO. 363 JUNE, 1931

Ontario Department of Agriculture

PARASITES INJURIOUS TO POULTRY

LIONEL STEVENSON, Provincial Zoologist

ROUND WORMS

A section taken from the intestine of a three months old chicken. This very common parasite causes much loss in the young flock reared in infected yards and pens. The practice of a high degree of sanitation about the poultry premises and the liberal use of the approved colony house system of rearing the new flock will keep the worm menace down.

THE POULTRY PARASITE HANDICAP

The losses due to the ravages of the parasites, attacking poultry in many farm flocks are serious. Practically all flocks are parasitized in some degree. Those flocks that are being reared and kept under the most approved and sanitary condition, suffer but little loss. The flock that receive no consideration as to hygeine, soon become unprofitable through loss in condition and production. Heavy infestations result in loss by death. The sum total of the parasitic loss is very large, when we consider loss by death, loss by poor development of young stock, loss by low production of eggs and loss by resulting poor fleshing of table stock. As with other classes of livestock a few parasites per head, will cause no noticeable symptoms or loss. But if the numbers are allowed to increase unduly, the loss will be in proportion to the degree of parasitic increase.

The carrying out of the plans of high class poultry hygiene will keep flocks relatively free from an injurious degree of parasitism, without the help of drugs. Drugs however are essential and very necessary in combating parasites, on premises where such factors as buildings, permanent yards, available land areas and the "will to do it" on the part of labor are not of the very highest standard.

Infection—The farm residence is usually a substantial, permanently located structure, hence the tendency has been to keep the poultry close at hand, in yards, pens and range that have been in continuous use for many years. This tendency to permanency in location, has perpetuated and increased to a dangerous degree on many farms, the parasitic menace to the poultry flocks. The soil of yards, the floors of pens have become heavily contaminated with the eggs of the various worms that inhabit the alimentary tract of any birds using such pens and yards. The point is this, a bird carying a large number of round worms, tape worms or caecum worms in its intestine, will be passing in its faeces, thousands of worm eggs daily. The fecal matter heavily laden with worm eggs is tracked everywhere the chicken's feet may go, contaminating feeding floors, and feed troughs. The eggs of the various worms are taken up while the birds are feeding from such contaminated floors and feed troughs. If the egg of the round worm or the caecum worm has reached an advanced state of incubation, by the time it reaches the intestine of a bird, the young worm will be released to grow and develop to maturity.

Worms produce eggs in enormous numbers and one heavily infested bird added to a formerly relatively worm free flock, will in a few weeks, so contaminate the premises as to cause the development of a very pronounced parasitism in the entire flock.

THE ROUND WORM (*Ascaridia perspicillum*)

Hosts—Chickens, Turkeys and Guinea fowl.

Description—A yellowish white round worm, that inhabits the small intestine. The adult females attain a length of three to four inches. The male worms are smaller. Both sexes taper toward the extremities. The tail end is bluntly pointed, while the head end terminates in a mouth consisting of three lips, the margins of which are dentate. The egg of the female is ovoid in form. The eggs are well protected and withstand adverse weather conditions for over a year.

Life History of the Round Worm—The eggs from the female Round Worm, resident in the intestine of the bird, pass out with the fecal matter to reach the floor or soil. Under favorable conditions for incubation, the embryo develops within the egg case, to a condition that is dangerous to the fowl, if taken up then. The young worm is released in the intestine and after a period of migration and growth, reaches sexual maturity.

Symptoms of Infestation—The heavily infested birds become blind, unthrifty, rough dirty plumage, the comb and wattles lose color, emaciation, a chronic diarrhea and death may follow.

ROUND WORMS (*Ascaridia perspicillum*)
Length,—the females are two to three inches long, the males are one and a half to two inches long.

Treatment—Worms may be expelled by use of drugs. No drug has been found fully efficient on single application, but all must be repeated. Individual treatment is always preferable, as some birds will not eat a medicated mash. In individual treatment capsules or pills or a drench must be purchased or prepared, and each bird given a suitable dose of known quantity. Commercial preparations containing Nicotine Sulphate, combined with either Lloyd's Alkaloidal Reagent or with casein, may be purchased through veterinarians and druggists. Nicotine Sulphate is efficient against Round Worms, but it is also highly toxic, and to be safe must be given combined with either of the above mentioned substances. Tetrachlorethylene may be purchased in capsule form. This drug is efficient when administered in proper dose and it is safe. Tetrachlorethylene is sold in capsule under the trade names "Nema Capsule" and "C-A Capsule." These capsules may be purchased through the local veterinarian. Birds should be confined to yard or building while under treatment, and 48 hours after the administration of the dose, move the flock to clean yards and clean pens. The old yards and pens should be thoroughly cleaned up before being used again.

The Oil of Chenopodium Enema in Round Worm Control.

This drug is mixed with Cotton Seed Oil in the following proportion.

Oil of Chenopodium	1 fluid dram,
Cotton Seed Oil	6 " ounces.

To administer use a small rectal syringe.

The dose is one teaspoon of the mixture, per rectum, to a chicken weighing 2 pounds. The discharge tube of the syringe is passed into the bird's rectum, and the injection made slowly.

The Nicotine Sulphate and Mineral Oil Drench in Round Worm Control.

This drench is prepared by mixing nicotine sulphate and mineral oil in the following proportion:

Nicotine Sulphate	1 ounce
Mineral Oil	24 ounces.

To administer, use a small rubber tube of three sixteenths of an inch diameter, and about 12 inches long. This should be attached to a small funnel or syringe. The bird's mouth is held open and the rubber tube gently pressed backward and downward into the proventriculus (crop). The dose of one teaspoonful of the mixture is then run in and the bird released.

The Turpentine Drench in Round Worm Control.

This drench is prepared by mixing equal quantities of Turpentine and Olive Oil. This drench is administered by means of the rubber tube and funnel, directly to the proventriculus (crop). The dose is from one-half to two teaspoonsful, according to the size of the bird.

After 48 hours the poultry houses, pens, dropping boards and feed troughs used by treated birds, should be thoroughly cleaned and scalded. The yards should be spaded deeply and limed if continued in use.

The Tobacco Dust as a Mass Treatment, for Round Worm.

Tobacco dust when mixed with the grain mash has a very fair efficiency if continued long enough and repeated, providing, of course, that the birds eat enough of it. Birds that need it most, sometimes will not eat it at all, if they can get other food. The proportion of Tobacco Dust to the dry mash is two pounds to each 98 pounds of ground grains. This preparation should be mixed fresh each week. Tobacco with one and one-half per cent. nicotine content should be used. This is generally obtained in Tobacco dust prepared from the last season crop and which has not been exposed to the air unduly after grinding. Old tobacco, that has been exposed for a long period, is usually of low nicotine content and therefore of little use as a worm destroyer. The practice is to feed the Tobacco treated mash to chicks for two to three weeks, then omit the Tobacco, for a like period, to commence again. With older birds it is fed for four weeks, then omitted (tobacco) to be repeated again at the end of four weeks. Change the ground and clean up.

Tobacco-Areca Nut Mixture for Mass Treatment against Round Worm.

The following mixture is very useful against Round Worms, but it is not as efficient as individual treatment:

Freshly ground Areca Nut	25 parts
Freshly ground Tobacco	25 parts
Powdered quassia	12 parts
Iron sulphate	36 parts
Oil of Thyme	2 parts

To be thoroughly mixed. The doseage is one heaping tablespoonful of this powder mixed with one quart of soft bran mash, to each 5 full grown birds, or to 30 chicks four to six weeks old. This treatment should be repeated in 24 hours. Follow last treatment, in four hours, by giving one quart of water in which 4 ounces of Epsom salts have been dissolved. Change the ground and clean up.

Oil of Chenopodium (Wormseed) in Mass Treatment for Round Worm.

Oil of Chenopodium can be used with fair efficiency as a mass treatment, by mixing thoroughly, one dram of this drug, with two quarts of moist mash. The birds must be hungry and deprived of all other feed, in order to get them to take it. The above mentioned quantity is sufficient for 12 birds. Mix the Oil of Chenopodium with the required quantity of dry mash, before adding milk or water to make a soft mash. A flavoring of any kind will make it more acceptable to the birds. Change the ground and clean up.

The Small Round Worm or Caeca Worm (Heterakis papillosa).

Hosts—Chickens, Turkeys, Guinea Fowl and Pheasant.

Description—A small white worm. The adult females do not exceed three fifth of an inch in length. The males are smaller than the females. These very small round worms are found in the caeca or blind pouches of the intestine.

Life History—In spite of the small size of these Caeca Worms, they produce very large numbers of eggs. The eggs pass out of the bird's intestine with the fecal matter and are picked up by other birds while feeding. If the Caeca Worm egg is in an infective condition, the bird taking it up will become infected. This worm is a more serious pest with the young birds than it is with the old birds. Young chicks reared on infected ground may become so badly infested as to die in ten days. In the old birds the Caeca Worm maintains its position at the extremity of the caeca.

Caeca Worms (*Heterakis papillosa*), as washed free from fecal matter in "blind ducts." This worm is very injurious to young chickens.

Caeca Worm (*Heterakis papillosa*)
Color white, length up to three-quarters of an inch.

Treatment against Caeca Worm. Individual treatment is to be preferred, having a somewhat higher efficiency than mass treatment. The following is recommended—Oil of Chenopodium one part mixed with twenty parts of Cotton Seed Oil and used as a rectal injection. It is administered by using a small rectal syringe, or bulb and tube. The solution is injected slowly into the rectum of the bird. Birds weighing one pound should receive 3 cubic centimeters, birds weighing 2 pounds should receive 6 cubic centimeters. The rearing of the young chicks on ground that has not been contaminated by older poultry is of great importance. For mass treatment, Tobacco Dust can be used as follows—mix one pound of freshly pulverized Tobacco leaf with each 50 pounds of dry mash. Feed in this way for two weeks, then discontinue the Tobacco for a like period and then repeat its use. Move the birds to clean soil weekly.

The Tape Worms of Poultry

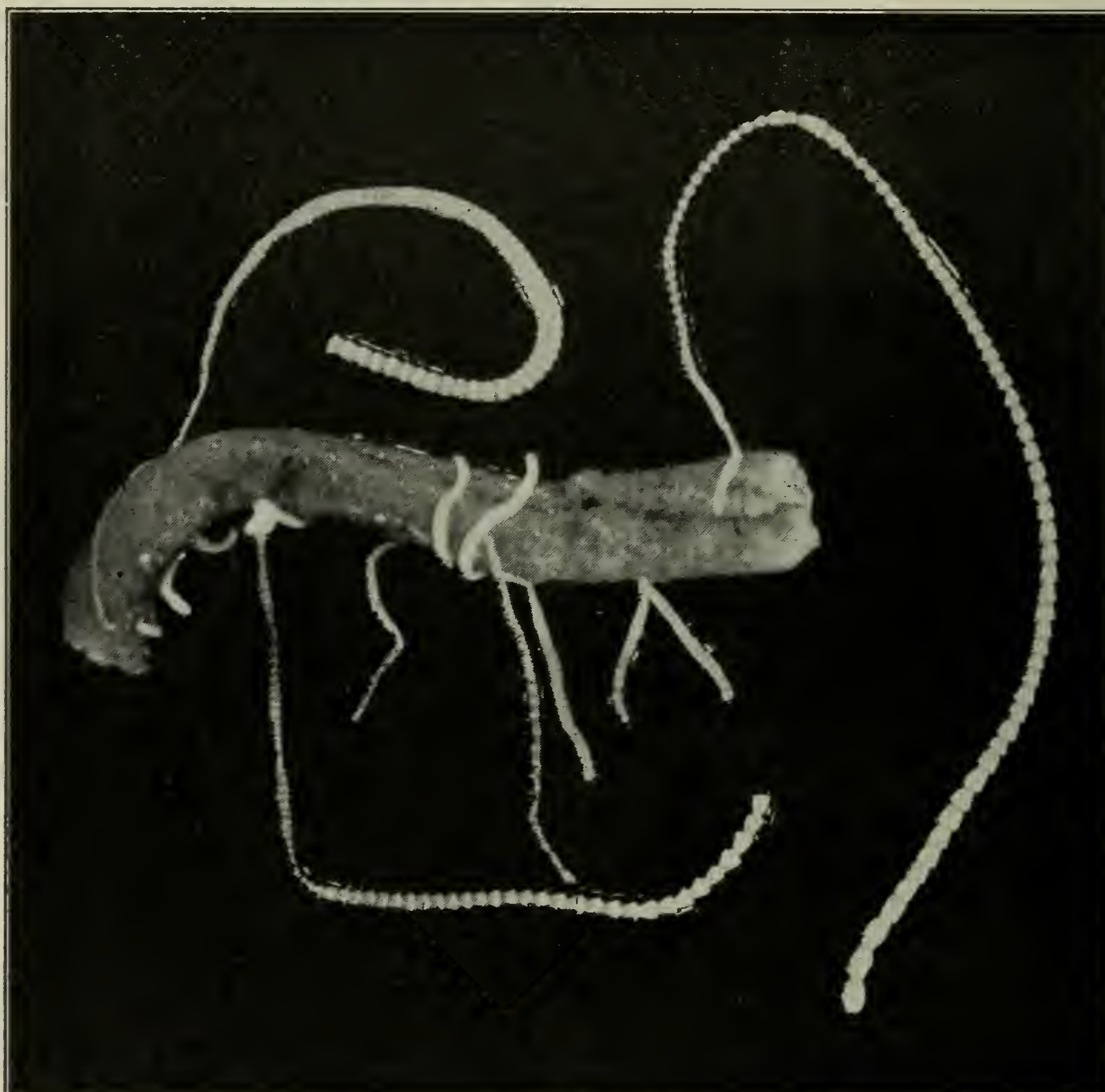
There are a number of varieties of Tape Worm infesting poultry in Ontario. These cestodes cause considerable injury to the young stock and some injury to the older birds. When present in numbers, the birds become anemic, emaciated, lame, blind, comb and wattles faded, plumage dull, and may be reduced to the death point. Tape Worms cause in birds of all ages, catarrh of the intestinal tract and diarrhea, with the associated conditions of droopiness, paleness, loss of appetite and frequently lameness.

The Large Tape Worm (Choanotaenia infundibiliformis).

Hosts—Chicken, Turkey, Pheasant, Guinea Fowl, Pigeon and Duck.

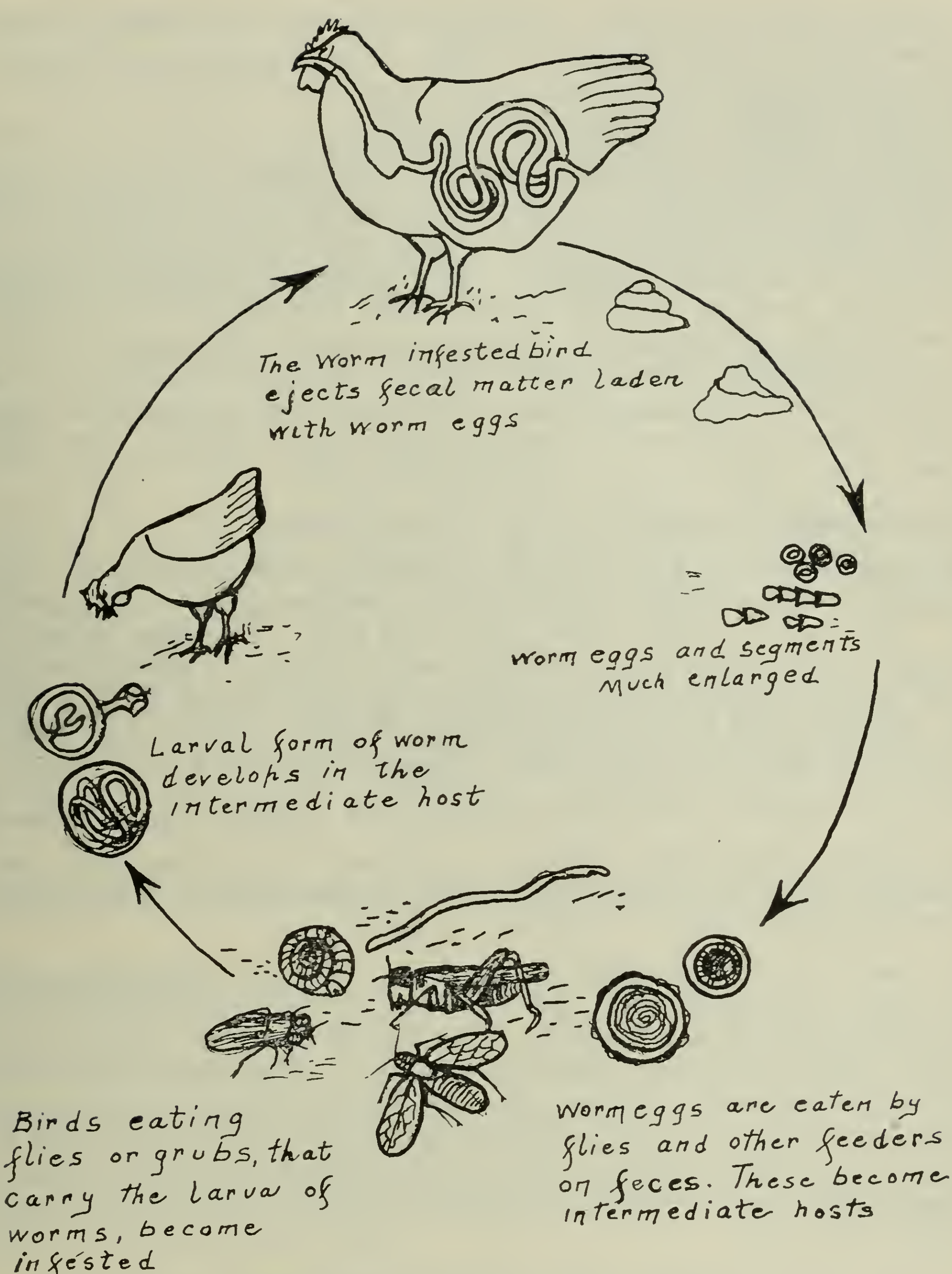
Intermediate host—The common house fly and its larvae.

Description—A white segmented worm, the joints of which are longer than broad. The Large Tape Worm is found attached to the mucous membrane lining the intestine and may be any length up to nine inches.



The large Tape Worm of Poultry, from one to nine inches long, a section of intentine is shown with the worms of various lengths attached. Note the segements.

Life History.—The adult or primary tape worm, with head attached to the membrane lining the intestine, grows many segments, each of which, when it is fully ripened an egg sac. These ripened egg sacs rupture, disperse their eggs, which mix with the reduced food material, and eventually pass out of the birds rectum with the food residues. Hundreds of thousands of tape worm eggs are therefore mixed with the faeces of tape worm infested birds. The common house flies that frequent the poultry pens and yards, deposit their eggs on the fresh poultry faeces, and should such faeces come from tape worm infested poultry, the young larvae coming from the hatched fly eggs, will in feeding on the fecal matter with which they are surrounded, take into their bodies the eggs of the tape worm. These tapeworm eggs once inside the body of the fly larva go through a transformation and eventually reach the cysticercoid stage. The fly larva becomes an active fly about the poultry yard, carrying the cysticercoid



The Tapeworms that infest poultry require an intermediate host in order that they may develop to a stage dangerous to poultry. The common house fly and its larva are the principal offenders, but any soft-bodied creature that feeds on fecal matter may be a host to these parasites. Anything that can be done to prevent insect life becoming abundant about the poultry premises is an aid in keeping down tape-worm infestation. Clean pens, fresh yards, screened manure and refuse piles will help.

within its body during life. Birds do not lose the opportunity of catching and eating a fly. Should the fly contain the cysticercoid of the poultry tape worm, the bird will become infested when the scolex or head within the cyst reaches the intestine. The attachment of the head to the intestinal mucosa is followed by rapid growth.

Control—Keep the poultry away from their own fecal matter, screen out flies and prevent them breeding. For individual treatment a successful single drug, that is easily procurable, is known as Kamala. It is given in capsule or in the form of a pill and it is fairly satisfactory in mass treatment, if repeated. A few birds should be treated as a test of the safety of the drug, as Kamala is apparently not safe to use in flocks affected with a number of the common poultry diseases. If found safe on a few birds, Kamala can then be administered to the entire flock. The dosage is as follows:

For birds weighing ½ to 1 pound, use ¾ gram.
For birds weighing 1 to 3 pounds, use 1 gram.
For birds weighing 3 pounds or over, use 2 grams.

These are to doses per bird, for both individual and mass treatments. For individual bird treatment have the drug put up in capsule of suitable size. For mass treatment, count the birds to be treated and then estimate the quantity of Kamala required. The weighed quantity of Kamala is added to corn meal, then thoroughly mixed and given to the birds when they are hungry. Shut off the feed hopper the night before treating and have the birds empty. The quantity of corn meal to be used with the Kamala is one-third of their usual feed. The flock can be given its usual feed, two hours after the Kamala dose has been administered. An additional purgative is not necessary when Kamala is used.

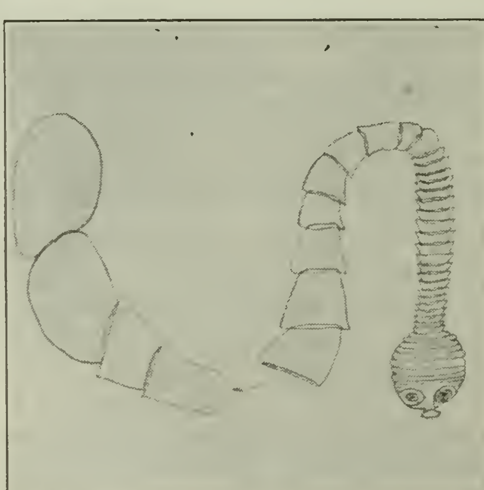
The Turpentine Drench in Tape Worm Control.

Prepare the birds to be treated, by fasting them for 24 hours, then give Epsom salts in the drinking water, using 4 ounces of the salts to a quart of water. Wait for 12 hours, then give each bird, according to size, two to four teaspoons of a mixture containing equal parts of Turpentine and Olive oil. This is best administered by rubber tube and funnel, or by hypodermic syringe, directly into the proventriculous (crop). Four hours after treating, give more salts in moist mash. Repeat treatment in 3 weeks.

The Lye (Sodium Hydroxide) Treatment in Tape Worm Control.

This easily procurable substance, common lye, is frequently used with satisfactory results in the removal of the Large Tapeworm from fowl. Lye is administered as follows.

For each 15 mature birds in the flock, use one level tablespoonful, of a good grade of concentrated lye. This quantity is boiled for two hours, slowly, with one gallon of wheat. This boiled lye and wheat mixture, is allowed to cool over night, and then given to the birds when they are hungry in the morning. All other feed should be kept out of reach until the lye treated wheat is eaten. This treatment should be repeated in 10 or 12 hours. Remember the eggs of the Tape Worm, are in the fecal matter, so anything that you can do to keep the poultry away from their own body discharges will help.



The Large Tape Worm of Poultry
Choanotaenia infundibuliformis
Length, up to nine inches.

Trade Remedies, in Tape Worm Control.

Capsules containing drugs that are known to be highly effective against Tape Worm in Poultry, are prepared by the drug trade and may be purchased from Veterinary Surgeons or Druggists. Of these commercial preparations, the C-A Capsule, is the most extensively used in Ontario. To administer a capsule to a bird, have it held by an assistant, open the mouth, insert the capsule and press it gently into the gullet. Follow the capsule gently with the fingers on the outside of the throat area, with a stroking down motion until the capsule reaches the crop.

The Short Tape Worm (*Davainea proglottina*)

Hosts—Chickens, Pheasants, Turkeys, Pigeons.

Intermediate hosts—Slugs and Snails.

Description—This is a very small Tape Worm, infesting the mucous membrane of the intestine. They do not exceed one sixteenth of an inch in length. This Tape Worm is found, buried head end inward in the mucous membrane of the intestine, a position in which it can not be reached by drug treatment.

Control—A high degree of hygiene in which the practice of rearing the young birds up on wire, offers the best chance for success. All old birds that are likely to be carriers of infection should be removed from the premises, and the houses thoroughly cleaned up before the new flock is required to occupy them.

The Nodular Tape Worms (*Davainea tetragona*) and (*Davainea echinobothrida*)

Hosts—Chicken, Turkey, Pheasant and Pigeon.

Intermediate host—Unknown at present, but will probably be found among the various insects, snails and worms on which poultry feed.

Description—The Davainea tetragonia is a small cestode that burrows through the mucous membrane of the intestine and causes the formation of nodules on its outer surface. The Davainea echinobothrida is also called the Spiny-suckered Tape Worm. This Tape Worm causes the formation of nodules in the intestinal wall.

Gizzard and Crop Parasites

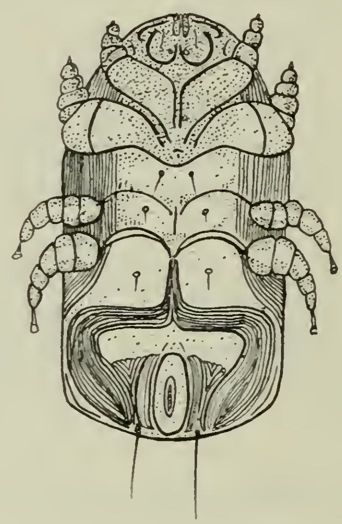
There are a number of parasites belonging to the Filariidae, that infest the gizzard, proventriculus and the oesophagus of fowl. These parasites if too numerous may cause considerable loss.

Dispharynx nasuta.—This worm is quite small, the females not exceeding three eighths of an inch in length. The males are smaller. This worm may be found in large numbers in the mucous membrane of the proventriculus (crop). They may cause if present in large numbers, enlargement and distortion of the organ. Any thickened areas in the crop will reveal the presence of many of these nematodes. The eggs of the worms are released to pass through the bird with the food and be discharged with the fecal matter. The eggs are eaten by numerous lowly creatures that feed on fecal matter, and those eggs finding a suitable host go through their larval development in the body of such host. The Sow Bug (Porcellio laevis) is the principal host, and birds picking up any of these that happen to contain the infective young worm (Dispharynx nasuta) will become infested.

Control.—Clean up all old boards or other rubbish, that gives protection to Sow Bugs, and do the necessary work to keep the premises dry and clean. Clean the houses and roosts daily and put the manure at a safe distance from the poultry yards.

Treatment.—Oil of Turpentine may be administered, morning and evening in half gram dose, to each bird. The twice dosing with Turpentine is a fairly effective treatment against this worm.

Dispharynx spirales.—This worm has much in common with the Dispharynx nasuta, inhabiting the crop and gullet, and having the same intermediate hosts for its larval development. It is usually found spirally rolled hence its name. The same control measures apply as in the case of Dispharynx nasuta.



THE CONNECTIVE TISSUE MITE (*Laminosioptes apticola*)

Length 1 M.M. Lives in the subcuteneous connective tissue, especially where the skin is loose, as neck, breast, sides and thighs.

Capillaria annualata.—This is a small worm found in and beneath the lining membrane of the gizzard of chickens and pheasants. The control is sanitation as recommended in the previous sections.

Capillaria gallina.—This worm is frequently found in the mucous membrane of the large intestine of the fowl. Heavy infestations seriously interfere with flock production and condition. It is a small worm, the females do not exceed three eighths of an inch in length.

Control.—A high degree of sanitation, coupled with the removal of all the birds out of condition is advised. The vermifuges recommended for intestinal parasites, as, Nicotine Sulphate, Oil of Chenopodium and Tetrachlorethylene can be used with good results. See previous sections on Round Worms. Thymol mixed with Gum Acacia solution can be injected per rectum, and is very useful in combatting this worm.

THE GAPE WORM (*Syngamus trachealis*)

Hosts.—Chickens, Pheasants, Turkey, Pea Fowl and Pigeon.

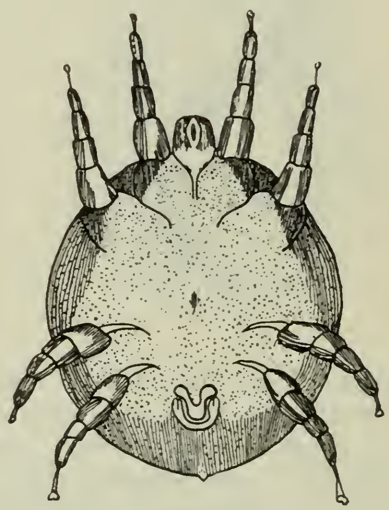
Description.—Reddish brown worms, found in the trachea. These worms attach themselves to the mucous membrane and draw their food supply therefrom (blood). The males and the females are found joined together, the two bodies presenting a forked appearance. The heads of both worms are attached to the mucous membrane of the trachea, during the entire copulatory period. The females are about three quarters of an inch long. The males are about one quarter of an inch in length.

Symptoms of Gape Worm Infestation.—During the first six or eight weeks of the bird's life, these worms if present in the trachea, sucking blood from the mucous membrane, cause considerable irritation and partly block the tube. This blocking of the trachea prevents an adequate supply of air reaching the lungs of the bird. The lack of sufficient air causes the bird to gape for more air. The interferance with breathing is such that the bird becomes weak, loses interest in life and does not feed well. The worms may become so numerous and their injury so extensive as to suffocate the unfortunate bird.

THE GAPE WORM (*Syngamus trachealis*)
Color reddish, length of females up to ¾ inch, males up to ¼ inch.

Life History.—The female Gape Worm and her consort, while attached to the mucosa of the bird's windpipe, are responsible for the production of large numbers of fertile eggs. These Gape Worm eggs are thrown out of the trachea with mucous and may be either sneezed out onto the ground or swallowed to pass out with the fecal matter. In any event they reach the soil, feed troughs and drinking water. After a short period of incubation the eggs reach the infective condition and are then dangerous to any bird that may take them up while feeding or drinking. After a few days development in the proventriculus (crop) of the bird, the young Gape Worms find their way to the trachea, where they complete their development. Young birds from 10 days to one month old, if infected with Gape Worms, will sneeze. The sneeze is characterized by an abrupt whistling sound. This is followed by the bird extending its neck and opening its mouth gasping for air. Birds become thin, weak, run down, and dull in less than a week's time if the infection is at all heavy. Heavily infested young birds stand with their wings drooping, their eyes closed and the head drawn close to the body. Older birds with a relatively larger diameter trachea are not troubled so much as the larger tube is not so easily obstructed. The older birds may therefore show no symptoms of the presence of Gape Worm, even though such are present.

Control of Gape Worm.—The soil of the yards and runs become heavily infested with the infective Gape Worm eggs. The first move therefore in combatting this pest, should be to manage the young flock in such a way that will keep the young birds off contaminated ground. Turkies commonly harbour Gape Worms over the entire year, and having a larger windpipe may show no evidence of being infested. However, if these worms infest the turkies on the farm, they in turn will distribute the worm eggs over the premises. This is dangerous to the young chick flock. So if both chickens and turkies are kept on the same premises, they should be kept entirely apart until the chickens are reared. When the chickens are hatched put them on board floors or fresh ground. Move frequently and do not permit them to enter to the old yards until autumn. If chickens are infested and gaping, the worms may be removed by means of a horse-hair loop or a very fine wire loop. An instrument of this kind is entered in windpipe and given a twist to engage the worms, it is then removed. This method is helpful if skillfully done, but dangerous for clumsy hands. An intra-tracheal injection of one cubic centimeter of a five percent aqueous solution of sodium salicylate is used with some success. This fluid causes the worms to let go, they may then be coughed up. The use of 12 drams of salicylate of soda to each gallon of drinking water is helpful in keeping down infection.



Air Sac Mite (*Cytoleichus nudus*)
Length,—very minute, about 600 microns, barely visible to the unaided eye.

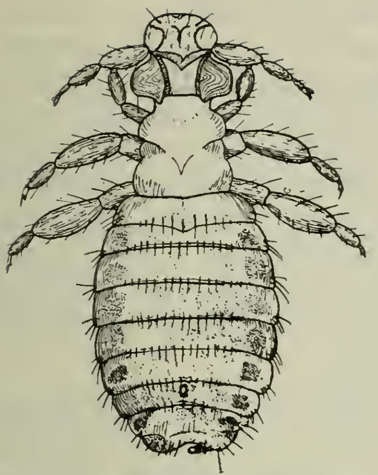
The Air Sac Mite (*Cytoleichus nudus*)

These mites are very small, but can be easily seen with a hand lens. The Air Sac Mite is most commonly found in birds that have not been kept under the best conditions of hygiene. They frequent the air sacs, lungs, trachea and body cavity. While quite common, these mites are not at the present time, considered a serious pest. Little is known of their life cycle, living as they do within the body cavity, out of reach of observation. This parasite can be controlled by the practice of a high grade of hygiene about the poultry houses and the removal of all unthrifty birds from the flock at once. Medicinal treatment can not well be applied as the mites are out of reach.

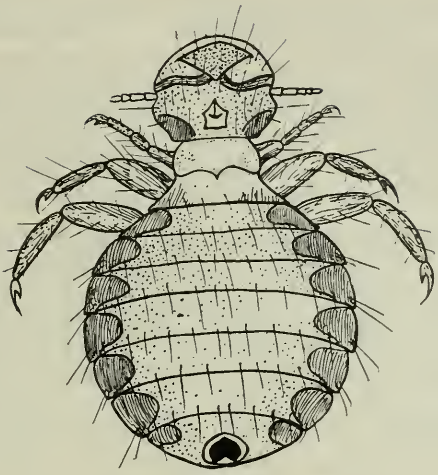
EXTERNAL PARASITES

Poultry Lice

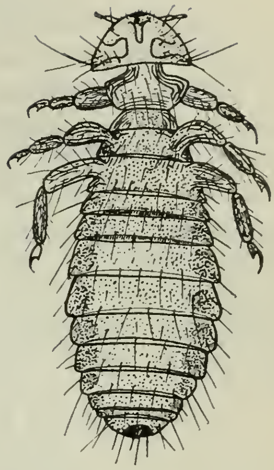
Great loss is sustained each year through the ravaging of poultry flocks by biting and sucking lice, which feed on skin, scales and feathers. Lice infesting poultry cause the birds much discomfort, resulting in a lower egg yield and poor condition for the older birds. The young birds may have their vitality so reduced by the lice pest as to become easy victims of the common diseases destructive to the young.



Head Louse of Chickens
(*Lipeurus heterographus*)
Colour pale yellow. Length 2 MM.



The Common Hen Louse
(*Goniocotes gigas*)
Yellow in color and 3 to 3.5 MM. long.



The Body Louse of Poultry
Found in the vicinity of the head. Length 2.5 MM.

There are many species of lice that attack domestic poultry, and each class of poultry has its own peculiar species. There are also several species of lice that attack more than one class of poultry. Common names such as head-louse, wing-louse, body-louse and etc., indicate the location on the bird most preferred by the species of louse present. Lice spend their entire life on one bird unless transferred to others of the same kind by contact. Eggs are produced in large numbers, by all species. These are attached to the feathers near the skin, in the location most favored by the species. Incubation is completed under favorable conditions in five days, several moults follow, bringing the young louse up to sex maturity in about twenty days.

Control of Lice.—Baby chicks, fresh from the incubator are, and should if properly handled remain free from lice. The chicks hatched by the hen, will if the mother bird happens to be lousy, become lousy as soon as their bodies are dry. The incubator hatching, the brooder and range rearing are factors against the louse pest, and therefore provide conditions favorable to rearing chicks free of this handicap. Poultry houses should be kept clean and receive a most thorough going over and disinfection during the summer to be ready for the new flock when the birds come in from the range. Every effort should be made to rid the birds and the houses of lice during the summer, that there may be none to breed and annoy the flock during the season of profitable egg production.

The Sodium Flouride Treatment in Louse Control.

This treatment is applied, by hand to each bird, or by dipping in a mixture of Sodium Flouride and water. The cost of treatment, both labor and material counted is about one cent per bird. The bird while being treated, with the dry powdered Sodium Flouride is held over a deep pan, and the amount of powder that can be held between the tips of the first finger and thumb, is placed in each of the following locations; on the head, neck, breast, below the vent, on the tail, on both thighs, inner side of spread wings and on the back. The dust from the dry powdered Sodium Flouride is unpleasant, to the person applying it to the bird, a mask is therefore recommended.

Sodium Flouride can be applied as a mixture with warm water, and without discomfort to the operator. The mixture is made as follows: in a tub or very large bucket, measure in warm soft water to the depth of 10 inches, counting on 5 gallons for each 100 birds, stir into this water one ounce of commercial Sodium Flouride for each gallon of water in the tub. The birds are held in this solution for one half minute, by one person holding the wings in one hand and using the other hand to ruffle the feathers over the entire body of the submerged bird, so that the liquid will reach the skin. The head of the bird is also dipped. The surplus fluid held by the feathers is permitted to drain out and the bird then released. Dipping should be done early on warm days only, in order that the birds may become thoroughly dry before night.

Commercial Sodium Flouride can be mixed with flour, in the proportion of one to three of flour and applied to the bird by means of a shaker can. This method is not as effective as the two other methods outlined. One pound of commercial Sodium Flouride will do 100 birds by this method.

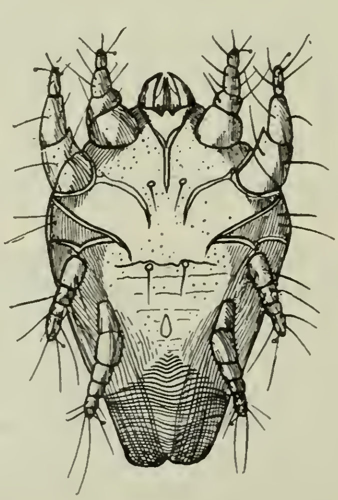
Powdered Sulphur as a Treatment in Louse Control.

Sulphur is cheap and easy to get. It is quite efficient as a louse killer, if frequently and thoroughly applied. Sulphur can be applied by the use of a shaker-can, being dusted on the skin while the feathers are being parted.

Dust Baths in Louse Control.

Poultry that have free access to suitable dust baths, that are made up in part with tobacco dust or sodium fluosilicate, can hold lice in check if the infestation is not too heavy. The bird is limited in its ability to spread the dust to all the areas where the lice are established, hence self dusting in a dust bath can be but partly effective. Very fine dry road dust makes a very good medium, with which to mix, tobacco dust or sodium fluosilicate. The proportions are three of dry road dust to one of either of those mentioned.

Insecticides such as Derris Powder, Pyrethrum Powder, Sabadilla Seed Powder, or compounds containing these or their active principle can be used successfully, but have no advantage over Sodium Flouride.



The Depluming Mite (*Cnemidocoptes laevis*)
Length,—this Mite is not visible to the unaided eye.

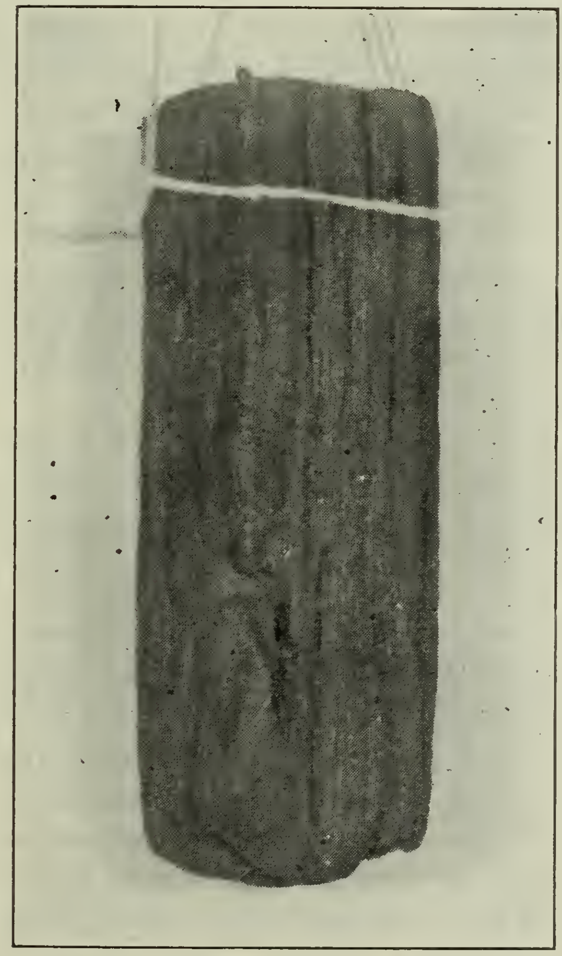
THE DEPLUMING MITE (*Cnemidocoptes laevis*)

The Depluming Mite is very minute. It penetrates the skin to the base of the feathers and causes an intense irritation. The birds attempt to relieve this irritation by pulling the feathers. This mite is most active during the warm weather and but little noticed during the winter.

Treatment.—The areas where the mites have established, should be well saturated with a mixture of Sulphur and Vaseline (one part Sulphur to four of Vaseline). This should be repeated in 10 days. Other ointments, as one part Carbolic Acid to 50 parts Vaseline can be used in the same way. If the infestation is at all extensive it is best to dip the flock in a mixture made as follows:

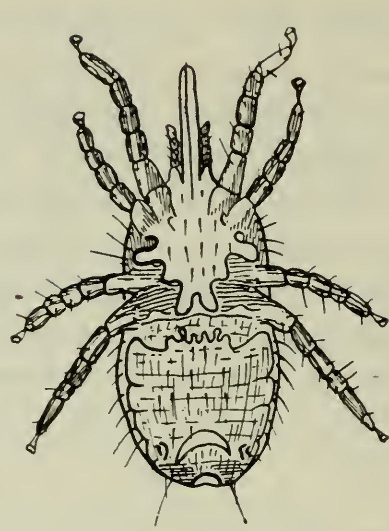
Warm water	1 gallon
Sodium Flouride	1 ounce
Laundry soap	½ ounce
Sulphur	2 ounces

Five gallons of this mixture will be required for 100 birds. Keep the mixture well stirred. Dip the birds for one half minute, in the manner described for lice. This mixture will destroy both lice and mites.



Old Rails make a most unsuitable roost, for chickens, as the cracks and rough surfaces provide shelter for mites, and keep the pest going strong.

Use only smooth surfaced wood or metal of a type that can be kept clean and free of the eggs of the mite.



Common Poultry Mite (*Dermanyssus gallinae*)
Length 1 M.M.

The Chicken Mite (*Dermanyssus gallinae*)

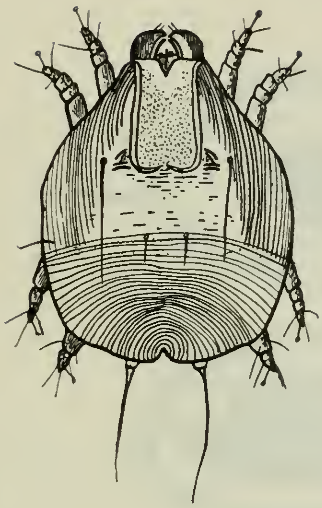
This mite is quite common and not difficult to locate on the body of a bird at night. During the day the mites hide away in cracks or other places where protection from light is given. These mites feed on blood and if present in large numbers can seriously injure the flock. To control the Chicken Mite a thorough clean up of the poultry premises and all equipment, such as nest boxes, feed troughs and roosts must be made. A thorough spraying with a spray-fluid containing Creosote is then applied. A wood preserving shingle stain, made from creosote, mixed with an equal quantity of Kerosene makes a very good spray in mite control. Crude oil diluted with kerosene is also good for this purpose. A white wash containing 5 percent carbolic acid is very useful, but not as effective as the other sprays mentioned in mite control.

Scaly Leg Mite (*Cnemidocoptes mutans*)

Hosts.—Chickens, usually the heavier breeds, Turkey, Pheasant, and Pigeon.

Description of Injury.—This parasite burrows into the skin of the bird's leg below the tarsal joint. Their presence causes an intense irritation, exudation and growth of the cells of the invaded area. The leg becomes distorted and enlarged. The scales covering the lower leg and toes are forced out of their natural position, giving the leg a rough scaly appearance. In severe cases the bird will become lame and move about but little, finally losing condition and passing out. The invading female mites, in their location in the skin, produce after fertilization a number of eggs. These hatch, each producing a nymph. The nymph goes through two or three moulting changes, in attaining sex maturity.

Treatment.—The scaly leg condition can be relieved if taken in time. The infected birds should be separated from the flock. The legs should be well scrubbed with warm soapy water to remove any loose scale and



SCALY LEG MITE (*Cnemidocoptes mutans*)

Length,—not visible to the unaided eye. Cause of conditions known as Scaly Leg.

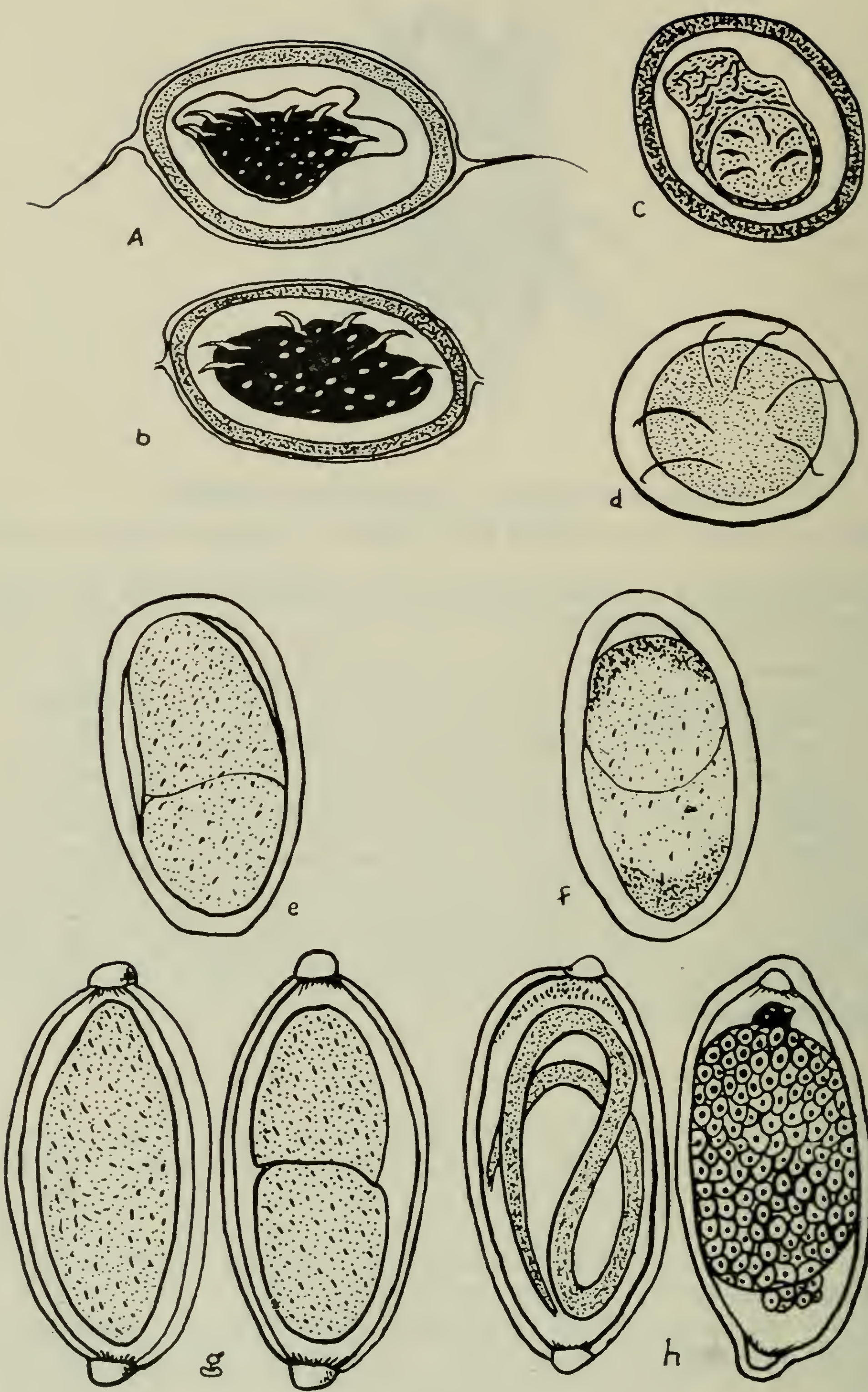
dirt. When dry apply a penetrating oil or ointment to kill the mites. The following are effective mixtures:

	Caraway oil	1 part
	Lard or Vaseline	4 parts
or	Peruvian Balsam	2 parts
	Creolin	1 part
	Alcohol	20 parts
or	Sulphur	1 part
	Lard	9 parts
or	Creosote	1 part
	Lard	20 parts

Kerosene can be used successfully, but it may blister the skin if it comes in contact with the feathered areas. If scaly leg appears in the flock, it is well to treat all birds, whether showing symptoms or not. Treatment should be repeated.

POULTRY KEEPERS CAN GROW TOBACCO.

Tobacco or its active principle Nicotine, is one of the most useful agents that can be used against fowl parasites. The tobacco leaf used in dry mash feeding or in nest boxes and dust boxes can be grown on the farm, at little cost. Tobacco plants will grow as easily as will burdocks or thistles, it therefore makes an excellent crop to grow in any poultry yards that are unused by poultry during the summer. The young tobacco plants are set out after danger of frost is over, much the same as cabbage plants are set and receive similar care. When the tobacco plants are well grown, they are cut near the ground and hung up in a shed to dry. When crisp and dry the leaves may be rubbed on a coarse wire screen (one-eighth inch mesh) to pulverize and make ready for mixing with the dry mash or the contents of the dust box. Figure on one plant for each five birds. Low grade leaf may be secured from growers in the tobacco growing sections of the Province. Such leaf may when crisp and dry, be run through a feed mill or an alfalfa grinder to pulverize it. The older tobacco is, the less its value in poultry parasite control, due to the loss of its nicotine. Relatively fresh dry leaf should contain approximately one and one-half percent of Nicotine Sulphate.



The presence of worms in the alimentary tract may be determined by a microscopical examintaion of the fecal matter from any bird thought to be wormy. The eggs of all the various worms show definite characters, making identification easily possible.

Figures A, B, C, D are eggs of the common varieties of tapeworms infesting fowl.

Figures E, F are Round Worm eggs.

Figures G, Capillarids.

Figures H, Cape Worm eggs.

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Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE
GUELPH, ONTARIO

MANURES AND FERTILIZERS

THEIR USE IN ONTARIO

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Pic. 1 A Profitable Crop of Oats on an Eastern Ontario Farm,
The result of good fertility management.

MANURES AND FERTILIZERS

Their Use in Ontario

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MANURES AND FERTILIZERS

Their Use in Ontario

There is an increasing demand for information regarding the use of manures and fertilizers in the growing of general farm crops. This is partly due to the introduction of new crops, but more to the desire of the producer to grow larger and better crops. To do this economically it is essential that the grower know his soil, the needs of his crops and the nature of the materials he purchases as fertilizers. Soils vary, not so much in their store of plant food, as in their physical characteristics and the way in which the food may be brought into a form that the plants can use it. Crops differ in their food requirements and in their ability to take that which they need from the soil. Fertilizers carry widely different amounts of plant nutrients and vary widely in the availability of these. Since many newer high grade materials such as synthetic products are being used in the manufacture of double and triple strength fertilizers, it is desirable that the grower should be informed as to the composition and characteristics of these newer high analysis materials which are now finding their place on the fertilizer market.

The study of plants, how they grow, how they feed, what they feed on and how they are influenced by the soil, is of vital importance to any one growing crops.

Most young plants start from a seed, which contains an embryo, or germ, that is extremely rich in protein fat, phosphates, and carries some potash. The seed also contains a store of food, in the form of starch, and other carbohydrates, intended to nourish the young plant until the roots and leaves are sufficiently developed to gather their own supplies. The future health and vigor of the plant depends on: (1) the amount of food available to the tiny rootlets sent out by the young plant; (2) the temperature of the soil; (3) an abundance of sunshine; and (4) a sufficient supply of oxygen. The plant requires oxygen for respiration, and it gives off carbon dioxide and water from its leaves, that is, it breathes; it assimiliates food, and it even excretes waste material. In all this it is very similar to the animal. But it goes further, and from such simple substances as carbon dioxide, and soluble salts found in the soil, builds up complex sugars, starches, fat and proteins which are essential to the life processes of the plant and which form the food of animals. It is entirely dependent upon the supply of food constituents within its reach. It has no way of drawing attention to its wants, excepting as its appearance may make them known to the careful and trained observer. A clear conception of the fact that the infant plant, like the infant animal, requires warmth, air, sunshine, and an abundance of easily absorbed food, will greatly aid in understanding the conditions under which the plant makes its best growth.

Essential Plant Nutrients and Their Functions

It has been generally agreed that the following elements are essential to the growth of crops:—

Carbon (C)	Potash (K)
Hydrogen (H)	Calcium (Ca)
Oxygen (O)	Sulphur (S)
Nitrogen (N)	Iron (Fe)
Phosphorus (P)	Magnesium (Mg)

Carbon, Hydrogen, Oxygen. The plant obtains its carbon, hydrogen and oxygen from the air and from water. Air and water are usually in abundance. Their supply is largely beyond human control. Carbon, hydrogen and oxygen in various combinations such as starches, sugars, fibre, fat, etc., compose a very large proportion of the dry matter of the growing crop.

Nitrogen. In the absence of nitrogen the plant makes no appreciable growth. With only a limited supply, the plant commences to grow in a normal way, but as soon as the available nitrogen is used up, the lower and smaller leaves begin gradually to die down from the tips and all the plant's energy is centred in one or two leaves. Nitrogen is one of the main constituents of protein, which is possibly the most valuable part of a plant. It is also a constituent of chlorophyll, (the green matter of plants), hence with a limited supply of nitrogen, leaves have a light green-yellowish color drying to a light brown-yellowish color. Plants with large, well-developed leaves of a deep green color are not suffering for nitrogen. An abundance of nitrogen produces luxuriant growth of leaf and stem, but retards maturity; with cereals, it frequently causes the crop to "lodge." Therefore, when crops such as cereals, tomatoes, potatoes, etc., are to be matured, an over supply of nitrogen is injurious; but with crops such as lettuce, cabbage, etc., which are harvested in the green condition, an abundance of nitrogen, other fertilizing constituents being present, will tend to produce a strong vigorous growth, and give crispness or quality.

Phosphorus,—commonly referred to as phosphoric acid (P_2O_5) in various forms of combination, is found in all parts of the plant, but tends to accumulate in the upper parts of the stem and leaves, and particularly in the seed. Another function of phosphorus apparently is to aid in the production and transportation of proetin. It also seems to aid the assimilation of other plant food elements. An insufficient supply of phosphates always results in a poorly developed plant, and particularly in a poor yield of shrunken grain. Phosphoric acid hastens maturity.

Phosphorus deficiency is difficult to detect in crops other than cereals.

Potassium,—commonly referred to as Potash (K_2O)—is one of the most important and least variable of all the elements of the ash of plants. It is quite evenly distributed throughout leaves, stem, and seed, and generally occurs in the entire plant in largest proportion next to calcium of any of the essential ash constituents. The function of potassium is apparently to aid in the production and transportation of the carbohydrates. This element seems to supplement the action of nitrogen by filling out the framework established by the latter. Potash with nitrogen is always an important fertilizer with special crops where the object is to produce sugar or starch—as with sugar beets and potatoes. It is also apparently essential for the formation of protein, and, thus, indirectly aids in formation of all organic matter.

Potash deficiency—a sickly appearance—roots highly susceptible to rot—the spaces between leaf veins at first show characteristic brownish stripes followed later by white spots causing a peculiar crinkling. Finally the leaves dry up with a more or less brown color.

Calcium,—used in agriculture in the carbonate form as limestone ($CaCO_3$) or as the hydrate $Ca(OH)_2$—is a constituent of the stem rather than the seed. It seems to impart hardiness to the plant. Soils containing an abundance of lime usually produce well nourished crops that are more capable of withstanding drouth and early frosts than crops not so well supplied with lime. The exact function of lime is not clearly understood, but it seems to aid in the construction of cell walls. According to some authorities the absence of lime is felt in less time than that of either potassium or phosphorus.

A deficiency of calcium results in (1) stunting and discoloration of roots, (2) a brown-spotting and subsequent death of leaves. The calcium supply regulates movement of fats in the plant. Calcium neutralizes organic acids in the plant. It is claimed that a supply of lime is just as essential to the plant to form cell walls from sugar and starch, as it is to the animal for forming bones. Calcium as lime has a decided influence on the mechanical condition of the soil, and is a liberator of plant food.

A proper balance in the supply of nitrogen, phosphoric acid, potash and lime has a decided influence on the nature of the plant produced. Each constituent has its own particular work to do, and the absence or deficiency of any one causes the death or the incomplete development of the plant. Moreover, plant nutrients are absorbed during the early stages of growth; for instance, a cereal crop contains at the time of full bloom, nearly all the nitrogen and potash which is found in the mature plant. The assimilation of phosphoric acid continues somewhat later. It is therefore necessary that crops have a good supply of these important constituents of plant growth in a readily available form if they are to make proper development.

Sulphur. This element is taken up in varying amounts by different types of crops. Sulphate of ammonia increases the yield of crops rich in protein.

Iron, is necessary for the formation of chlorophyll. It is usually present in sufficient amount in any soil.

Magnesium. Like phosphorus, magnesium finally moves to the seed unlike calcium and potassium which remain behind in the leaf or straw. Magnesium is necessary to healthy maintenance of chlorophyll. A lack of magnesium causes a streaky leaf known as "sand-drown." Magnesium seems to be necessary for the formation of oils.

OTHER CONSTITUENTS

It is common experience to find in addition to the ten elements mentioned above, 6 other elements:—

Chlorine (Cl)	Sodium (Na)
Manganese (Mn)	Silicon (Si)
Iodine (I)	Boron (B)

Chlorine enters the plant in solution of chloride salts. Small amounts have been found to be beneficial, especially to barley grain. In greater quantities chlorine becomes toxic. For instance, an excess of Sodium chloride is commonly seen in alkaline soils.

Sodium, does not appear to be essential to crops. It can substitute to a limited extent for potash, hence it staves off potash starvation. Sodium functions somewhat the same as potash in the building up of starch and the filling of cereals.

Manganese, is claimed by some investigators to be essential to plant growth. It seems to be of special importance to legumes, oats and barley on certain types of soil. It has been found to be especially valuable to tomatoes on very sandy soils. Citrus fruits growing on sandy soils showing chlorosis are successfully treated by the addition of Sulphate of Manganese.

Silicon. Just what is the function of silicon is not clearly known. It has been observed that "silicates act by causing an increasing assimilation of phosphoric acid by the plant, the seat of action being in the plant and not in the soil."

Iodine, appears to increase plant growth.

Boron, is apparently an essential for the development of some but not all legumes. One of the most striking indications is the development of root nodules. Boron has a distinct stimulating effect upon the growth of tobacco and tomatoes, according to Swanbach and Johnston. Other investigators claim traces of Boron increase the effectiveness of nitrates. Director J. G. Lipman of New Jersey Agricultural Experiment Station claims that the leaves of Boron-deficient plants contain about twice as much sugar as those of Boron-treated plants. Like relations were found in the case of starch. Boron is not able to replace any one of the essential elements, but a definite asociation with the absorption of calcium is strongly suggested. A considerable amount of Boron proves toxic to growing crops.

N.B. Most of the information regarding the rarer elements of plant constitution has been taken from E. J. Russell's "The Rothamsted Monographs of Agricultural Science."

DIFFERENCES IN HABITS OF GROWTH

Plants differ very much in their habits of growth and in their ability to secure that which they need. Cereal crops contain much less nitrogen than legumes, but they have more difficulty in securing it. Autumn sown cereals have both deeper roots and longer period of growth than those sown in the spring, consequently are better able to supply themselves with necessary ash constituents. Spring tillage for barley, oats, and garden crops aids nitrification in the soil, hence these crops have less difficulty in securing nitrogen. Barley, however, has a very short period of growth and is shallow rooted. Corn and root crops besides being spring sown, have a much longer period of growth than cereals, hence have command of nitrates produced during the whole summer. They have fairly extensive root development, but do not always secure all the potash and phosphoric acid required for the production of a maximum crop of best quality.

A striking characteristic of all legumes is the large amount of nitrogen, potash, and lime found in them. Although they contain fully twice as much nitrogen as cereals, by virtue of bacteria in the nodules on their roots, legumes can make use of atmospheric nitrogen. On the other hand, they have difficulty in collecting potash. Consequently, legumes sometimes suffer for want of this constituent in the soil while cereals may find an abundance of it in the same soil. Legumes do not thrive in an acid soil.

SOURCE OF PLANT NUTRIENTS

Plants obtain the elements out of which they are built partly from the atmosphere and partly from the soil. From the atmosphere crops gather carbon and oxygen, and some plants, through outside agencies, are able to collect nitrogen. Nearly fifty per cent. of the dry matter of the plant is made up of carbon which is entirely derived from the carbon dioxide of the air. Although this compound forms but 3 or 4 parts in 10,000 of the atmosphere, the quantity is sufficient, owing to the wind continually bringing fresh supplies to the leaves. For the same reason there is an abundance of oxygen around the leaves of the plant; but, if the soil is not open and porous, there may not be enough in contact with the roots. It is worthy of note that air in the soil, in which crops are growing, is as essential to plants as air in the stable is to the animal. This ventilation of the soil is required to supply oxygen for the germinating of seed and to permit roots to live. They, too, must breathe. Moreover, air must be available to the millions of microscopic organisms in the soil which are busy preparing soluble food for the plant. The ventilation of the soil is required to supply free nitrogen for the use of nitrogen-fixing bacteria, and to remove the excess of carbon dioxide which is being set free continually in the soil.

From the soil the plant derives nitrogen, (chiefly in the form of nitrates) ash substances, and water. Fortunately, although a number of nutrients are essential for the growth of the plant, there are only four that especially interest the farmer since the others are usually found in abundance. These four are, nitrogen, phosphoric acid, potash and calcium. A continuous supply of all the essential constituents of plant growth is absolutely necessary; for, if one constituent is lacking, or is present in insufficient quantity, no matter what amount of the other nutrients may be available, the plant will not develop fully. Just as a chain is as strong as its weakest link, so the crop-producing power of a soil is limited by the essential nutrient present in least quantity.

THE SOIL—THE PLANT HOME

In the preceding paragraphs we have stated that the plant derives its sustenance from two main sources, the atmosphere and the soil. Climatic conditions are a controlling factor in agriculture, but are not within the control of man. The soil is a vital part of plant environment. In so far as it fails to supply necessary constituents, it limits plant growth. If we can increase the amount of available plant nutrients in the soil, we can affect plant growth accordingly.

A prime requisite of successful soil management is a proper conception of the soil. Few people realize its complexity and many failures to obtain satisfactory yields with fertilizers arise from an inadequate knowledge of the soil.

All soils have this in common; they are composed of two classes of materials, mineral matter and organic matter. If you examine a sample of soil closely, you can distinguish between these two materials readily. Mineral matter has come from the weathering of rocks and is composed largely of tiny fragments of quartz, feldspar, mica, limestone, shale, etc. It is as variable in chemical composition as the various rocks from which it is derived. In some localities glaciers have helped to crumble, mix, and transport these rock materials. Waters from melting glaciers have sorted out different sized particles and aided in their distribution and deposition. The sorting action of glacial waters has been chiefly responsible for the differences in texture of our soils, i.e., sandy, sandy loam, loam, silt loam, clay loam, clay, etc.

Organic matter is composed of the bodies of plants and animals in varying stages of decay. It is less in amount than mineral matter in average "mineral" soils, being about three to five per cent. In muck or peat soils which are almost wholly organic, the amount may be as high as seventy-five to eighty per cent.

Soil is a complex medium because of the nature of its constituents. In it mineral and organic constituents are constantly interacting upon each other. Soil may be likened unto a very complicated, sensitive machine, which by reason of its complexity and sensitiveness requires most skilful handling for successful operation.

But just as there are many types of machines, there are many types of soils, some of which have been mentioned above. Each presents its own problems of management. Sand, loam, clay loam and clay are all distinct in their physical properties. We can go farther than merely distinguishing our soils by differences in texture. What of the influence of the parent rock from which the soil has been derived? A limestone soil we assume to be rich in lime; while shale and sandstone soils are apt to be quite deficient in lime. So, too, is soil derived largely from granite and other crystalline rock material. Some soils have developed under conditions conducive to the accumulation of much organic matter. These soils are dark brown to black, and are very different to ashy grey or yellow grey soils which are almost devoid of this constituent. Some soils have been deposited in deep glacial waters and are the finest sediments, carried into these waters by streams from the surrounding land. Such soils are fertile because they contain an abundance of soluble nutrients. These differences and others form the basis for classification of soils. A study of the soils of Southwestern Ontario in connection with the Soil Survey, ‡ based on such a classification, revealed many striking differences in our soils. These differences are reflected not only in physical and chemical composition but also in crop adaptation, crop yields and cultural requirements.

In order to illustrate differences in amounts of plant nutrients contained in some of our soils the analyses of several types appear below:

Table 1

Type	Nitrogen (N) Lbs. per ac. plow depth	Phosphoric Acid (P_2O_5) Lbs. per ac. plow depth	Potash (K_2O) Lbs. per ac. plow depth
Muck	15,000	1,000	2,500
Black clay	7,200	4,488	48,000
Red clay	1,200	4,000	40,000
Yellow gray clay loam	4,460	3,957	40,840
Yellow brown sandy loam	3,880	2,542	33,000
Yellow sand	2,000	2,093	25,000

While the figures given are for total quantities of plant nutrients, and do not give any definite clue as to amount of available nutrients, yet they are suitable for relative comparisons.

To use an extreme illustration, consider the nitrogen content of muck soil as contrasted with red clay. The analysis shows it to contain ten times as much nitrogen as red clay soil. It is obvious that a nitrogenous fertilizer would give more profitable returns on red clay soil than on muck.

In muck soil there is an abundance of nitrogen, while red clay is quite deficient in this element.

Now contrast the amounts of phosphoric acid and potash in the same two soils. Red clay contains four times as much phosphoric acid and over fifteen times as much potash as does muck soil.

Aside from a consideration of the crop, in this case we have two soils with distinctly different fertilizer requirements. Muck soil needs both phosphoric acid and potash. Red clay in turn needs nitrogen alone.

Again, compare the analysis of red clay and black clay for content of plant nutrients. Black clay has six times as much nitrogen, about the same amount of phosphoric acid, and slightly more potash than red clay. Here, too, the nitrogen requirements of the two soils are distinctly different. Further comparisons between other types disclose differences quite as marked as those mentioned above.

It is apparent from what has been said concerning different soil types that the nature of the soil has a great influence on its manurial requirements. When we have studied the relationship of the crop and its requirements, to the soil and its characteristics, then we shall be in a position to most efficiently treat the soil for more profitable production.

‡ Bull. 298, Prelim. Soil Survey of S.W. Ontario.

PROFILE STUDY

Study your soils.

The Department of Chemistry, for some time, has been conducting a survey of the soils of various counties in Ontario. In this survey not

Typical Profile Development in Naturally Well-drained Soils in Southern Ontario.

1. Cultivated surface layer containing more or less organic matter. Gray brown in color, 5 to 8 inches in depth. May be slightly alkaline, neutral or acid in reaction.

2. Leached layer-yellow gray to yellow brown color. 12 to 18 inches in depth. Lighter textured than the surface layer. May be neutral to strong-acid in reaction. More friable in nature than layer 1.

3. Reddish brown-chocolate brown or coffee colored clayey layer containing materials leached from the layers above. Compact, dense and less pervious to movement of water. Neutral to alkaline in reaction.

4. Parent geological material from which soil above has been formed. Usually high in lime, hence quite alkaline in reaction. May be gravel, sand, or clay or mixture of these. Color usually gray to drab.

Diagram A.

NOTE—In light sands, or extremely heavy clays and in natural poorly drained soils, the layers as shown above may be absent or only imperfectly developed.

only is the surface-vegetation and the composition and nature of the soil of plow depth recorded, but investigators have taken samples of the soil immediately below plow depth to what is known as parent material. These studies have enabled the Department to classify types of soils. These studies have made possible an interpretation of the origin, characteristics and correlation of soil types, and a tracing of changes the soils have undergone. The farmer's understanding of his soil, however, should not wait for a complete soil survey. You can study your own soils and classify them accordingly.

The area commonly thought of as the "soil" consists of the top 9 to 12″. This is the portion that has been worked by the plow and other tillage implements. This top soil is important inasmuch as its texture, its content of organic matter and its reaction, whether sweet or sour, determine whether or not it is a favorable medium wherein seeds may sprout and crops grow. Moreover the amount of plant nutrients it contains in an available form or in forms which nature can readily render available, determines to a large extent the quantity and quality of the crop it produces. The character of the soil underneath plow depth,—the subsoil—also has a very important bearing on its productivity. If you take a spade and carefully dig a hole into the soil you will discover differences in colour and physical condition. The darkness of the surface area indicates the amount of organic matter in it. The amount of organc matter is a direct measure of the soil's suitability for bacterial growth and its power to catch and hold water. For these reasons the frequent growing of green manures, plowing under crop residues and addition of farm manure are both desirable and essential to the keeping of the soil in good condition. The colour below the plow depth shows the condition of the circulation of air in the soil. **A yellow or reddish yellow colour** in this subsoil **indicates a good circulation of air** while **grey-blue or slate colour indicates poor drainage and poor aeration.** Air is absolutely necessary for the growth of crops and microscopic life in the soil.

In testing the soil for acidity, if the surface soil should be a pure sand the probability is that it will show considerable sourness. In the area 16 to 24″ underneath you may find the soil more acid than that above. The parent material, underneath all, will likely be alkaline. The reason for this is, that by processes of weathering and leaching of water through naturally drained soils such as sands, much limestone is dissolved and the lime is carried down through the area of accumulation to that of the parent material. The depth of the soil layers will depend entirely upon the nature of the soil, but the colour and characteristics of the layers are nature's report of activities which have occurred in the soil, making it suitable or unsuitable for large crop production.

It appears an easy thing to send a small sample of soil to the College for analysis. Chemical analysis can be made of such samples and the total content of nitrogen, phosphoric acid and potash reported. However, if the sample is taken from the surface only, it is not representative of that which is underneath,—the area which roots of farm crops penetrate. Modern soil survey aims at gaining knowledge of location, nature and depths of soil areas. It should be with this same purpose that the farmer takes spade in hand and studies the prevailing areas of his farm fields.

With facts in hand gained by personal examination,—facts concerning the depth and colour of the surface soil,—facts concerning the depth and reaction of the sub-surface soil and facts concerning the nature and reaction of the parent material below,—the observing farmer can regulate his farm practice so as to correct bad conditions in his surface soils and so as to place suitable crops upon soils of varying adaptabilities. Where unweathered soil indicates a distinct need of drainage the addition of plant nutrients in the shape of manure or fertilizers will not give their best results. Drainage is the first step in improvement. Study your soils, examine the organic content of plow depth, determine the nature and reaction of your subsoils, and ascertain how deep are your soils to the parent formation. This information will give you a definite basis on which to regulate your tillage and fertility practices.

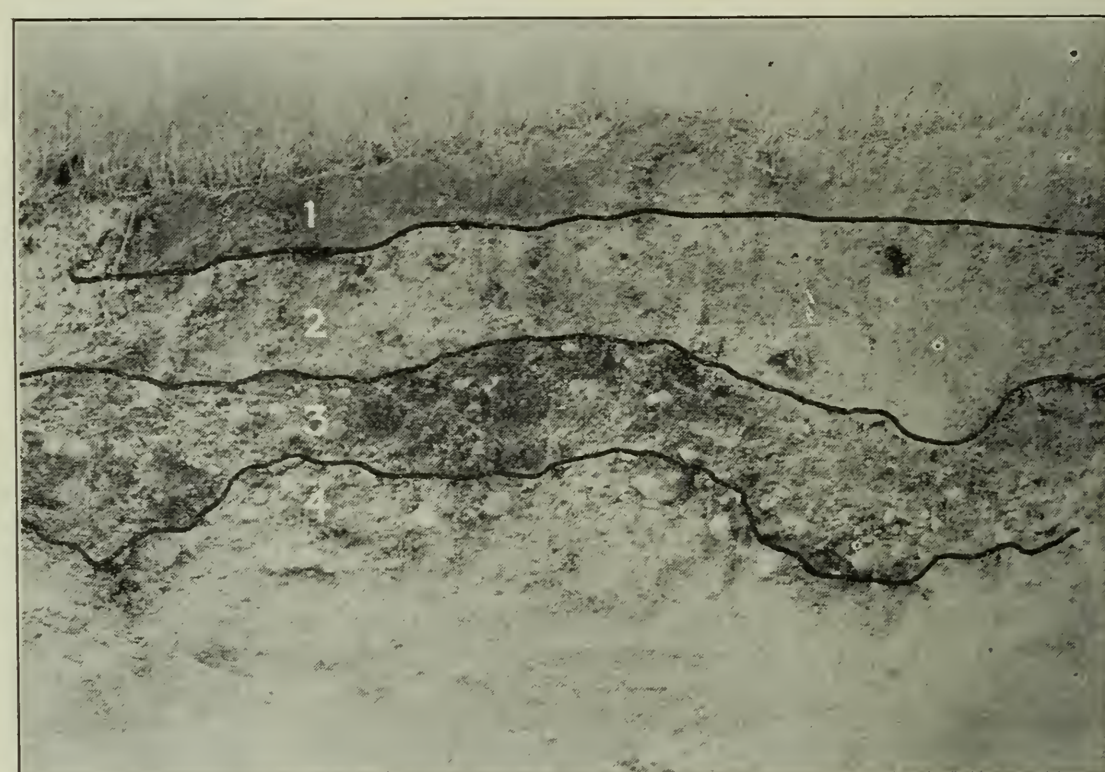


Fig. 1 Profile of Guelph Series

DRAINAGE

The first essential in soil improvement is to supply adequate drainage for all soils which are in need of it. A soil that contains more than its optimum amount of moisture is not a warm, well-aerated soil. It does not provide ideal conditions for growth of plant roots, nor is it a suitable medium for the development of the micro-organisms responsible for the decay of organic matter, changing of its nitrogen into an available form and the fixing of nitrogen from the air.

These processes which, in a well drained soil, indirectly make the nutrient elements available for plant use, are to a large extent restricted in the undrained soil. Such a soil cannot give maximum production. Nor is the response to fertilizer treatment as satisfactory on the undrained soil as it is on the well drained soil. In order that the plant may make the best use of fertilizers, the plant-environment must be the best possible. To this end proper drainage is absolutely a first essential. If a field is properly drained according to the needs of the soil type, the first great step has been made toward creating the best possible plant environment.

LIME WHERE NECESSARY

Although lime is not a fertilizer it is proper to discuss its place in connection with the use of commercial fertilizers.

Not all poorly drained soils are sour or acid and in need of lime. Frequently areas of low-lying poorly-drained soils are richer in lime than the surrounding higher, well-drained soils. In fact these latter are more lacking lime. Their rolling topography and coarse open texture, which account for their excellent natural drainage, make possible more vigorous leaching and washing out of their lime, and the leaching of it into the lower poorly drained soils.

It is not our intention here to discuss liming and soil acidity. The reader is referred to Bulletin No. 313 Liming and Soil Acidity, published by the Department of Chemistry, O.A.C., for a comprehensive, complete treatment of this subject.

The point to be brought out, however, is that on an acid soil fertilizers cannot give as good results as on a neutral soil. An acid soil, like a water-logged soil is not a healthy environment for most crops, and even though nutrients are supplied in the form of fertilizers in liberal quantities, the plant's feeding capacity will be limited by its environment. To sum up then, good soil management for most profitable returns from fertilizers, involves first, adequate drainage, second, where the soil needs it, the application of lime.

ORGANIC MATTER

Straw, stubble, or other crop residue, green manure crops and the bulky absorbent of barnyard manure, as well as fibrous roots of plants, and animal waste constitute organic mattter. This fibrous material is of supreme importance. Organic matter benefits the soil in four ways.

1. **Physical Effect.** Organic matter gives to sandy soil a binding medium which enables it to retain moisture and form a suitable home for growing crops. Organic matter opens up clay, adding to its water-holding capacity, but especially benefitting the circulation of air within the clay.

2. **Biological Effect.** Organic matter constitutes a medium or home for the microscopic life of the soil. It also constitutes the food supply upon which these micro-organisms live.

3. Organic matter in its decay liberates plant-food from the mineral part of soils.

4. Organic matter enables the soil to retain plant nutrients which have been brought into solution.

Experiments demonstrate clearly that carriers of potash and soluble nitrogen which would otherwise leach through the soil and escape in drainage waters, are more firmly held by a soil having a generous supply

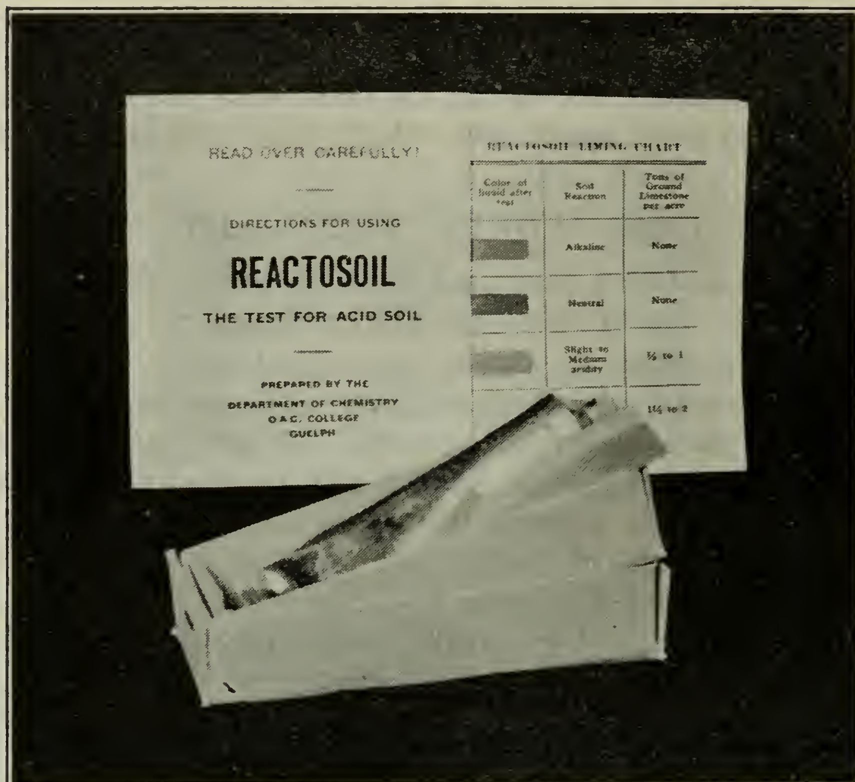


Fig. 2

The Reactosoil kit, consisting of Indicator material, Package of Waxed Papers, and Chart with full instructions for Testing the Acidity of Soils.

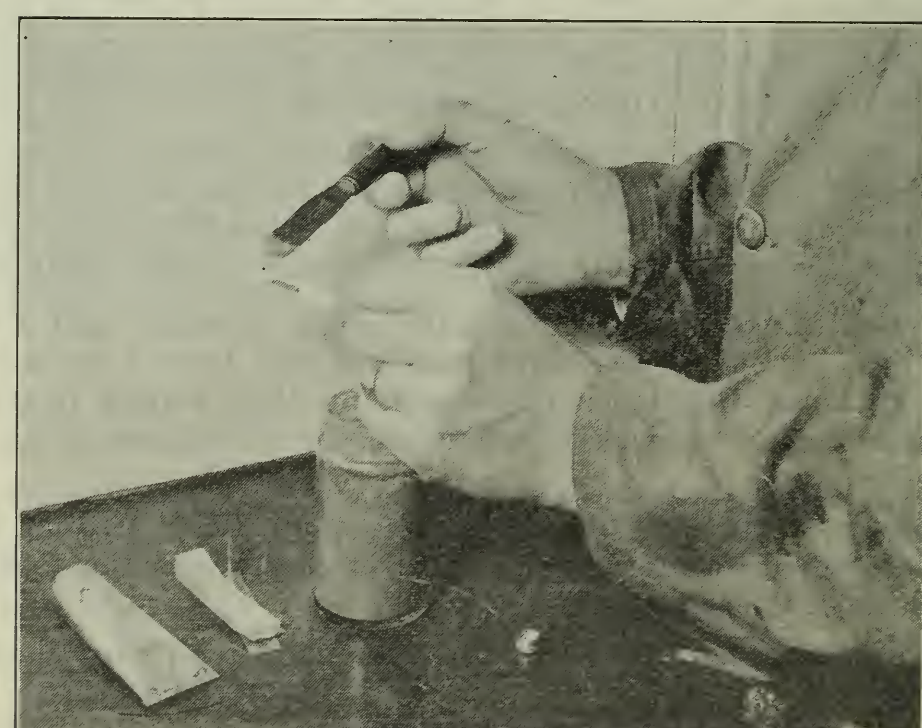


Fig. 3

How to Test Soils

Make a trough of one of the pages of waxed paper, do not allow fingers to touch the surface of same. Place a small sample of soil on the trough.

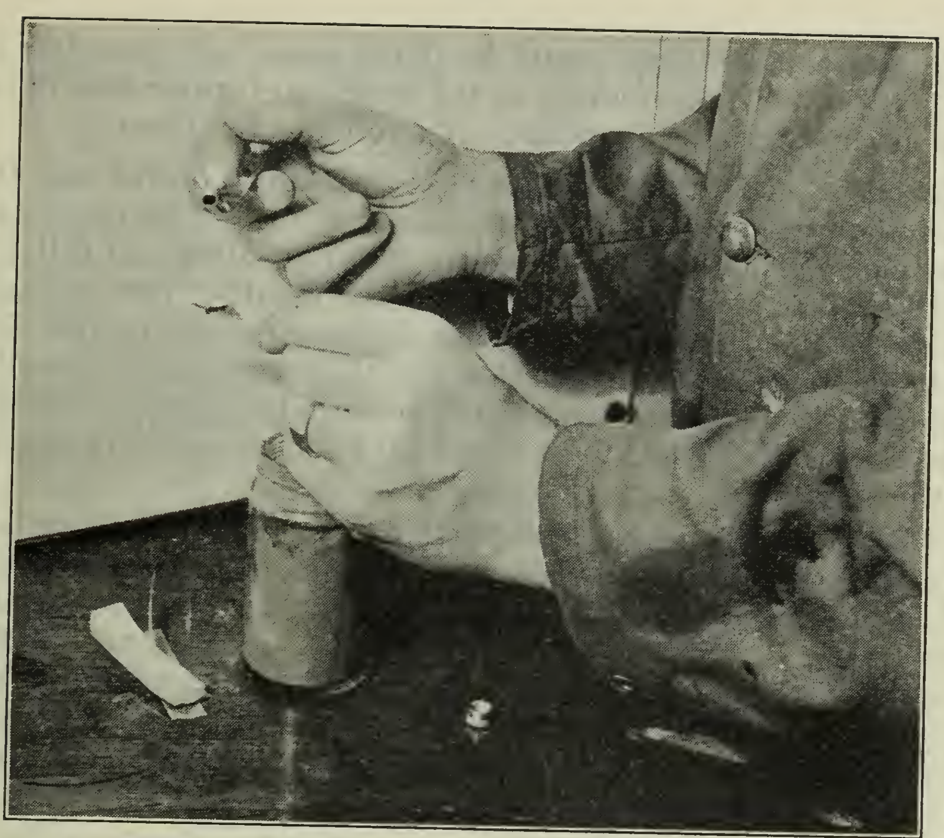


Fig. 4

Remove top of metal tube. Allow indicator to drop on soil until all is absorbed and there are one or two drops extra on the paper.

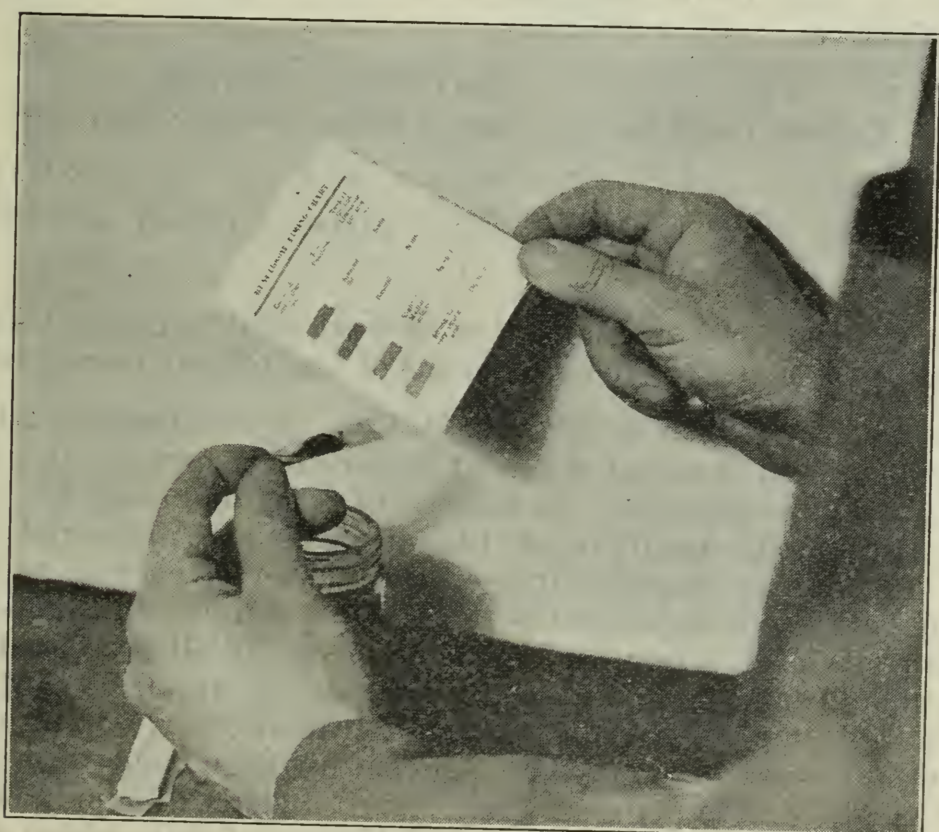


Fig. 5

Compare the color of the liquid with the color indicators on the chart and the degree of alkalinity or acidity of soil will be indicated.

of organic matter than they would be if the same soil were low in fibre. This is a point of definite interest to the practical farmer who is annually investing in considerable quantities of available fertilizers.

Sources of Soil Organic Matter. As already pointed out the main source of soil organic matter is plant tissue. Some of this matter accumulates from above ground, parts of plants that have died and fallen become mixed with surface soil; The remainder is the result of root extension and subsequent decay. Roughly we may divide organic matter into two classes (1) the more resistant portion (2) that part which is well decomposed. The first portion has most to do with the physical condition of the soil while the latter has most to do with the chemical changes taking place in the soil.

The Decomposition of Organic Matter. In nature nothing is wasted. Plant and animal residues in the soil become food for a lower type of life, such as fungi, yeasts, molds and bacteria. These proceed to break down the more or less complex compounds in organic matter and finally convert the material into a form in which it can be used again by higher plants. Thus we have higher plants building up their growth out of products discarded by lower forms of life; at death they in turn act as food for those lower forms.

During decomposition all mineral elements contained in organic matter are made available to plants. Further, carbon dioxide (CO_2) which results from decomposition, combined with water, exerts a solvent action on the minerals of the soil, rendering them available. This is illustrated by lime in the soil which is dissolved and made so that it becomes effective.

CO_2	+	H_2O	=	H_2CO_3
Carbon Dioxide		water	gives	carbonic acid

$CaCO_3$	+	H_2CO_3	=	$CaH_2(CO_3)_2$
Limestone		carbonic acid	gives	calcium bicarbonate
(Insoluble)				(Soluble)

From the above we see the action of weak acid in the soil dissolving limestone. This is one of the chief means of loss of lime from a soil.

Changes in Nitrogen in Organic Matter. It has been mentioned already that nitrogen is one of the most important elements. It is also one of which the loss is greatest. An important function of organic matter is to act as a storehouse for nitrogen, liberating it as it is required for plant growth. In order to supply nitrogen, the material plowed under must contain it. Hence it is desirable to use as a source of organic matter, materials containing a fair amount of nitrogen. Well preserved manure contains about ten pounds of nitrogen per ton. An application of ten tons per acre would supply sufficient nitrogen for almost any crop for a season. Dry clover hay contains about three per cent nitrogen, hence a second crop of clover yielding a ton per acre when turned under will supply 60 pounds of nitrogen which is equal to 1/5 ton of Nitrate of Soda which at $50.00 per ton=$10.00. This has been secured from the atmosphere. Non-legumes such as rye or buck-wheat, oats, etc., return to the soil only the nitrogen they removed from the soil. There is no gain.

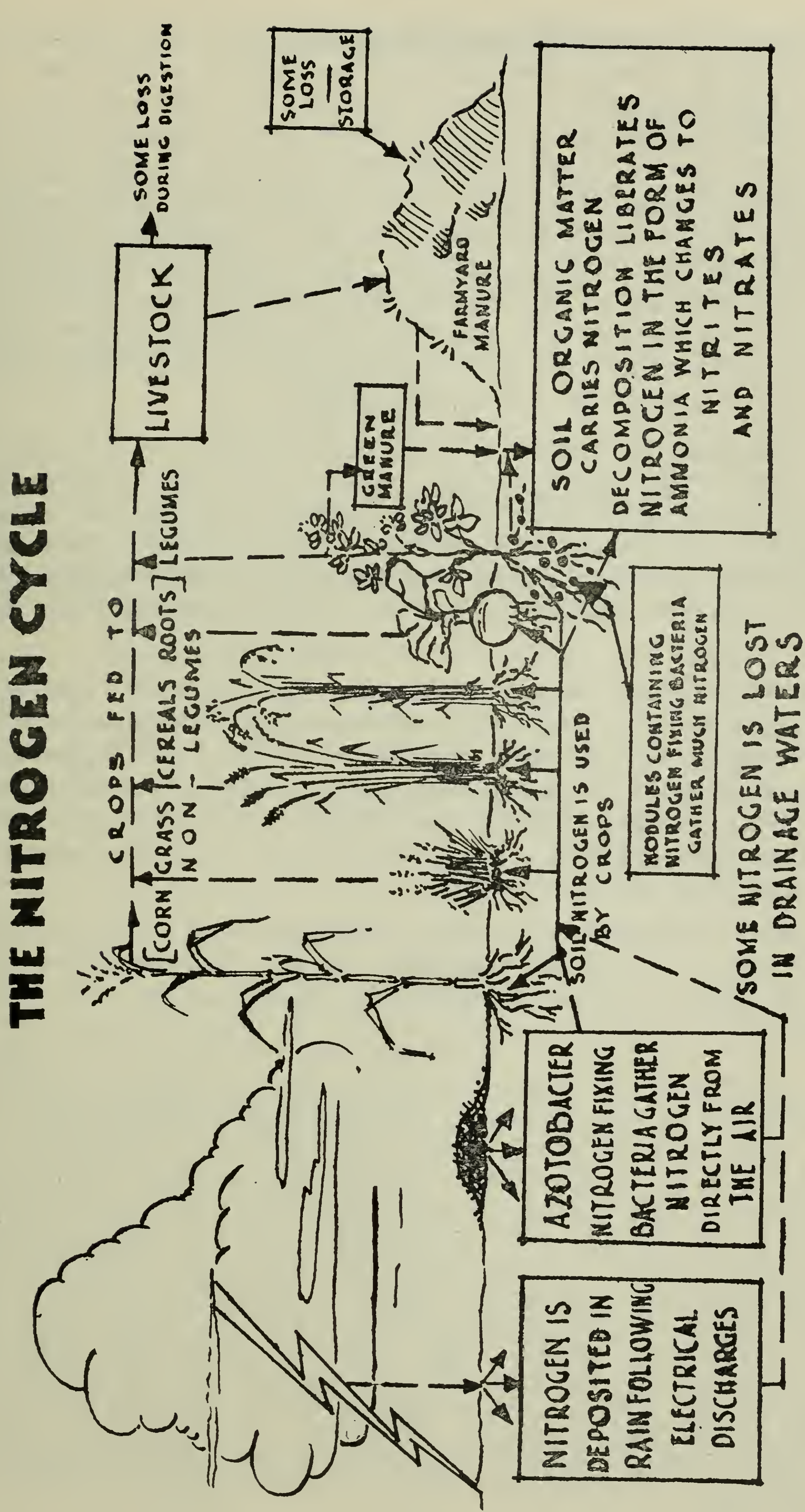


Diagram B

The above diagram shows the entry of Nitrogen into the soil, the passing of nitrogen into the crops which are fed to livestock, and the return of nitrogen to the soil through manure and through the nodules of legumes.

Changes of Nitrogen During Decomposition. The process of organic matter releasing mineral constituents has already been noted. Changes which nitrogen undergoes are very important. Soil analysis gives the total nitrogen content of a soil as high as 6,000 pounds per acre, on the basis of 2,000,000 pounds soil, plowdepth over one acre. Thus there would be enough nitrogen present to grow a sixty bushel crop of wheat for a number of years. If it were all available, (soluble) it would be lost by leaching. During that period of the year when frost does not prohibit bacterial activity, nature is constantly letting loose nitrogen from decaying organic matter. In the case of the summer fallow, this liberation of nitrogen may reach such quantities that much is lost by leaching, even though considerable is stored for succeeding crops.

The nitrogen in organic matter is mostly in the form of complex organic compounds which a plant cannot assimilate. When the plant decomposes these are broken down by bacteria into simpler forms finally appearing as compounds of ammonia. This breaking down process is termed ammonification. Plants can make use of ammonium compounds, but it is generally conceded that they prefer their nitrogen in nitrate form.

A further change then is necessary. Other bacteria use ammonium compounds, and, by a process of oxidation, build them into nitric acid. The nitric acid combines with calcium and other bases forming nitrates. Nitrates are soluble. Crops absorb nitrates through their roots and use the nitrogen contained therein. In younger stage of growth many crops absorb ammonia nitrogen. The change from ammonium compounds to nitrates is termed nitrification.

Diagram B depicts the cycle of nitrogen from the soil to the plant, from the plant to the animal, and from the animal and other sources back to the soil again. It also indicates where losses occur.

This cycle takes time. All the nitrogen is not converted into nitrates at once. We rarely find more than fifty pounds of nitrogen as nitrates per acre, although the total nitrogen content may be upward of five thousand pounds. The time required varies with the soil, temperature, rainfall, cultivation and the crop grown. The presence of lime hastens decay. It is most effective in its action in nitrification. Nitrifying bacteria require the presence of lime in order to function properly. Generally speaking, manure plowed under in spring begins to show effect within two months, providing conditions are right. Green manures decay rapidly and the nitrogen becomes available to the crop in a very short time, if green manures are not too mature. Such materials are blood-meal are very rapid in decomposition, and are converted into nitrates in a very short time. The rule with regard to formation of nitrates is—"the higher the nitrogen content of the material the more quickly it becomes available to plants."

How Organic Matter is Lost. Organic matter is depleted by continuous cropping and working the soil without putting back manure or without turning under green manure. Ohio Agricultural Experiment Station after thirty years investigation publishes the following results illustrating this point:

A THIRTY YEARS' TEST

Table 2

How the Soil was Treated	Organic matter left in 1 Acre of soil 9 in. deep.
The original soil contained	36,925 lbs.
1. Corn grown continuously	12,516 "
2. Oats grown continuously	21,722 "
3. Wheat grown continuously	21,826 "
4. A 5-year rotation (corn, oats, wheat, clover, timothy)	26,515 "
5. A 3-year rotation (potatoes, oats, clover)	29,549 "
6. A 5-year rotation plus 8 tons manure per A.	32,340 "
7. A 5-year rotation plus 16 tons manure per A.	36,510 "
8. A 5-year rotation plus Nitrate 320 lbs. A. Phos. 240 lbs. Potash 180 lbs.	32,410 "

Manure increases Water-holding Capacity.

Rothamstead Experimental Station, England, says: "Soil receiving 14 tons manure annually for 35 years, holds 32 tons more water per acre in the top 9″, than does the same soil without manure."

MAINTENANCE OF ORGANIC MATTER

It is obvious that the organic matter content of the soil must be kept up if the crop-producing power of the soil is to be maintained. Old organic matter has lost most of its nitrogen and the rate of decay is slow. As a result the amount of carbon dioxide given off is small, and its dissolving effect on the mineral constituents of the soil is almost negligible.

Fresh organic matter gives off a great deal of carbon dioxide and gives up its nitrogen readily. Hence it is desirable to keep adding fresh organic matter to the soil every year. This is quite satisfactorily accomplished by using manure. If the supply is limited it is preferable to spread it thinly over a greater area than to apply heavily on a small area. If the manure supply is limited, a system of green manuring must be practiced.

In selecting a cover crop suitable for green manures there are several points that should receive attention. First, the season in which the cover crop is to be grown. A crop selected for October sowing will differ from a crop selected for August sowing. Second, the ability of the crop to collect atmospheric nitrogen. Rye, buckwheat, oats, barley and other non-leguminous crops do not add nitrogen to the soil in the way that clovers and other leguminous crops do. Third, the presence of free lime in the soil. The majority of clovers do not grow well unless lime is present. Rye and other acid-resistant plants will grow if free lime is limited. Fourth, the soil preparation that is necessary for the specific crop; for large seeds such as rye and wheat, less careful preparation is necessary than for smaller seeds such as clover and timothy. Fifth, the time the green manure crop matures or is large enough to plow down. Sixth, the vigour of growth exhibited by the plant. If large growth is required, then sow a crop that will give bulk. If large root development is desired, as on soil with a tight sub-soil, then select a crop that has an abundant root system. Seventh, the cost of the seed. Some seed is dearer than others and poor seed is dear at any price.

With these points in mind crops can be selected intelligently,—particularly so, if the chemical composition of the crop is considered. The following table gives an idea of the value of an acre of cover crop turned under:

Table 3

Crop	Nitrogen	Phosphoric Acid	Potash
	lbs.	lbs.	lbs.
Clover, new	49.0	11.6	63.5
Clover, second crop	51.4	12.0	36.1
Clover, sweet	75.	48.	60.
Cow peas	61.9	15.4	77.2
Rye	24.0	11.4	39.0
Soy beans	152.2	27.3	100.8
Timothy	30.	10.5	39.
Vetch	121.2	27.2	85.5
Spring wheat	20	7	26
Winter wheat	20	7	26

The crop chosen should be such that it will not interfere materially with the regular rotation, nor will it displace a cash crop. If there are weeds to be destroyed and a summer fallow is necessary, a crop of soy beans may be sown. It will smother weeds and, at the same time will add the fertility of the soil. It is questionable whether bare fallows are profitable when one considers the loss of plantfood and crop.

The effect of a cover crop on soil moisture is also important. A growing crop removes from the soil large quantities of water. If it is grown before the revenue-producing crop there may be a scarcity of water for the cash crop. If two or three weeks elapse between plowing down the cover crop and seeding the main crop, the soil has a chance to recover from the draught made upon it by the cover crop. Therefore it is advisable to grow a cover crop after the cash crop rather than before, unless it can be turned under several weeks before the main crop is seeded.

Pic. 2

A Good Growth of Sweet Clover Being Thoroughly Plowed into the Soil.

Cover crops sometimes give trouble. If a heavy growth is plowed under the supply of water from beneath may be completely cut off with the result that the growing crop suffers and frequently dies from lack of moisture. Many promising crops have been ruined by plowing under a

Pic. 3

Condition of the Organic Matter Plowed into the Soil Six Weeks after Plowing.

Pic. 4

A Good Growth of Barley and Oats Being Plowed into the Soil as Green Manure.

heavy cover crop too late in the spring, where the resulting conditions were aggravated by insufficient packing and working of the top soil.

The proper time to turn down cover crops is when they are in a succulent condition—still growing. Rye is best turned under before heading. This is a safe rule in all cases. With soy beans, and other legumes it does not matter so much, because they are naturally soft and decay readily, even when fairly mature. This is not true, however, of sweet clover.

In the Western provinces large quantities of straw are burned annually. This is true in too many centres in Ontario. It has been suggested that straw might be added to the soil to supply organic matter. In this connection it is possible that difficulties might arise due to the peculiar action of straw.

However it may be suggested, that while it may be detrimental to apply straw immediately preceding the sowing of the crop, it could be applied satisfactorily in the fall or in conjunction with a second crop of clover or alfalfa in spring. This would offer a means of combatting excess nitrogen in rich alluvial soils.

Bacteria need carbon for the production of energy and they secure it from organic matter in the soil. At the same time they need nitrogen to build up their own bodies. Recent investigations have shown that for every hundred pounds of carbon decomposed, about one and one-half pounds of nitrogen are required. If there is much nitrogen in the straw no ill effects will be noted. But if the nitrogen content of the cover crop is lower than two per cent., the growth of the crop seeded on the land will suffer. The explanation is that the bacteria in an attempt to do their work, find themselves short of nitrogen in the straw on which they are working, hence they actually compete with the growing crop for the nitrates in the soil. As a result there is insufficient left for the growing crop. It has been pointed out that crops secure their nitrogen as nitrates, hence, when the supply is cut off, growth stops. **Nitrogen starvation sets in.** This condition can be remedied by applying with the straw sufficient nitrogen to supply the bacteria. They will then leave the nitrates in the soil alone and the application of straw will not have a detrimental affect on the crop unless the straw cuts off the supply of moisture rising by capillary action in the soil.

The straw of red or alsike clovers, soy beans or alfalfa will not have such detrimental effect since these straws contain a fairly high percentage of nitrogen.

If straw is to be incorporated with the soil it is preferable to stack it in the barnyard and allow the stock to run over it during the winter, rather than put it on the land directly from the stack. In this way it becomes partially decayed and the ill effects are not noticed so much. Put on in light applications, say up to five tons per acre, no serious results will likely be seen.

ARTIFICIAL MANURE

During the world war large production per acre was a necessity. With shortage of fertilizer materials at hand, effort was made to produce artificial manure from the straw of cereals. The original work was done at Rothamsted Experimental Station but has since been repeated at several American stations. A commercial material known as "Adco" is used to produce rapid decomposition.

In manufacturing artificial manure the straw, or plant refuse is built into a pile. From time to time other materials required are added. The pile is kept damp with a hose having a spray nozzle. When the heap is completed it is thoroughly soaked and let stand for a few days. It is again soaked and sprinkled liberally every two or three days; until it has been wet five times. It is recommended that at least 800 gallons of water be applied to a ton of straw. It is then allowed to stand until ready for use; which should not be more than three months.

This would appear to be impracticable for farmers but has a possible value for market gardeners or golf clubs that have difficulty in obtaining manure. At present the process is not recommended but further information will be given to any one applying to the Department of Chemistry, Ontario Agricultural College.

SUMMARY OF ORGANIC MATTER

1. Organic matter comes from decaying plant and animal residues.

2. When decomposing, organic matter gives up plant food to the growing crop and evolves carbon dioxide which brings into solution mineral portions of the soil.

3. Organic matter is of great value for improving the physical condition of the soil.

4. Organic matter acts as a storehouse for the soil nitrogen supply.

5. The nitrogen contained in organic matter must generally be changed into nitrates before growing crops can use it. Such change is gradual and sufficient to supply the needs for growing crops.

6. Organic matter may be kept up by manure, crop residues and cover crops plowed under.

7. The choice of a cover crop is important. It is affected by several conditions.

8. Cover crops are better grown **after** a revenue producing crop than before.

9. Leguminous crops are better than non-legumes.

10. Plowing under a cover crop should be done at least three weeks before seeding the revenue crop. It should be rolled immediately after plowing and worked.

11. Straw can be used to restore organic matter, but must be carefully handled.

12. Organic matter and cover crops prevent leaching and loss of plant nutrients.

THE NEED FOR MANURE AND FERTILIZERS

Of the plant nutrients lost from the soil nitrogen is the only one which is partly replaced in crops. We have seen elsewhere that approximately 40 per cent. of the loss is met by additions of nitrogen in rain and snow and by organisms in the soil.

The losses of phosphorus, potash and lime on the other hand are complete and must be replaced.

If the normal fertility of the soil is to be kept up additions of materials carrying necessary nutrients must be made. By returning to the soil manure made from crops grown upon it, a portion at least of the nutrients will be replaced. The value of such manure will depend on many factors, and is quite variable.

Frequently the quantity of manure to be obtained is small, especially so in specialized farming areas. Therefore it must be supplemented with fertilizers which contain plant nutrients in proper proportions and amounts, to suit the needs of soils and crops.

Under these circumstances it is necessary for us to have a thorough knowledge of the nature, composition and uses of farmyard manure and fertilizers so that it may be possible to maintain economically, maximum production with the minimum exhaustion of our soils.

LOSSES OF PLANT NUTRIENTS FROM THE SOIL

There are two ways in which plant nutrients are removed from the soil, viz: cropping and leaching. In order to fully appreciate the drain on our soils, it is necessary to consider each of these factors separately.

By Cropping

In nature the actual loss of nutrients from the soil is comparatively small, for the plants when they die, fall on the soil and in the process of decay the nutrients they contain are almost wholly returned to the soil. At the same time there is an actual gain of organic matter since this has been built up from carbon, hydrogen and oxygen taken from air and water. The decay of this organic matter is indirectly responsible for the release of mineral nutrients in the soil and the maintenance of soil fertility. In some cases fertility may even be increased, for losses through leaching are slight and are counter-balanced by the disintegration processes in the soil, and the fixation of nitrogen from the atmosphere.

When soil is brought under cultivation however, the condition is entirely changed. Crops are removed from the soil and only a portion of the nutrients they contain is ever returned to the soil. Every bushel of wheat made into flour and consumed far from the point of production; every gallon of milk that goes to the city milk route, or to the cheese factory, every animal sold, every crop of vegetables, tobacco, sugar beets, or potatoes removed from the farm, represents a direct loss to the soil.

In dairy farming the great proportion of the crop grown is fed on the farm, hence there is the greatest possible return of fertility to the soil. Yet the loss in milk or animals sold from the farm remains.

The following table taken in part from "Chemistry of the Farm" by Warington, details the amount of nitrozen, phosphoric acid, potash and lime in pounds per acre, removed from the soil by some of the common crops.

CONSTITUENTS REMOVED PER ACRE BY CROPS

Table 4

Crop		Yield per ac. lbs.	Nitrogen lbs.	Phosphoric Acid lbs.	Potash lbs.	Lime lbs.
Wheat						
	Grain	1800	34	14.2	9.3	1.0
30 bus.						
	Straw	3158	16	6.9	19.5	8.2
	Total	4958	50	21.1	28.8	9.2
Barley						
	Grain	2080	35	16.0	9.8	1.2
40 bus.						
	Straw	2447	14	4.7	25.9	8.0
	Total	4527	49	20.7	35.7	9.2
Oats						
	Grain	1890	34	13.0	9.1	1.8
45 bus.						
	Straw	2835	18	6.4	37.0	9.8
	Total	4725	52	19.4	46.1	11.6
Beans						
	Grain	1920	78	22.8	24.3	2.9
30 bus.						
	Straw	2240	29	6.3	42.8	26.3
	Total	4160	107	29.1	67.1	29.2
Turnips						
		36,000	98	21.7	79.7	42.4
Corn		4 tons	150	67	106.0	30.0
Red Clover		2 tons	102	24.9	83.4	90.1
Alfalfa		5 tons	238.0	55.0	223.0	465.0
Potatoes		200 bus.	46.0	21.5	16.5	3.4
Sugar beets		12 tons	65.0	24.0	80.0	18.0
Tobacco		1,200 lbs.	55.5	8.0	42.0	.....

AMOUNT OF ASH CONSTITUENTS AND NITROGEN IN 1000 LBS. OF VARIOUS ANIMALS AND THEIR PRODUCTS.

Table 5

Animal	Nitrogen lbs.	Phosphoric Acid lbs.	Potash lbs.	Lime lbs.	Magnesium lbs.
Fat Calf	24.64	15.35	2.06	16.46	0.79
Half fat Steer	27.45	18.39	2.05	21.11	0.85
Fat Steer	23.26	15.51	1.76	17.92	0.61
Fat Lamb	19.71	11.26	1.66	12.81	0.52
Fat Sheep	19.76	10.40	1.48	11.84	0.48
Fat Pig	17.65	6.54	1.38	6.36	0.32
Wool not washed	54.00	0.70	56.20	1.80	0.40
Wool washed	94.40	1.80	1.90	2.40	0.60
Milk	5.76	2.00	1.70	1.70	0.20
Hen's eggs	20.00	4.22	1.75	60.82	1.09

By Leaching

The loss of plant nutrients by leaching was first determined at Rothamsted Experimental Station, by analysis of the drainage water collected from tile drains under each of the variously treated plots. Determinations were made from five collections (1866-1868) and conclusions reached from these analyses are as follows:

(1) The nitrogen leached out of the soil is mainly in the form of nitrates. (2) Phosphoric acid does not appear in the drainage water except in traces. (3) Calcium (lime) appears in the highest concentration, with sulphur next.

The influence of treatment is quite marked on the amounts of lime, nitrogen, potash and sulphur present in drainage water. The addition of farmyard manure increased the losses of all nutrients. The application of nitrate of soda increased the amounts of nitrogen, potash and lime leached from the soil. All treatments seem to increase the amounts of lime in the drainage water. It is safe to assume that any fertilizer applied to the soil would have a similar effect.

Recent investigations over a period of ten years at Cornell Experiment Station, N.Y., provide valuable data regarding losses of nutrients through leaching and cropping, and the total loss of the two combined. The soil used in the experiment was a silty clay loam, of the same origin as soil extensively worked in Ontario. This fact should make these findings of special interest.

Average Annual Loss of Nutrients by Percolation and Cropping.
Table 6 Cornell Lysimeter Tanks. Average of 10 Years.

	Pounds to the Acre per Year				
Condition	N	P_2O_5	K_2O	CaO	SO_3
Drainage Losses:					
Bare	69.0	....	86.4	557.0	132.0
Rotation	7.3	....	68.7	345.9	108.5
Grass	2.5	....	74.0	363.8	111.0
Crop removal:					
Bare	....	....	....	....	....
Rotation	70.5	43.5	105.4	34.3	41.0
Grass	54.4	28.6	74.0	12.8	29.2
Total loss:					
Bare	69.0	....	86.4	557.0	132.0
Rotation	77.8	43.5	174.1	370.2	149.5
Grass	56.9	28.6	158.0	376.6	140.2

The findings of the Cornell investigation confirm the observations made at the Rothamsted Station. Phosphoric acid is not lost by leaching from either a bare or cropped soil. The effect of cropping a soil is to reduce the losses by leaching of nitrates, potash, lime and sulphur. In fact the combined losses due to cropping and leaching on a cropped soil are only slightly greater than the losses by leaching alone from uncropped bare soil, except in the case of phosphoric acid and potash.

Another point of interest brought out by this work, is the comparative effect of permanent pasture and rotation of crops on conserving nutrients in the soil. From the above table it will be seen that, while grass land removes less nutrients than rotation of crops, it has almost as great conserving effect on the nutrients in the drainage as have the crops in rotation.

The losses due to cropping and leaching may be summarized as follows:—

	Losses of				
Cropping	**Nitrogen**	**Phosphoric Acid**	Potash,	Lime	Sulphur
Leaching	Nitrogen	....	**Potash,**	**Lime**	**Sulphur**

Heavy type indicates where the loss of nutrients is greatest.

With representative figures for removal of nutrients from the soil and the analyses of average Ontario soils we should be able to calculate how long the nutrients in the soil will last under these conditions. Such calculation however does not take into consideration the return of nutrients in manures and residues from crops, nor the addition of nitrogen in rainfall and by means of nitrogen-fixing organisms in the soil.

Nitrogen Added to Soil by Rain

The analyses made of the rain and snowfall at the Central Experimental Farm, Ottawa, over a period of seventeen years, show that an average of six pounds of nitrogen is added to each acre of soil annually by rain and snow.

Investigations carried on in other countries seem to corroborate the Ottawa findings.

Nitrogen added to Soil by Micro Organisms

There is another way in which a portion of the loss of nitrogen from the soil is made up. Certain small microscopic forms of plants in the soil, known as bacteria have the power to draw on the nitrogen of the air, and utilize it for their growth provided the soil's acidity varies from pH of 6 to alkaline. Ultimately this nitrogen becomes available to higher plants. It is an important source of nitrogen in the soil.

The amount of nitrogen added to the soil by nitrogen fixation organisms is variable. It is generally assumed that the figure varies from 25 to 100 pounds of nitrogen per acre a year.

Comparing the amount of nitrogen added to the soil by organism with the additions made by rainfall, it is apparent that the soil organisms are about four times as productive of nitrogen as rainfall.

FARMYARD MANURE

Farmyard manure is one of the most important by-products of the farm. It contains materials which, when incorporated with the soil, serve as food to the plant. It is made up largely of organic matter, the importance of which has been discussed in previous paragraphs.

The composition of manure will vary with the kind and age of the animals contributing to it, the quality of the feed given the animals, the nature and proportion of the materials used as bedding and the care taken in preserving it.

Influence of Kind of Animal Contributing to it. In the case of a full grown animal neither gaining nor losing in weight—a working horse for instance—the quantity of nitrogen and ash constituents voided in the manure are nearly the same as that in the food consumed. Where the animal is increasing in size, is producing young, or furnishing wool or milk, the amount of nitrogen and ash constituents in the manure is less than that in the food; that is, it is in direct proportion to the quantity of these substances which have been converted into animal increase. Thus, with fattening cattle, sheep and with work horses more than 95 per cent. of the nitrogen and ash constituents in the food are voided in the manure. The pig retains a large proportion of nitrogen, but no more of the ash constituents. A milking cow retains a still larger proportion of nitrogen and ash. The largest animal increase is obtained in the young calf, when 70 per cent. of the nitrogen consumed is built into new tissues of the body and only 30 per cent. excreted as manure.

Influence of Quality of Feed. Some feeds are much richer in plant-food constituents than others. This is well illustrated in the following data which is taken from Warington's Chemistry of the Farm:

Table 7

	In 1000 pounds of food			
	Dry Matter lbs.	Nitrogen lbs.	Phosphoric lbs.	Potash lbs.
Cotton cake (decorticated)	918	72.0	32.5	15.8
Linseed meal	908	36.1	13.9	10.3
Beans	857	40.7	12.0	12.9
Peas	860	36.0	8.4	10.1
Brewers' grains (dried)	905	33.0	16.1	2.0
Wheat bran	868	22.6	26.9	15.2
Wheat	866	18.7	8.0	5.3
Rye	866	18.3	8.6	5.8
Oats	870	18.1	6.9	4.8
Barley	857	17.0	7.9	4.8
Corn (maize)	890	16.6	5.7	3.7
Clover hay (medium)	837	21.8	5.6	18.9
Meadow hay (medium)	863	14.7	4.1	13.2
Bean straw	816	13.0	2.7	18.7
Oat straw	855	6.4	2.8	17.7
Barley straw	858	5.6	2.0	10.6
Wheat straw	864	4.8	2.2	6.3
Potatoes	250	3.4	1.6	5.7
Mangels	120	2.0	0.8	4.8
Carrots	130	2.0	0.9	2.6
Swedes	107	2.2	0.6	2.0

Naturally excrements derived from cereal grains or clover hay are richer in plant-food than those from straw. For the same reason, it is evident that the kind and amount of bedding accounts for differences in composition of manure.

Distribution of Plant-food Constituents in Animal Excrements.

Farm manure consists of two original components: solids, or dung, and urine. They are in about the ratio of three to one. The solid excrement contains nearly all the phosphoric acid, the greater part of the lime, and some of the nitrogen; while the urine contains the greater part of the potash and usually the greater part of the nitrogen. The distribution of these constituents in the excrement of different animals is well illustrated in the following table:

Quantity, Composition and Value of Manure from Different Classes of Animals ‡‡

Table 8

	Horses	Dairy Cows	Steers	Sheep	Swine	Poultry
Lbs. manure produced per day per 1000 lbs. live weight	35-45	70-80	40-50	30-40	40-50	30-40
Lbs. per ton, Nitrogen	11.8	9.7	13.8	27.5	15.2	22.0
Phos. acid	5.6	5.4	5,6	9.9	9.5	17.0
Potash	14.6	9.4	10.5	22.7	14.6	11.2
Value per ton on basis of analysis ‡	$2.57	$2.00	$2.57	$5.16	$3.17	$4.16
Tons manure produced per year per 1000 lbs. live weight						
Value manure produced per year per 1000 lbs. live weight						

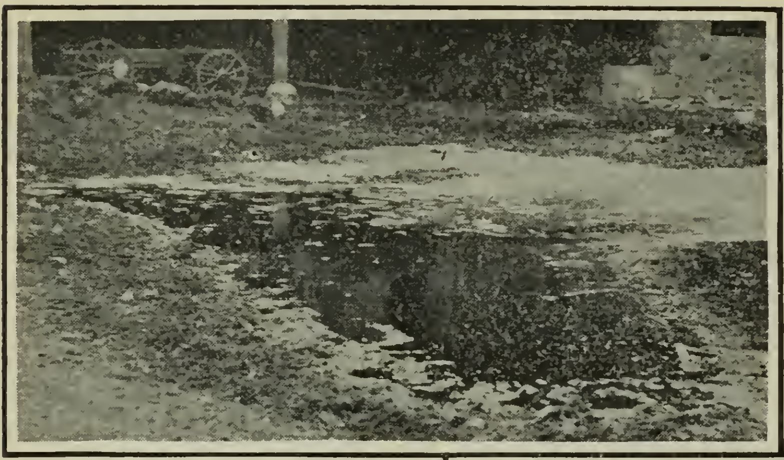
‡‡ This table is based on the records and analyses of a number of leading experiment stations.

‡ Nitrogen is valued at 12c; phosphoric acid at 5c; potash at 6c per lb.

Treatment of Manure. The treatment of manure is very important. As stated above, the greater part of the nitrogen and potash are found in the urine, consequently, if the liquid is lost or the manure is leached with water and the leachings are allowed to drain away, serious loss of nitrogen and potash occurs. Again, the nitrogen in the urine is largely in the form of urea, a compound that is speedily changed by fermentation into ammonium carbonate. This compound is readily broken up with liberation of ammonia, which being volatile, may be lost. This loss of nitrogen occurs while manure is still in the stable. German experimenters have pointed out that in the case of horses and cows the loss may amount to 30 per cent. of the nitrogen voided by the animal. The most effective method of diminishing this loss is by a liberal use of bedding which absorbs all the liquid. On the average Ontario farm straw is used for this purpose and is effective to a fair degree. Dried peat may also be used as an absorbent in the stable.

Farmyard manure readily undergoes decomposition; the nature of the products formed depend on the amount of air admitted or excluded. If the manure is thrown loosely into a heap it becomes very hot and rapidly wastes. The organic matter in this case is virtually burned, or is 'firefanged" as it is commonly termed, and ammonia is one of the products lost. If, on the other hand, the manure is consolidated and kept thoroughly moist so that air is excluded, the mass ferments with but little rise in temperature, and some nitrogen is volatilized. The loss of organic material will be far less with this kind of fermentation than in the previous one, but in both cases nitrogen is given off from the manure. Experience proves that there is the least waste of manurial constituents when manure is preserved in a box stall. Warington quotes an experi-

WASTEFUL VS. ECONOMIC METHODS OF HANDLING MANURE



Pic. 5

Where rain and snow is allowed to seep through manure piles the escaping brown liquid contains over half the potash and nitrogen carried by manure.

Pic. 6

Placing manure in small piles in the field is wasteful on account of weathering which destroys organic matter.

Pic. 7

Where manure has to be placed in a pile in the field, keep the pile compact.

Pic. 8

Hauling manure direct to fields and spreading entails some loss but is the most economical way of handling manure.

ment which showed that a quantity of food and litter which, in a box stall, yielded 10 tons of manure containing 108 pounds of nitrogen, and when carried daily to a heap, yielded only 7.5 tons, containing 64 pounds of nitrogen.

Undoubtedly, especially on heavy lands, the best returns from manure can be obtained when it is put on the land and at once plowed in. Losses that are inevitable when manure is stored, are prevented and a greater amount of organic matter is added to the soil. This is not always possible, but when manure must be stored it should be made without delay into a solid heap or mass and should not be allowed to become too dry. The practice is sometimes followed of drawing manure to the field during the winter months as fast as it is made. Provided the land is not too hilly, or too clayey, this will give good results. It is evident, however, that this method does not prevent losses, but is recommended to economize labor. When manure is drawn to a field and put in a big heap, care should be taken to make the heap as firm as possible, and, theoretically, it should be covered with earth, but this under our conditions of labor is possible.

Pic. 9
The manure spreader conserves labor and provides uniform application.

From what has been said it is evident that there are heavy losses of plant-food during the storage of manure. Lawes and Gilbert in their early work on this subject in estimating the manurial value of feeds supplied to fattening animals, first deducted the nitrogen, phosphates and potash which they estimate are retained by the animal. They then reckoned on having one-half of the remaining nitrogen, phosphates and potash. Even this they thought was too high. Lyon and Buckman in their book on the Nature and Properties of Soils, say: "Considering the losses which the food sustains during digestion and the waste of the manure in handling and storage, it cannot be expected that more than 25 per cent. of the organic matter, 30 per cent. of the nitrogen, 50 per cent. of the phosphoric acid, and 30 per cent. of the potash of the original crop will reach the land in the manure."

It is evident, considering all the factors affecting the composition of manure as it reaches the field that it is impossible to give an accurate statement of the amount of plant-food in stable manure. The nitrogen will vary between .45 and .65 per cent. or even higher if produced by highly fed animals. The amount of potash may vary from .4 to .8 per cent. and the phosphoric acid from .2 to .4 per cent. Thus one ton of farmyard manure may contain from 9 to 13 or 14 pounds of nitrogen, 8 to 16 pounds of potash, and 4 to 8 pounds of phosphoric acid. An approximate figure readily remembered is that one ton of manure contains 10 pounds of nitrogen, 5 pounds of phosphoric acid and 10 pounds of potash or in a fertilizer ratio of 6-3-6.

THE NEED OF FERTILIZERS

Fertility conditions on Ontario farms force three important facts to the attention of our farmers:

1. The supply of farmyard manure is inadequate to meet requirements, and is constantly diminishing.

2. Farmyard manure is unbalanced for many crops in the supply of plant nutrients that it carries.

3. Competitive acre yields in Europe and elsewhere are fast outstripping those harvested in Ontario.

The inference is clear. We must operate our plant more efficiently if Ontario farming is to hold its place in the business of the world. To this end an effective implement has been developed in the use of commercial fertilizers.

FERTILIZERS

The discovery and development of fertilizers dates to the early part of the past century and extends to the present. Bones were ground and added to the soil with excellent effect. The availability of the nutrients which they carried was greatly increased by treatment with sulphuric acid. As demand increased for phosphatic fertilizers, American phosphate-bearing rock was substituted for bone, and has since become practically the sole basis of this important constituent of fertilizers.

Nitrogen-carrying salts from Chile, and potassic salts from Germany and France rounded out the plant meal. Premier credit in discovery and in the development of this great industry must go to Liebig, Hellriegal, Lawes, Gilbert, Pugh and DeSaussure. A host of the world's most brilliant scientists have since contributed to the scientific development of fertilizers. Large increases have been made to the list of carriers of nitrogen, phosphoric acid and potash, now employed in the making of

Pic. 10 Sugar Beet Fertilizer Demonstration Plot
On farms throughout the Province demonstration tests of fertilizers of different analyses are maintained.

fertilizers. Especially since the Great War have material contributions been made in synthetic carriers of nitrogen. These rapid developments have made possible the manufacture of much more highly concentrated fertilizzers than were offered to the farmer a decade ago. Such rapid developments, however, emphasize the necessity of a more thorough understanding of the nature and function of fertilizer ingredients.

SOURCES OF PLANT NUTRIENTS IN FERTILIZER MATERIALS

Before any discussion of the uses of fertilizers can be dealt with, it is necessary to consider the sources of the different plant food elements which are purchased in these materials. The sources are varied and are well worth studying.

SOURCES OF NITROGEN

The sources of nitrogen may be divided into two classes: (1) Natural, and (2) Synthetic. The first are natural deposits such as nitrate of soda and organic materials; the latter are manufactured products from nitrogen obtained from the air. The natural products will be considered first.

Nitrate of Soda, Chile Salpeter (a natural product).—The commercial article is a fairly pure substance containing about 95 per cent. sodium nitrate. It is obtained from deposits on the west coast of South America, chiefly Chile. Nitrate occurs as the chief ingredient in the mineral caliche. It is dissolved out of the caliche with water, the solution evaporated and the solids remaining separated. Iodine is recovered during the process, and it has been suggested that since natural nitrate of soda contains small amounts of iodine it is superior to synthetic nitrate.

Chilean nitrate of soda contains from 15.5 to 16 per cent. of nitrogen, is water soluble and since it is a nitrate, it is immediately available to plants. In use it must be applied sparingly, never more than 250 pounds per acre in one application and never in direct contact with seeds or plant roots. An exact analysis of this salt is as follows:

CHEMICAL ANALYSIS OF CHILEAN NITRATE OF SODA

Table 9

Moisture at 130° C	1.470%
Insoluble Matter	0.097
Iron, Oxide and Aluminum	0.045
Calcium Nitrate	0.132
Magnesium Nitrate	0.699
Sodium Chloride	1.670
Sodium Iodate	0.086
Sodium Chlorate	0.043
Sodium Borate ($Na_2B_4O_7$)	0.368
Potassium Sulphate	0.309
Potassium Nitrate	1.140
Sodium Nitrate (by difference)	93.941
	100.000%

Synthetic nitrate of soda contains approximately 15 to 15.5% Sodium Nitrate.

Dried Blood or Blood Meal (a natural product).—Dried blood is quite extensively used as a fertilizer material. When animals are killed in modern abattoirs blood is collected and dried. The better qualities are used in various industries such as making buttons and other small articles. The poorer grades are used for fertilizers. The nitrogen very quickly becomes available to crops, i.e., it is changed into nitrates. It is an excellent fertilizer.

Blood meal is variable in analysis and averages about 13 per cent. It has a distinct advantage over soluble forms of nitrogen carriers in that, not being soluble, it cannot injure the roots unless in excessive applications. It has a particular field in gardening, in planting crops grown in hills where it can be mixed with the soil before planting without any danger of injuring or retarding germination.

Bone Meal.—See Bone Meal under Sources of Phosphoric Acid.

Tankage (a natural product).—Organic nitrogenous waste materials such as leather, felt, wool, hair, feathers, etc., are digested in large tanks with steam under pressure, with sulphuric acid added. The product is then dried and ground and is highly available as an organic nitrogenous fertilizer material containing from five to ten per cent. nitrogen, generally about six per cent. It also contains about ten per cent. phosphoric acid, hence is increasingly valuable since it supplies two elements. The nitrogen in this product is quite available.

Nitrate of Soda (Synthetic).—This product is purer generally than the natural form, but is essentially the same. It is prepared by the union of nitric acid with caustic soda, and crystallized out. Generally it contains a slightly higher per cent. of nitrogen than the natural product (about 16.5 per cent.) It is handled in the same manner.

Sulphate of Ammonia; Ammonium Sulphate (manufactured).—This is a salt formed from ammonia and sulphuric acid. The ammonia liquor from gas works and coking plants is treated in a still with lime. This sets free ammonia as a gas which is led into absorbing tanks containing dilute sulphuric acid. Sulphate of ammonia is formed, separated out and dried.

It is also being manufactured extensively in Europe from nitrogen obtained from the air. This form is now competing with the home product. Ammonium sulphate is soluble in water, but must be converted into nitrates by bacteria before growing plants can use it. It contains 20 per cent. nitrogen, approximately. It does not act as rapidly as nitrates.

Cyanamid (manufactured).—Cyanamid is a trade name for material containing about 21% nitrogen and 74% lime. It is made by passing nitrogen over a heated mass of calcium carbide. The nitrogen present is not as available as ammonium compounds and nitrates. It is used to supply up to 40% of the nitrogen carried in certain mixed fertilizers. It is also applied alone with good success. Experimental work has shown that in some cases it has depressed germination and, if used, should be applied some weeks before seeding. In actual practice, however, little difference is seen.

Ammo Phos. (manufactured).—A trade name for a commercial grade of ammonium phosphate made by combining ammonium sulphate with phosphoric acid. This is manufactured in several grades, hence the analysis is variable, from 10 to 16 per cent. nitrogen and from 20 to 47 per cent. phosphoric acid. In use, attention must be paid to the percentage of plant food present. The nitrogen is quickly available and it is excellent for use as a top dressing.

Ammo Phos Ko.—A further development of the above carrying all three plant nutrients. It is offered in 4 analyses:

Table 10

	Nitrogen	Available Phosphoric Acid	Potash	Plant-food Ratio
Ammo-Phos-Ko No. 1	12%	24%	12%	1-2-1
Ammo-Phos-Ko No. 2A	9%	18%	18%	1-2-2
Ammo-Phos-Ko No. 3	10%	30%	10%	1-3-1
Ammo-Phos-Ko No. 4	12%	16%	12%	3-4-3

Calcium Nitrate—Nitrolim, Nitrate of Lime (manufactured).—This is a compound formed from lime and nitric acid. It is produced in considerable quantities from nitric acid made from nitrogen secured from the air. The grade at present on the market contains about 15.5 per cent. of nitrogen and 28 per cent. lime. It is soluble in water and immediately available. In the field it is handled exactly the same as nitrate of soda.

Ammonium Sulphate--Nitrate (Leunasalpeter).—One of the newer synthetic nitrogen fertilizers. It contains a total of about 26 per cent. nitrogen of which one-fourth is in the form of a quick acting nitrate and three-fourths in the form of slower acting, but more lasting ammonia. It is made from sulphate of ammonia and ammonium nitrate. This product is of German origin.

Urea (trade name "Floranid").—This is also one of the newer nitrogenous fertilizer materials. It is produced by combining ammonia and carbonic acid under high pressure and at high temperature. It contains 46 per cent. nitrogen, which is higher than that of any other fertilizer on the market. It is a neutral material which contains nothing but plant food, and which leaves no acid or alkaline residue in the soil. As it is a very concentrated product it must be used carefully. Its nitrogen is in a form which becomes available very readily and the substance itself is soluble in water.

Nitro-Chalk (N15.5%) is an English product carrying approximately half its nitrogen as nitrate and half as ammonia. In addition it contains 48% lime.

Potash-Ammonium Nitrate.—This substance supplies both potash and nitrogen to the plant. It is a new product made from nitrogen obtained from the air. Where both nitrogen and potash are required it might be valuable, but there are few instances of this type since our greatest need in Ontario is phosphoric acid. It contains 15.5 per cent. nitrogen in an available form and 27 per cent. potash, also available.

Nitrophoska.—A highly concentrated fertilizer manufactured synthetically in Germany, and offered in Canada under four grades.

	Composition		
	Nitrogen	Phosphoric acid	Potash
No. 1	15%	30%	15%
No. 2	16.5%	16.5%	20%
No. 3	15.5%	15.5%	19%
No. 4	15%	11%	26.5%

Table 11

SUMMARY OF SOURCES OF NITROGEN

Material	Appearance	% N.	When available	Natural or manufactured	Remarks
Nitrate of soda: 1. Natural .... 2. Mfg.	 White crystals... White crystals...	 15.5 15.5	 At once At once	 Natural Mfg.	Used for top dressing. Never more than 250 lbs. per acre at one application. Danger of loss by leaching and of injury by too heavy application.
Blood meal	Red brown powder	12	3 weeks	Natural	No loss by leaching. Splendid for fertilizing hill or row crops in gardens. Safe to use in reasonable quantities. Does not give immediate results.
Tankage	Red brown powder	5-10	1-3 weeks	Natural	Same as blood meal.
Fish scrap	Variable	6-10	1-3 weeks	Natural	Same as blood meal. Rarely used or sold in Ontario.
Sulphate of ammonia	White crystals or yellowish	20	1-3 weeks	Mfg.	Used for top dressing or in complete fertilizers. Soluble in water. Must be used carefully. No loss by leaching, but slower in action than nitrates.
Cyanamid	Grey to black powder	20-25	3 weeks or longer	Mfg.	Rarely used alone. Used in manufacture of complete fertilizers.
Ammo, phos	White powder	10-16	1-3 weeks	Mfg.	Good for top dressing. No loss by leaching. Used mainly in vegetable work and on golf greens.
Calcium nitrate	White crystals	16-5	At once	Mfg.	Used the same as nitrate of soda, but also supplies calcium, and is therefore superior. May be lost by leaching
Ammonia sulphate-nitrate	White crystals	26%	At once	Mfg.	An excellent product used for same purpose as nitrate of soda, but effects last longer. Loss by leaching small.
Urea	White crystals	46	1-3 weeks	Mfg.	Can be used for any purpose that nitrate of soda can. Should be used carefully. Is not as rapid in action as the nitrates. Can be mixed with anything but lime. Little loss by leaching. An excellent product.
Potash ammonium nitrate.	White crystals		At once	Mfg.	Little value for Ontario conditions. Possible uses in floriculture.

SOURCES OF PHOSPHORIC ACID

Rock Phosphate — CalciumPhosphate.—This is a natural deposit occurring in many parts of the world. In Tennessee it occurs as a reddish brown rock, while in Florida it occurs as white or greyish white pebbles. It is quarried or dug with steam shovels and crushed. Mr. W. H. Waggaman, Scientist in Fertilizer Investigation, United States Department of Agriculture, says, "While the better grades of material (Tennessee Rock Phosphate), will analyze as high as 78% tricalcium phosphate, the average grade is about 72% with 5% combined oxides or iron and aluminum. Some of the lower grades analyzing 60% tricalcium phosphate and combining relatively large amounts of iron and aluminum oxides are very finely ground and sold for direct application to the soil.

Basic Slag—Thomas Slag—Thomas Phosphate.—This slag is a by-product of the manufacture of steel. Pig iron or iron ore may contain from 2 to 3% of phosphorus, which must be removed in order to produce high grade steel. The ore is melted in a converter which has been lined with lime and magnesia. Air is blown through the molton iron, oxidizing the phosphorus, which immediately combines with the lime and magnesia lining of the converter. When the molten iron, deprived of its phosphorus, is drawn off, the lining of the converter is removed. It now consists of a combination of lime and phorphorus, or tetra calcic phosphate. This is ground and offered to the trade as Basic Slag or Thomas Slag.

When steel was made by the Bessemer process the Basic Slag contained from 17 to 21% tetra calcic phosphate. A new method of melting the ore, known as the Open Hearth method was devised. This method required the introduction of considerable silicon into the flux, which in turn weakened the phosphoric acid in the slag just as the addition of water weakens the strength of a brew of coffee. The Fertilizer Act is now amended to require a minimum of 10% total phosphoric acid to be present in basic slag that is offered for sale in Canada.

Bone Meal—Crushed Bones.—The fertilizer industry got its start when Sir John Bennett Lawes in 1842 took out the first patent for making superphosphate from bones by adding acid thereto.

To-day the amount of acid phosphate used is far in excess of the amount of bone meal, but ground animal bones are still an important raw material in the fertilizer industry. A large supply of bones comes from abattoirs and butcher shops. These bones are steamed to remove grease and are then ground and sold for fertilizers. Raw crushed bones contain from 3 to 4 per cent. nitrogen and from 18 to 24 per cent. phosphoric acid. The availability of the phosphoric acid is dependent on the fineness of grinding.

Steamed Bone Meal.—When grease and other organic matter is removed from bones by steaming, the residue is chalky in appearance and easily crushed. Steamed bone meal carries less nitrogen than the crushed bones, 1 to 2 per cent. and the phosphoric acid content is slightly greater. As a source of phosphoric acid the steamed form is preferable.

Bone Ash.—When bones are burned with free access to air they burn to a greyish white ash. This ash contains practically no nitrogen but is high in phosphoric acid, containing from 35 to 38 per cent. Bone ash is not extensively produced or used in the fertilizer business.

Bone Black.—When bones are heated in closed retorts similar to those for making coke from coal, the residual charcoal is known as bone black. By this treatment a large part of the volatile organic matter is driven off. This consists of ammonia, and a gas similar to illuminating gas. Bone black prepared in this way is used for refining sugar, oil, etc., and brings a much higher price than bone meal. After the bone black has been used for some time by the various refineries it becomes unfit for their use and is usually sold to fertilizer manufacturers. Fresh bone black contains about 1 per cent. nitrogen and from 32 to 35 per cent. phosphoric acid.

Ammo. Phos.—See under Sources of Nitrogen.

Tankage.—See under Sources of Nitrogen.

Superphosphate–Acid Phosphate.—This is the chief material supplying phosphoric acid used in fertilizers. It is made by mixing together approximately equal weights of finely ground phosphate rock and sulphuric acid. The mixing is done in flat circular pans provided with heavy stirrers, which give a quick and thorough mixing of the rock and acid. From these pans the mixture, still liquid, is dropped into a "hot den" where it solidifies. After remaining in this bin a time the mass becomes solid and may be removed with a pick and shovel or by some mechanical device. The material is then crushed and allowed to cure, after which it is used alone or in mixtures as a fertilizer.

The purpose of treating the rock with sulphuric acid is to render the phosphoric acid available. The reaction is as follows:—

$$Ca_3(PO_4)_2 + 2H_2SO_4 + 5H_2O$$

$$= CaH_4(PO_4)_2.H_2O + 2CaSO_4.2H_2O$$

The mixture of mono-calcic phosphate and gypsum is what is called acid phosphate. Acid phosphate contains 16% available phosphoric acid, although the total phosphoric acid content may be as high as 18 per cent.

New Methods of Manufacturing Acid Phos. or Superphosphate.

Wet grinding of phosphate rock is displacing dry grinding. Phos. Rock is ground 0.25–0.50 inch in dilute phosphoric acid containing about

12–15% P_2O_5. Specially constructed acid resistant mills make this possible. By this method up to 3% dust loss is prevented; operating costs are lowered and the by-product $CaSO_4$ is crystallized and can be more easily removed.

A new method of superphosphate manufacture originating in Baltimore is now in use. Cured superphosphate is delivered in one hour with a reduction in the amount of acid used. The product is in granular form, having approximately 2–3% water, 20–21% total P_2O_5, and citrate insoluble P_2O_5 of 1—2%.

Double and Treble Superphosphate

When superphosphate is made by treating finely ground phosphate rock with H_2SO_4, soluble acid phosphate and calcium sulphate are formed. $CaSO_4$ forms about 50% of the product.

If the rock phosphate is treated with an excess of dilute sulphuric, acid, and the gypsum is removed, the liquid that remains can be concentrated by evaporation, and used to treat high grade phosphate rock. The result is a soluble phosphate that contains 45% available P_2O_5 in the form of mono-calcic phosphate. This is almost 3 times as strong as 16% acid phosphate.

Other Phosphoric Acid Carriers.—Several other substances carrying phosphoric acid are at present on the market, but they are no better than those we have here listed. The percentage of phosphoric acid is variable and care should be taken to examine closely the analysis tag. If analysis is not given as required by the Fertilizer Act, such materials should be reported to the Department of Agriculture, Seed Branch, Ottawa.

Table 12

SOURCES OF PHOSPHORIC ACID

Material	Appearance	Per cent. available P_2O_5	Per cent. Total P_2O_5	When available	Remarks
Rock phosphate	White grey or yellow powder	0	18-30	Very slowly	Not used greatly in Canada as results are too slow. Possibly of value in a soil which is very low in phosphoric acid.
Basic slag	Black grey powder	Variable, 5-12%..	12-14	Part at once. Rest same as above.	Bessemer slag better than open hearth. Lime contained haas benefit on very acid soil. 80% must pass 100-mesh sieve.
Bone meal, crushed bones	Grayish white	Depends on fineness of grinding	18-24	Throughout the season and after.	Good garden material. Used for roses, etc. Too expensive for general farm use.
Steamed bone meal	Grayish white, quite fine		24-28	Throughout the season and after.	More quickly available than crushed bone. No odour. Decays very readily.
Bone ash	Grayish white	Variable................	35-38	Throughout the season	Not much obtainable for use.
Bone black	Black	Variable...............	32-35		Used Generally in mixed fertilizers. Rarely used separately.
Acid phosphate	White or grayish. Some has odour.	14-22	14-25	At once	The best and cheapest source of phosphoric acid. Instantly available, easy to handle, economical and satisfactory.

SOURCES OF PHOSPHORIC ACID—Continued

Material	Appearance	Per cent. available P_2O_5	Per-cent total P_2O_5	When available	Remarks
Ammo.-phos.	White powder	20-47	20-47	At once	A concentrated product. Carries nitrogen as well as P_2O_5. Only one grade sold—the 20%. Used for golf greens. The 47% grade sold to fertilizer manufacturers. See nitrogen summary.
Tankage	Red to brown material	Variable	10-14	Throughout the season	Carries 6% nitrogen as well. Not used much alone, but is used in making complete fertilizers. Used for golf greens and by gardeners.
Double superphosphate.	White or grayish powder.	40-50	40-50	At once	Very concentrated—really concentrated acid phosphate used in less quantities. Used for making high analysis fertilizers such as 10-16-14.

NOTE 1.—If bone products are treated with sulphuric acid the availability of the P_2O_5 is greatly increased. This is done in some cases.

SOURCES OF POTASH

Potassium Chloride–Chloride of Potash–Muriate of Potash. This is a natural product, somewhat purified as it is sold. It exists in large deposits in Germany and France, from which we obtain most of our supplies. It is a soluble substance, varying in appearance and colour, and the potash contained in it is instantly available. For fertilizer purposes it is usually sold on a basis of 80 per cent. potassium chloride, equivalent to 50.5 per cent. potash, but may contain as high as 62 per cent.

Potassium Sulphate–Sulphate of Potash.—This substance can be made by the action of sulphuric acid on caustic potash. Some of it occurs naturally in French and German deposits. In practice, however, it is nearly all made by treating muriate of potash with magnesium sulphate. For fertilizer purposes, sulphate of potash is sold on a basis of 90 per cent. sulphate of potash, equivalent to 48.7 per cent. potash.

Since it is a manufactured product it retails at a higher price than the muriate, so that fertilizer dealers usually state: "In case potash is required as sulphate an additional charge per ton will be made."

Sulphate of potash is instantly available and is preferred for specialized crops such as tobacco, grapes and sometimes potatoes.

Carbonate of Potash–Potassium Carbonate.—This is a domestic product obtained by the incineration of the mother-liquor by-product of beet sugar manufacture. It contains 50 per cent. potash, which is all available.

Sulphate of Potash–Magnesia.—This is a potash salt containing not less than 25 per cent. sulphate of magnesia and not more than 2.5 per cent. chlorine. This has been known as double manure salts, but this name is being discontinued. The potash content varies considerably, ranging from 20 to 30 per cent. It is not used here to any great extent.

Kainit.—This is a natural product obtained from French and German deposits and contains potash in the form of potassium chloride. The potash content ranges from 12.4 to 16 per cent., all available. It is used in mixed fertilizers.

Kemfert.—The trade name for high grade muriate of potash. It is condensed from the waters of Searles Lake in California. It usually contains from 58 to 60 per cent. of potash.

Hard Salts—One of the minerals occurring in the French and German potash deposits. It contains potash as muriate (KCL). The average analysis is about 61 per cent. potash, all available. Rarely seen here.

Feldspar.—A mineral containing silica, alumina, and potash, soda or lime. The potash feldspar are very plentiful and furnish a possible source for potash. The potash in feldspar is insoluble in water and dilute acids, and hence not available to plants. There are a number of chemical methods for converting the potash into water-soluble forms, but these processes are expensive and cannot compete with the French and German deposits. The potash content is variable.

Kelp—A species of seaweed which occurs in many parts of the ocean. At one time a good deal of potash was obtained from kelp and the harvesting of this seaweed was a thriving industry on the coasts of Scotland and Norway. The giant kelps which grow along the coast of California were harvested during the war to a limited extent and turned into fertilizer material. It contains from 15 to 20 per cent. potash.

Tobacco Stems.—The stems and leaf ribs of tobacco are ground and used as a fertilizer material containing nitrogen and potash. The nitrogen varies, but will average between 1½ to 3 per cent. while the potash ranges from 4 to 9 per cent. This potash does not become available until the material decays.

Wood Ashes.—This is a satisfactory and cheap source of potash. In an unleached condition the potash content is about 5 to 10 per cent. Leached ashes, of course, contain much less, depending on the amount of leaching. Besides potash, wood ashes also contain much lime and all ashes produced on the farm should be carefully preserved and returned to the land.

Table 13

SOURCES OF POTASH

Material	Appearance	Per cent. available K_2O	Form in which potash is present	
Muriate of potash	White or gray crystals	50-62	Muriate	Best general source of potash. Not suited for tobacco and some claim not for potatoes. All potash available.
Sulphate of potash ..	White crystals	48.7	Sulphate	Higher price than the muriate. Preferred for tobacco. All potash available.
Carbonate of potash			Carbonate	
Sulphate of potash-magnesia (double manure salts).	Light coloured crystals	20-30	Sulphate	Used largely in making mixed fertilizers. Not sold to general public to any great extent.
Kainit	Light coloured crystals	12.4-16	Muriate	Same as sulphate of potash-magnesia.
Kemfert	White	58-60	Muriate	High grade muriate of potash. An American product.
Hard salts		16	Muriate	Natural European mineral. Used in manufacture of mixed fertilizers.
Feldspar	Variable	Variable	Silicate	A natural product, but cannot be made available so as to compete with European goods.
Kelp	Seaweed	Total 15-30	Organic	Used on sea coasts. Rarely seen in Ontario.
Tobacco stems		Total 4-9	Organic	By-product of tobacco factories.
Wood ashes	Grey	5-10	Carbonate	Excellent material. Should be saved on every farm.
Potash amm. nitrate..	White crystals	27	Nitrate	Also contains nitrogen and is not bought for potash alone. Little used yet in this country.

SOURCES OF NITROGEN, PHOSPHORIC ACID AND POTASH

	Nitrogen	Phosphoric acid	Potash
Milorganite.	6½%	2½%	¼ to½%

Milorganite is a high grade organic fertilizer. It is activated sludge, the by-product of sewage plants. The nitrogen is in organic form but fairly available.

Ammo Phos. Ko.—See under Sources of Nitrogen.

Nitrophoska.—See under Sources of Nitrogen.

DOUBLE AND TRIPLE STRENGTH FERTILIZERS

Within the last decade remarkable advancement has been made in concentration and combination of fertilizer materials. It is now commercially possible to obtain nitrogen three times as strong as formerly. Also superphosphate carrying 33% and 45% phosphoric acid. In the early days of mixed fertilizers the tendency was to manufacture low analysis goods that cost less per ton. With the development of new methods of manufacture, and much more highly concentrated raw materials the tendency is toward much higher analysis of goods. For instance 2-8-2 and 2-12-2 were common formulas in 1910. They are replaced by 2-12-6, 4-12-4, 4-8-10, etc. Double and triple strength fertilizers such as 8-24-8 and 15-30-15 are now offered to the farmer. It is obvious that cost per pound of plant nutrients is much less in high grade fertilizers than in low since cost of handling, manufacture and selling is about the same for high and low grades alike. Some difficulty is experienced in obtaining an even distribution in the soil of higher grade fertilizers. Investigation is proceeding to overcome this difficulty.

COMPOSITION OF A TON OF FERTILIZER

In speaking of mixed fertilizers the formula is usually given e.g. 4-8-10. This means that the ton of fertilizer is guaranteed to contain 4% or 80 lbs. of nitrogen; 8% or 160 lbs. of available phosphoric acid; and 10% or 200 lbs. of potash. To obtain these amounts it would be necessary to combine or mix the following ingredients:

Pic. 11

A demonstration plot where 3-10-5 fertilizer at 1250 pounds per acre on tomatoes yielded 303 bushels per acre.

Check yielded 52.3 bushels per acre.

Pic. 12

A Potato Demonstration Experiment on the Boys' Training School Farm, Bowmanville.

YIELDS

To the left	In centre	To the right
4-8-6 fertilizer 500 lbs. per acre 205.7 bushels	Check Plot 163.1 bushels	4-8-10 fertilizer 500 lbs. per acre 205.7 bushels

Let the nitrogen be one-half organic (from Tankage carrying 7%N.) and one-half mineral sulphate of ammonia.

Tankage

40 lbs. of Nitrogen are required.

In 7% Tankage.

7 lbs. of Nitrogen are supplied by 100 lbs. Tankage.

1 " " " is " " $\frac{100}{7}$ " "

40 " " " are " " $\frac{100}{7} \times 40 = 572$ lbs. "

Sulphate of Ammonia

40 lbs. Nitrogen from sulphate of ammonia carrying 20% Nitrogen will require..200 lbs.. Sulphate of Ammonia.

Superphosphate

160 lbs. Phosphoric acid from 18% superphosphate will require ....889 lbs. Superphosphate.

Potash.

200 lbs. K_2O from potash carrying 50% K_2O will require 400 lbs. Potash.

Summarizing, the 4-8-10 will require for a ton a total of 2061 lbs. of these carriers of N/P/K. In actual practice, a little more sulphate of ammonia and less Tankage would be used so as to bring the total to 2000 lbs.

THE FERTILIZER ACT

The Federal Department of Agriculture is administering regulations which aim to make certain that when a farmer purchases a fertilizer having a certain analysis, he actually obtains what is represented on the tag. The Fertilizer Act covers this point fully, and is designed for the protection of the user of fertilizers. It is not the purpose of this bulletin to go into the details of the act, but merely to point out some of the most important points, with respect to the analysis.

In the first place every container of fertilizer must be marked as follows, either on the container itself or on a tag attached thereto.

(a) the name and address of the manufacturer or importer.
(b) brand name.
(c) registration number and designation of year of issue.
(d) guaranteed analysis stating separately in minimum percentages only,

1. Water soluble nitrogen.
2. Total nitrogen.
3. Available phosphoric acid.
4. Total phosphoric acid.
5. Potash soluble in water.
6. In the case of basic slag or natural rock phosphate or a mixture of both, the fineness thereof.

7. Whenever present in fertilizers the percentage by weight of leather, hoof, horn, hair, wool-waste, peat, garbage, tankage or any similar organic material unless it has been treated in such a way as to make the nitrogen or phosphoric acid or potash therein available as determined by methods of analysis to be prescribed by regulation.

It is seldom that the fertilizer tag is as complicated as would be indicated by the above regulations. In the ordinary fertilizers sold number 7 rarely appears. Number 6 applies to basic slag and rock phosphate alone. In the mixed fertilizers, however, the points of particular interest are (1) water soluble nitrogen. This is a measure of the availability of this element. It may be advisable to go further and specify what form the nitrogen is in. For example ammonium sulphate and nitrate of soda are both soluble in water, but the latter is available at once while the former may not be available for from a few days to several weeks, depending on weather conditions.

The total nitrogen is also important as it all becomes available in time and generally speaking we can regard all the nitrogen in the average mixed fertilizer as available. Further, since it is the most expensive element we have to purchase, it is necessary to pay particular attention to it.

Regarding the phosphoric acid content the principal part of the analysis is the percentage available. The total content is of interest in basic slag and rock phosphate.

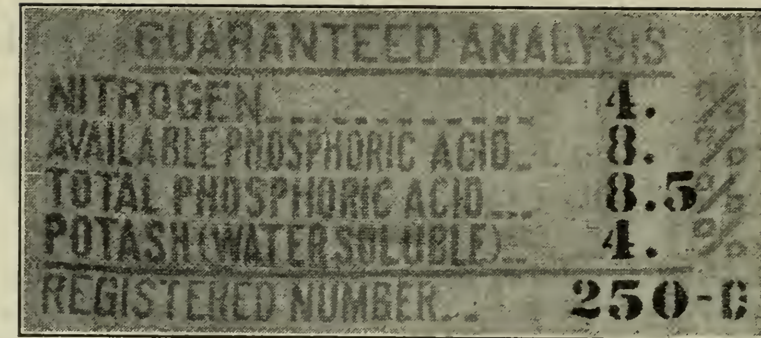
The potash, since it is water soluble is available, so there is no need of any information as to the total content.

A recent amendment to regulations under the Fertilizer Act reads as follows:—

Regulation 4: The brand name shall not include the name or other designation of any field or garden crops or group of crops or type of soils; except that the brand name "tobacco fertilizer" may be used when the guaranteed analysis and the constituent materials of the fertilizer are accepted for registration as suitable for tobacco, and provided that an additional statement is made on each package containing the fertilizer or on a label attached thereto, showing the percentage of each of the forms of nitrogen present in the fertilizer as follows:

Nitrate nitrogen	........%
Ammoniacal nitrogen	........%
Organic nitrogen	........%

Provided also that there is not more than 2% of chlorine (Cl) present in the fertilizer.



Pic. 13

Showing how the analysis of a fertilizer is marked on the bag itself or on a tag fastened to it. Buy by analysis only.

The three points of interest are, then:—

(1) Total nitrogen; (2) Available phosphoric acid; (3) Water soluble potash. Hence when speaking of a mixed fertilizer we call it a 2-12-6 or 5-10-5 or any other analysis, the first figure is the total nitrogen, the second the available phosphoric acid and the third the available potash. Generally speaking it does not matter in what form the three elements occur. The fertilizer act requires that they be available.

The analysis of fertilizers has a definite bearing upon results. A fertilizer must supply proper proportions of nutrients to meet the characteristic requirements of the crop, and to make up for the characteristic deficiencies of the soil on which the crop is grown, if best results are to be obtained. An improperly balanced fertilizer such as a high nitrogen fertilizer on a heavy clay for grain will aggravate bad conditions, while a properly balanced fertilizer—providing high phosphate and medium potash for the instance above, will give good results.

BUY BY ANALYSIS ONLY

In purchasing a fertilizer the only basis of choice is analysis. One may have a liking for some particular brand, but the principal point is the actual plant food contained in it. This is stated in the analysis. For example a farmer might require only phosphoric acid and potash. His requirements would be met with an 0-14-6 fertilizer. He would be unwise to purchase a 4-8-6 or a 4-12-8 unless his conditions indicate the need of a complete fertilizer. At times there is a tendency to use certain types of fertilizers "because the neighbours use it," but each farmer should study his requirements and buy the analysis which suits his particular case. This he can do by buying on analysis only.

SOME FACTORS AFFECTING THE USE OF FERTILIZERS

There are many factors which determine the kind and amount of fertilizer to use under a given set of conditions and the extent to which this fertilizer will influence crop yields. Some of the factors are as follows:

1. Fertility of the soil.
2. Annual rainfall and its distribution.
3. Length of growing season.
4. Feeding habits of crops.
5. Fertilizer requirements of crops.
6. The soil reaction, or need of lime.
7. The type of farming.
8. The cropping system, or rotation.
9. Intensity of culture.
10. The analysis.
11. The quantity.
12. The method of applying fertilizer.
13. Insect pests and plant diseases.
14. Quality of seed.
15. Thoroughness of soil preparation and cultivation.

The relative effects of these factors will vary from province to province and from farm to farm, but they are all of more or less importance.

A brief discussion of each follows:—

1. Fertility of the Soil.—The number of soil types in this province is large, though many of them are quite similar in so far as their response to fertilizers is concerned. Nevertheless, soils vary widely in fertility. They vary all the way from sandy soils, deficient in all essential plant foods to thin clay loams rich in potash but low in nitrogen and phosphoric acid, to muck soils rich in nitrogen and deficient in all of the minerals. Many soils that were fertile 50 to 100 years ago are now in serious need of fertilizers. Thus we find within the same type, soils that give only moderate returns from fertilizers, and others that require liberal applications for the production of satisfactory crops.

2. Annual Rainfall.—This does not affect Ontario to any great extent although where the summer is very dry, the results obtained from fertilizers will be very uncertain. Even where the total annual rainfall is 30 to 40 inches, summer drouths are frequently severe enough to seriously reduce crop yields.

3. Length of Growing Season.—There is a vital relationship between length of growing season and fertilizer requirements. This is particularly true with reference to nitrogen. In this province we have a short growing season,—shorter the farther north we go—consequently soil nitrogen does not become available early in the season. Hence for early crops it is considered necessary to use high nitrogen fertilizers. Furthermore, the deficiency of soil nitrogen is not so apparent in northern soils as it is in central or southern soils, hence there is not the same need to purchase nitrogen as there is in southern sections.

4. Feeding Habits of Crops.—There is a great difference in feeding habits of crops. Some are shallow rooted or surface feeders, for example, barley, and some grasses and vegetables. Corn on the other hand is a deep-rooted crop, its roots being distributed through the first, two, three, or four feet of soil. Alfalfa is specially noted for deep roots. The depth and nature of the rooting system of a crop has a definite bearing on the analysis of fertilizers to use on it.

The feeding of crops varies greatly. This is a complex subject involving the chemistry of cell sap and other related factors. It has been shown that some crops are able to secure the greater proportion of their requirements of plant food from relatively unavailable sources than others. Sweet clover for example will thrive in a very poor soil, providing the soil is not acid. Crops of the crucifereae family such as turnips and cabbage can make better use of low grade or slowly available phosphates than other farm crops.

5. Fertilizer Requirements of Crops.—Crops vary in their response to different elements of plant food. Potatoes and tobacco for example, respond to potash. Grain fertilizers should be high in phosphoric acid and relatively low in nitrogen and potash. Grasses require high nitrogen while legumes require phosphates and potash.

6. The Soil Reaction.—As already pointed out, right reaction of soil is necessary for best growth of crops. Proper reaction of soil is necessary if fertilizers are to give best returns. A sour soil is one from which lime has been removed. When soluble phosphates are applied to such a soil, they combine with iron or aluminium, forming combinations which are unavailable as nutrients of crops. Hence, if results are to be realized from fertilizers a prerequisite is sweet soil or soil supplied with lime.

7. Type of Farming.—No other factor has greater influence on the choice of fertilizer than this. Contrast a dairy farm where the only product sold is milk or cream and where feed is purchased in quantities, with the farm specializing in seed potatoes or canning crops. Again contrast the tobacco producing areas of Norfolk and Essex with the apple producing section of Durham and Northumberland. Even compare different types of farms in the same community and it will readily be seen that the best fertilizer practice for each type is determined very largely by the type of farming.

8. The Cropping System or Rotation.—This factor is closely related to type of farming, but even on farms of the same type the cropping system may be sufficiently different to affect materially the use of fertilizers. Thus we find many distinct cropping systems on all types of farms. One potato grower may follow a three year rotation of potatoes, oats and clover, while another may raise potatoes continuously on the same land with rye and vetch as a cover crop for green manure.

The extent to which legumes are grown introduces another important factor in determining the best fertilizer practice. No one who is informed would recommend the same fertilizer for potatoes following clover or alfalfa, that he would recommend for potatoes following timothy or oats. It is admitted that the farmer should grow clover before corn, but if he wants to grow corn after timothy he should choose a fertilizer which will fill the needs.

9. Intensity of Culture.—As urban population increases, the demand for food grows. This means that farming in the vicinity of growing towns and cities necessarily becomes more intensive. As larger yields per acre are required, more and higher grade fertilizers must be used upon the soil.

10. The Analysis.—The effectiveness of fertilizers will depend upon the amount of plant nutrients which it supplies. This is shown by the analysis declaration. Obviously a 4-12-8 fertilizer or a 15-30-15 will carry materially more plant nutriment to the ton than will a 2-10-2 fertilizer.

11. The Quantity.—Besides being of suitable analysis, fertilizers must be applied in sufficient quantity if best results are to be realized. It is apparent that 200 lbs. of 2-8-4 fertilizer will supply but a small amount of plant nutrients to the acre, while 200 lbs. of 6-24-12 fertilizer would supply considerable. In getting at the quantity of fertilizer to use one must keep in mind both the analysis of fertilizer and the rate at which it is to be applied.

12. Method of applying Fertilizers.—This subject is receiving increasing attention since it is apparent that the proper placing of fertilizers has an important bearing upon their effectiveness. If placed too near the seed or seed piece, serious injury to vitality results.

13. Insect Pests and Plant Diseases.—Crop losses from the ravages of insect pests and plant diseases are very heavy. Methods of control have been worked out in many cases. As an instance of insect control might be cited the case of the Hessian fly. By late sowing of wheat farmers are able to escape the late brood of the Hessian fly. However, late sowing of wheat necessitates use of considerable fertilizers to overcome this handicap.

In the partial control of disease, potash plays an important rôle. Such plant diseases as leaf scorch, rust, mildew, potato blight, stripe disease of tomatoes and others, are held in partial control if crops are provided with vigor of growth to withstand their inroads. It is fairly well established that the use of an adequate amount of suitable fertilizers provides many crops with strength of growth that enables them to withstand disease.

14. —Quality of Seed.—The influence of quality of seed is also obvious. Farmers using poor quality seed cannot possibly obtain maximum benefits from fertilizers. Good seed is absolutely essential.

15. Soil Preparation and Cultivation.—The value of thorough soil tillage and cultivation is well known. The better the plowing and preparation of the seed bed and the more thorough the cultivation of the crop, the more profitable will be the results from fertilizers.

All of the above factors have a definite bearing on the profitableness with which fertilizers are used. Hence the choice of fertilizers is not merely guess work. It should be given much scientific study. With reference to determining the best fertilizers to use, the Department of Chemistry, O.A.C., offers its assistance to farmers of the province. Much valuable help can be provided to farmers who care to avail themselves of this opportunity.

SOIL AMENDMENTS

The term "soil amendment" is applied to all materials which are not applied to the soil for the purpose of supplying nitrogen, phosphoric acid or potash. This includes all forms of lime, gypsum or land plaster, salt, sulphur and other substances.

The action of these substances on the soil is largely indirect since they do not supply any deficiency of plant food elements. Soil amendments may act in two ways: (1) They may, by altering reaction, change the degree of acidity or alkalinity of the soil. In view of the fact that these materials are used in Ontario, a short discussion of each will be of interest.

Lime.—Lime in its several forms acts as a neutralizer of soil acidity. It liberates some plant food, mainly potash, from the soil. A complete discussion of this important soil amendment is given in Bull. 313, Soil Acidity and Liming.

Gypsum.—Gypsum is of great value as a corrective for alkali soil. It changes the sodium carbonate (black alkali) into the sulphate, thereby reducing its harmful effect. It has been used extensively in this province but is not used to such an extent now. As a corrective for soil acidity it is useless, but it is of value, particularly to legumes, on account of its calcium and sulphur content. The chief action of gypsum or landplaster is to liberate the potash of the soil. The continuous use of gypsum or landplaster alone leads to the depletion of the potash of the soil.

Salt.—Salt contains only two elements, sodium and chlorine, neither of which are deficient in soils. It is therefore of no direct value to crops, but has some action in releasing potash, calcium and magnesium from the soil. Its use is not recommended.

Sulphur.—Sulphur has been used to a considerable extent in United States and to a less extent in Ontario. It is applied as ordinary flour of sulphur, from 100 to 500 pounds per acre. Its action in the soil tends always to increase acidity, which in some cases is beneficial and desirable. This is particularly true with respect to potatoes, where a moderate degree of acidity tends to prevent potato scab. It is also beneficial when the sulphur is applied with rock phosphate, the acid formed combining with the rock phosphate rendering some of the phosphoric acid available.

In consideration of the fact that rainfall deposits annually considerable sulphur on the soil and that the demand for sulphur in plant growth is small, the use of sulphur is not generally recommended. Further, all mixed fertilizers contain sulphur in combination, therefore where they are used, sulphur is supplied in sufficient quantities to supply all requirements.

There are other materials which, when added to the soil, give increased crop returns, but they are not generally used and are not recommended. At present, fertilizer practice is confined to materials containing the three essential elements—nitrogen, phosphoric acid and potash.

THE MANUFACTURE OF FERTILIZERS

The use of fertilizers in Ontario has increased from 25,000 tons in 1920 to over 100,000 tons in 1930. Six fully equipped plants produce supplies for Ontario farmers both spring and fall. This necessitates assembly of large quantities of nitrogen carriers, acid phosphates and potash several months before fertilizers are used by the farmer. Preparations are in progress for the importation of phosphate rock and the acidulating of same at one large plant in Ontario.

The manufacturing of fertilizers has necessitated the assembly of extensive and complicated machinery so that a wide range of materials may be used, properly mixed and thoroughly blended. Sensitive scales provide control of accurate weights in mixing. All raw material is blended in accurate amounts based on chemical analysis of the materials. After mixing, the combined materials generate considerable heat and set. The mixture is allowed to cure thoroughly, and is then reground, resifted and prepared for shipment to the farmer.

Fertilizers are continually subject to inspection and control under the terms of the Canadian Fertilizer Act already explained. This is the farmer's protection so that he may have assurance that he is getting the quantity of available nitrogen, phosphoric acid and potash that is guaranteed in the formula that he is purchasing.

MIXING FERTILIZERS ON THE FARM

Formulas can be mixed on the farm. In making these, the range of materials is confined largely to a few mineral salts. The process of mixing fertilizers may be performed on a smooth, firm floor, by means of a square mouthed shovel, a screen and a tamper, with which to break lumps. It is not advisable to use fanning mill screens but to mount one of suitable mesh on a frame as illustrated. The one in use at the Department of Chemistry, O.A.C., is a 6 mesh screen or has thirty-six equal sized openings to the square inch. The additional equipment necessary is a set of scales.

The materials to be mixed can be assembled on the mixing floor, and the one which is in greatest quantity—generally acid phosphate, is emptied out. The other materials are crushed, if lumpy, screened and spread evenly over the heap. The whole mass is then mixed with a shovel in the same way that wheat is turned, when treated with formaldehyde. Since no filler or conditioner is added, caking may occur after mixing, so that the material should be applied to the land as soon as possible after mixing, certainly within two or three days. As to quantities of materials required to make a mixture of a definite analysis let us take a concrete example. Suppose for instance we wish to make a fertilizer having the analysis of 2-12-6. The following calculations illustrate the method:

$$\text{Total amount of nitrogen } \frac{2}{100} \times 2000 = 40 \text{ lbs.}$$

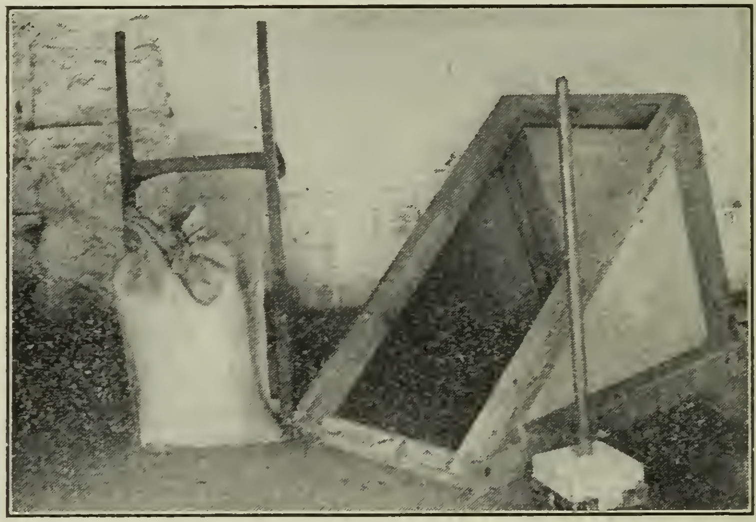
$$\text{" " " } P_2O_5 \ \frac{12}{100} \times 2000 = 240 \text{ "}$$

$$\text{" " " } K_2O \ \frac{6}{100} \times 2000 = 120 \text{ "}$$

Let us choose as a source of our materials, ammonium sulphate (20 per cent. N.), acid phosphate (16 per cent. phosphoric acid) and muriate of potash (50 per cent. potash.)

We require 40 lbs. of nitrogen.
This will be supplied by 40 ÷ 20 x 100=200 lbs. ammonium sulphate.
We require 240 lbs. P_2O_5.
This will be supplied by 240 ÷ 16 x 100=1,500 lbs. acid phosphate.
We require 120 lbs. potash.
This will be supplied by 120 ÷ 50 x 100=240 lbs. muriate of potash.
Total weight, 1940 lbs.

The manufacturer making up this fertilizer would add to it during grinding and mixing, 60 lbs. of filler such as sand, peat or some other material which will make the weight up to a ton, and keep the mixture more open and less liable to cake, or he could obtain part of his nitrogen from an organic carried such as tankage. The addition of the tankage will prevent caking and obviate the use of filler.



Pic. 14 Equipment necessary for home mixing of fertilizers.

COMPATABILITY OF MATERIALS

In mixing it is necessary to know what chemical reactions take place when two materials are mixed together. For example lime, or any other basic material, mixed with ammonium sulphate will always cause a loss of nitrogen, liberating it as ammonia. Any form of lime mixed with acid superphosphate causes superphosphate to revert, that is, changes it into an insoluble form. Potash-bearing compounds mixed with basic slag, cake in a few hours. Therefore, before fertilizers are mixed it is necessary to know what substances may be combined without loss, or caking. This is shown in the following table. Many ready-mixed goods contain nitrate and it is highly desirable that they should, but the amount present is generally quite small, rarely over 1 or 1½ per cent. nitrogen. Further, there is generally a filler used which assists in keeping the mixture dry. If left standing or if it becomes damp there is almost certain to be unsatisfactory results.

Compatability of Fertilizer Materials

Table 13

Fertilizer Material	Can be mixed with	Do not mix with
Nitrate of Soda Sulphate of Ammonia Calcium Nitrate Cyanamid Urea Blood Tankage Manure	Acid Phosphate Bone Meal Potash Salts Sulphate of Potash Muriate of Potash Carbonate of Potash	Lime Basic Slag
Acid Phosphate or Superphosphate	Nitrogen Salts Blood Tankage Potash Salts	Lime Use immediately if mixed with nitrates
Potash Salts	Nitrogen Salts Superphosphate Basic Slag	Lime
Lime Limestone		Blood Tankage Any Salts carrying nitrogen Acid Phosphate

EFFECTS OF FERTILIZERS

(a) Effect of continuous use of One Element Only.

The general principle on which the doctrine of this bulletin is built is balance. There must be right growing conditions for crops if best yields of best quality are to be harvested. There must be a desirable balance among nitrogen, phosphoric acid and potash. If one or more are emphasized to the overbalancing of the remainder, undesirable results will be realized.

A few years ago the great importance of nitrogen in fruit growing was announced. Some growers immediately jumped to the conclusion that all that was necessary in fruit-growing was to apply a carrier of nitrogen. They proceeded to act in accord with this idea. Not a few are reporting greater vigor of tree, very heavy leafage, poor set of fruit and delayed ripening—due entirely to an over supply of nitrogen.

Some farmers say "Use acid phosphate only, on grain and other crops." As explained, superphosphate is made by treating finely ground raw rock phosphate with sulphuric acid in about equal quantities by weight. Two products result—soluble acid phosphate (16%) and calcium sulphate or landplaster. In the finished product over 55% is calcium sulphate or landplaster. Hence, when superphosphate is added to the soil the soluble phosphate builds up the phosphoric acid of the soil but the calcium sulphate releases the potash of the soil. If the practice of using acid phosphate alone is continued the result will be a building up of the phosphoric acid of the soil and a depletion of the potash. The result will be an undesirable balancing of the plant nutrient ration.

(b) Effect of Fertilizer Materials on Soil Reaction when used Continuously.

When certain fertilizer materials are used continuously on soils, they cause reactions as noted in the following table:

Table 14

EFFECT OF FERTILIZER MATERIALS ON SOIL REACTION WHEN USED CONTINUOUSLY FOR A PERIOD OF YEARS

Material	Turns the Soil
Nitrate of Soda	Alkaline
Ammonium sulphate	Acid
Ammonium sulphate nitrate	Acid
Blood meal, tankage and other organic compounds	Little or no action
Ammo-Phos.	Acid
Calcium nitrate	Little or no action
Sulphur (natural)	Acid
Acid phosphate	None
Rock phosphate	Alkaline
Basic slag	Alkaline
Bone meal	None
Potash compounds	Very slight acid

Nitrate of soda applied alone tends to puddle clay soil. This is readily corrected by liming.

RESIDUAL EFFECTS OF FERTILIZERS

How long will the effect of fertilizers last? This is a common question. If the soil is sweet in reaction and contains a sufficient supply of organic matter, and if reasonably large applications of fertilizer are applied, beneficial effects should be seen for three or four years after the fertilizers are applied. In a three year rotation—mangels, barley, hay—conducted by the Department of Chemistry, the following yields were harvested the second and third year after fertilizers had been applied to mangels:

Table 15

Treatmen on Mangels only	MANGELS Yield Tons	MANGELS % Increase	BARLEY Yield Bus.	BARLEY % Increase	HAY Yield	HAY % Increase
—0—	19.4		31.		2900	
Complete Ferts.	23.5	21.3%	40.7	31.1%	3540	22. %
Phosphate-Potash	20.8	7.4%	38.2	23.0%	3540	22. %

EFFECTS ON FOLLOWING CROP OF WHEAT, OF FERTILIZERS APPLIED TO PEAS

Table 16

Fertilizer applied to PEAS	Yield of Wheat following PEAS	GAIN
0-16-0	38.64 bus.	11.58 bus.
2-12-4	44.39 "	17.33 "
0-12-4	41.02 "	13.96 "

Long time experiments at Rothamsted Experimental Station, England; and Ohio, Pennsylvania, New York and Massachusetts experiment stations in America have demonstrated that yields can profitably be maintained by judicious choice of fertilizers in connection with a system of crop rotation.

Other experiments carried on by the Department of Chemistry show that where wheat has been fertilized, followed by clover, not only has the yield of wheat been increased approximately fifty per cent., but the clover first year was increased 30 per cent. and the second year 27 per cent.

METHODS OF APPLICATION

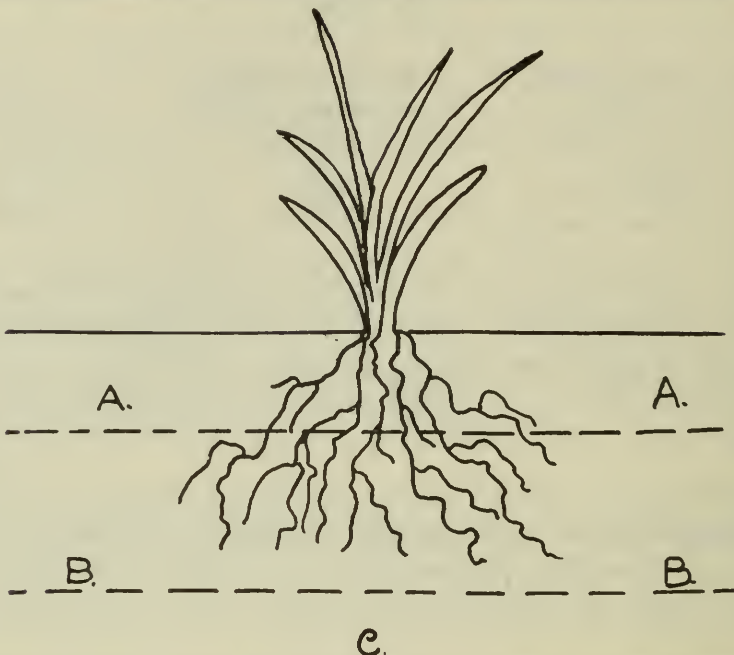
Fertilizers Were First Applied by Hand

As areas have increased on which fertilizers have been used, hand application has entailed too much labour. Specially designed machinery for fertilizer application is found in connection with modern grain drills where a special hopper or box is built for the distribution of fertilizers. Tubes lead from this hopper to spouts down which grain and grass seed fall. When fertilizers of ordinary strength are applied at prevailing rates, a grain drill with fertilizer dropping compartment gives satisfactory application. As large amounts of fertilizers of more concentrated analysis are employed, however, it will be necessary to use machines designed to more thoroughly mix the fertilizer with the soil. Fertilizers are composed of concentrated salts. As these dissolve, if they are placed in close proximity to seeds, especially large fleshy seeds or seed pieces as in the case of potatoes—they will draw moisture from the seed or seed piece, causing injury to its vitality. For this reason potato planters with fertilizer compartment and various seed drills provide for the fertilizers to be mixed with the soil before the seed or seed piece is dropped.

Investigations are proceeding relative to the best position of fertilizers with reference to the seed or plant for which they are applied. The final word as to the best placing of fertilizers has not yet been spoken, but indications are that for cereal crops fertilizers should be worked in about the same depth as the seed. For such crops as potatoes, fertilizers placed below the depth of the seed-piece apparently give best results. For transplanted crops such as tomatoes, cabbage, tobacco, etc., fertilizers worked in slightly above or on the level of the rooting system of the crop apparently give greatest increases.

Much attention is being paid to improvement of fertilizer-applying machinery and more definite information will be available in the near future.

Diagram C shows positions at which fertilizers are applied.



Showing location of fertilizer with respect to root system.
B is the best position.
A—Side upper plane. B—Side lower plane.
C—Beneath plant.

SUMMARY

1. Plants, like animals, take in nourishment which they build into new combinations in their bodies. Certain elements are taken from the air, others in solution from the soil. Under the impetus of energy from the sun, new combinations of these elements are formed in the leaves. These are transported to various parts of the plant for storage. Certain elements which the plant uses are held in readily available forms, slowly available or unavailable forms in the soil. When the supply of nutrients is exhausted, if yield and quality of crops are to be maintained, additional stores must be supplied by means of manure and fertilizers.

Crops have characteristic needs. For instance, leafy or bulky crops draw most upon nitrogen. Root crops, potatoes, bulbs and the like re-require large supplies of nitrogen and potash. Grain crops including vegetables use large quantities of phosphoric acid with medium supplies of the other elements. Proper balance of supplies must be provided if largest yields of best quality products are to be harvested.

2. Soils have a history. Soils differ in colour, texture, weight and composition. The surface soil does not tell the whole story. Modern soil survey includes a study of plow-depth soil and subsoil down to where parent material appears from which the top soil came. The necessity of such thorough investigation of the soil is apparent when the importance of soil reaction is realized. If by leaching and cropping the supply of lime in the surface soil has been exhausted, or the lime of the subsoil has been exhausted so that these areas show acid reaction, conditions are unfavorable for the retention in available form of important plant nutrients such as phosphates. Moreover, such sour areas of soil are unfavorable media for the growth of valuable legumes.

3. Organic matter is of primary importance. Organic matter from plant or animal tissue performs valuable physical duties with reference to soils. Organic matter provides a favorable medium for the growth of microscopic life in the soil. In its decay organic matter reacts on the minerals of the soil so that valuable plant nutrients are liberated. It is readily destroyed by tillage or cropping. Organic matter must be maintained if best conditions of growth are to be realized. Where residues of crops such as straw are turned under, microscopic life which cause decay call upon considerable supplies of nitrogen. Care must be taken in plowing under of such organic material that the reaction is not a shutting up of the nitrogen supply of the soil.

4. Farm manures supply a most valuable source of crop nutrients and of organic matter. Available plantfood is easily depleted from manures. Care must be taken to avoid physical and biological destruction of this valuable source of plant nutrients.

5. Fertilizers carrying nitrogen, phosphoric acid and potash fill an increasingly large place in farm practice. With supplies of farmyard manure diminishing and stores of the important nutrients, nitrogen, available phosphoric acid and potash, growing less and less as a result of cropping, additions to the soil must be made, especially if most economic returns are to be realized from its cropping. Fertilizers have been tested for the last century. If suitably chosen so as to meet the special needs of the crop and to supplement the characteristic weaknesses of the soil type, and if properly applied, fertilizers give profitable results.

6. The farmer has protection. One cannot tell by observation, smell, texture or weight, the value or content of fertilizers. However, the Dominion Fertilizer Act requires that all fertilizers must be registered and their formulas guaranteed by manufacturers and declared on the packages in which the fertilizers are contained.

7. Buy by analysis. The formula statement of the fertilizer is a declaration of the composition of the material in the bag and is an index of its value and adaptability. No other basis on which to buy fertilizers is sound.

8. Factors that influence success. The returns that accrue from the use of fertilizers, depend not alone upon the composition of the fertilizers, but upon a large number of factors many of which are controllable by the farmer.

9. Production of fertilizer. As the demand for fertilizers has increased, production has increased accordingly. The fertliizer industry is now one of the major industries of the world, involving the assembly of raw materials from all parts of the globe. In factory production of mixed fertilizers, materials are ground, processed, and combined in various formulas. Quantity production has diminished unit cost. Long experience has enabled manufacturers to devise machinery which gives most thorough combinations. Chemical and physical studies have been instrumental in making possible means of curing and fitting fertilizers for the market, and have enabled manufacturers to guarantee the durability of their products.

With the use of a limited number of primary carriers of nitrogen, phosphoric acid and potash, farm mixing can be accomplished. If done thoroughly, and if the fertilizer is applied soon after mixing, satisfactory results can be realized. Farm mixing involves expenditure for labour, and usually the buying of ingredients on a cash basis.

10. Effects of fertilizers. Fertilizers not only increase yields but improve weight per bushel of grains, sugar content of sugar beets, and various qualities of other crops, provided the fertilizers are suitably chosen and correctly applied in sufficient quantities. The crops to which fertilizers are applied do not use the entire amount but residual effects are evident for two or three years following the application, hence the general practice is developing of applying fertilizers to cash crops and allowing crops following for one or two years to benefit from the residual effect. One exception to this practice is developing in the new attention being given to fertilization of meadows and pastures.

11. Recommendations for the application of fertilizers to various crops under various methods of cropping are made in the following table. These recommendations are based upon field results obtained by this institution, along with results accumulated from elsewhere. They are subject to change as further information warrants.

FERTILIZER RECOMMENDATIONS, 1931.

Department of Chemistry—Ontario Agricultural College

Table 17

	ON SANDY OR GRAVELLY TO LIGHT LOAM SOILS					
	Without clover or manure		Following clover or manure		Following clover and manure	
	Mixture	Lbs. per Acre	Mixture	Lbs. per Acre	Mixture	Lbs. per Acre
1. Cereal crops	2-12-6	250	2-12-6	250		250
	3-10-5	375	0-14-6	375	0-14-6	376
2. Corn			4- 8-6	375	2-12-6	375
			3-10-5	500	0-14-6	500
3. Beans	3-10-5	250	2-12-6	250	2-12-6	250
Peas	4-8-10	375	3-10-5	375	0-14-6	375
4. Mangels			3-10-5	500	2-12-6	375
			2-12-6	625		500
5. Sugar Beets			2-12-6	375	2-12-6	250
			2-12-6	500	2-16-6	375
6. Turnips			2-12-6	500	0-16-0	375
			3-10-5	625	0-14-6	500
7. Early Potatoes			3-10-5	750	2-12-6	750
			4- 8-6	1500		1500
8. Late Potatoes			4-8-10	750	4-8-10	750
9. Tomatoes	3-10-5	500	3-12-6	500	2-12-6	500
	4-8-10	1000	3-10-5	1000	0-14-6	1000

ON CLAY LOAM TO HEAVY CLAY SOILS

1. Cereal crops	2-12-6	250	2-12-6	250	0-16-0	250
	3-10-5	375	0-14-6	375	0-14-6	375
2. Corn	3-10-5	250	2-12-6	250	0-16-0	250
	2-12-6	250	2-12-6	250	0-16-0	250
3. Beans	2-12-6	250	3-10-5	250	0-14-6	250
Peas	3-10-5	375	2-12-6	375	0-16-0	375
4. Mangels	3-10-5	375	2-12-6	375	0-16-0	375
		500	3-10-5	500	0-14-6	500
5. Sugar Beets	2-12-6	375	2-12-6	250	2-12-6	250
		500	2-16-6	375	2-16-6	375
6. Turnips	2-12-6	375	2-12-6	375	0-16-0	375
	3-10-5	625	0-14-6	625	0-14-6	625
7. Early Potatoes			2-12-6	750	2-12-6	750
			3-10-5	1000	3-10-5	1000
8. Late Potatoes			2-12-6	750	2-12-6	750
			3-10-5	1000	0-14-6	1000
9. Tomatoes	3-12-6	500	2-12-6	500	2-12-6	500
	3-10-5	1000	0-14-6	750	0-14-6	750

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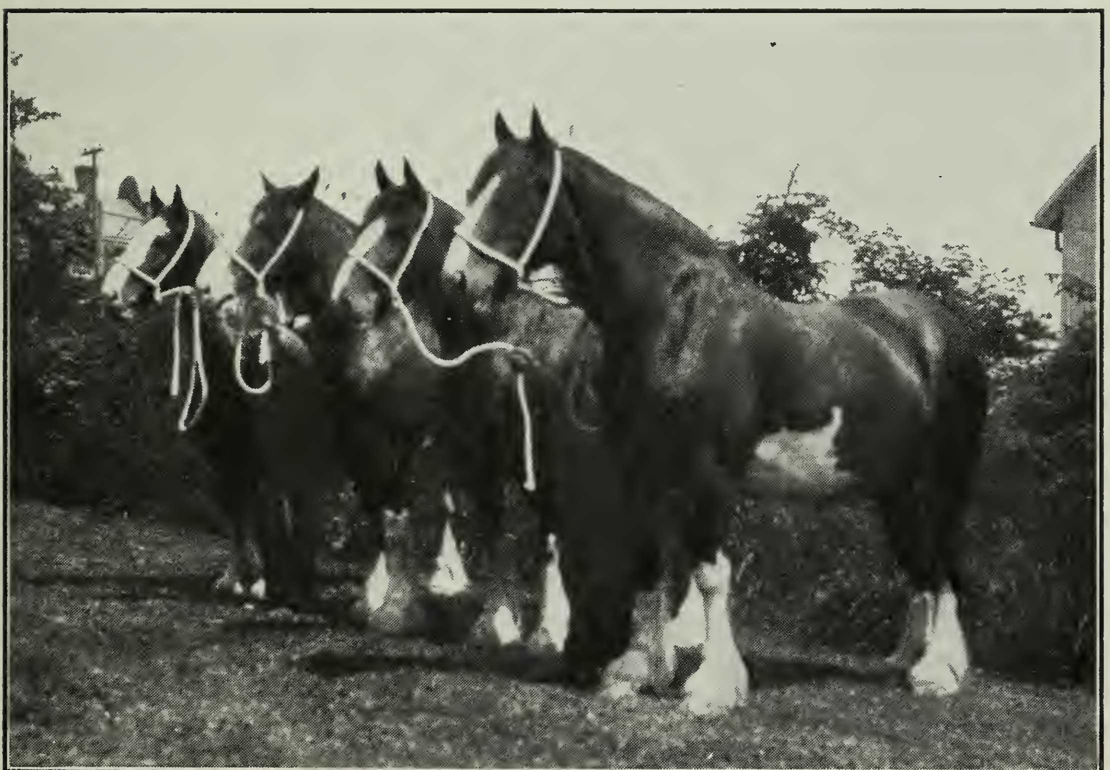
Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

DRAFT HORSES

J. C. Steckley, Professor of Animal Husbandry, and M.W. Staples,
Lecturer in Animal Husbandry.



A group of Clydesdale Brood Mares on the Ontario Agricultural College Farm.

DRAFT HORSES

Despite the inroads of trucks, tractors and automobiles the horse population in Ontario has decreased less than twenty per cent. in the last twenty years. Draft horses have decreased less than light horses. Comparatively few light horses are used for driving purposes at the present time but for farm work the draft horse still has an important place. Tractors and trucks have a place on the larger farms where they supplement rather than displace the horse. The draft horse is still used for delivery purposes in our towns and cities, particularly for short hauls or where frequent stops are necessary.

People, generally, admire the horse more than any other class of live stock. Ever since the dawn of civilization the horse has been closely associated with mankind, both in his business as well as his pleasure. At one time they were the most effective weapon in warfare and for many years supplied the power for transportation. People today admire horses just as much as ever but are less inclined to be interested in their care and management.

The horse has a longer life of usefulness than any other animal on the farm. He serves mankind in an entirely different way than other classes of live stock. His service is not to render food for man as is the case with other classes of animals, but his usefulness rather depends on his power of locomotion. By this he may assist the farmer and citizen generally by rendering power for various purposes. As a source of power he is dependable and, at the same time capable of rendering service during the whole year. He can perform this work on feed grown on the farm, much of which is not readily marketable. By the use of brood mares to do the work on the farm colts may be raised and thus replacement of power can be had at comparatively small cost.

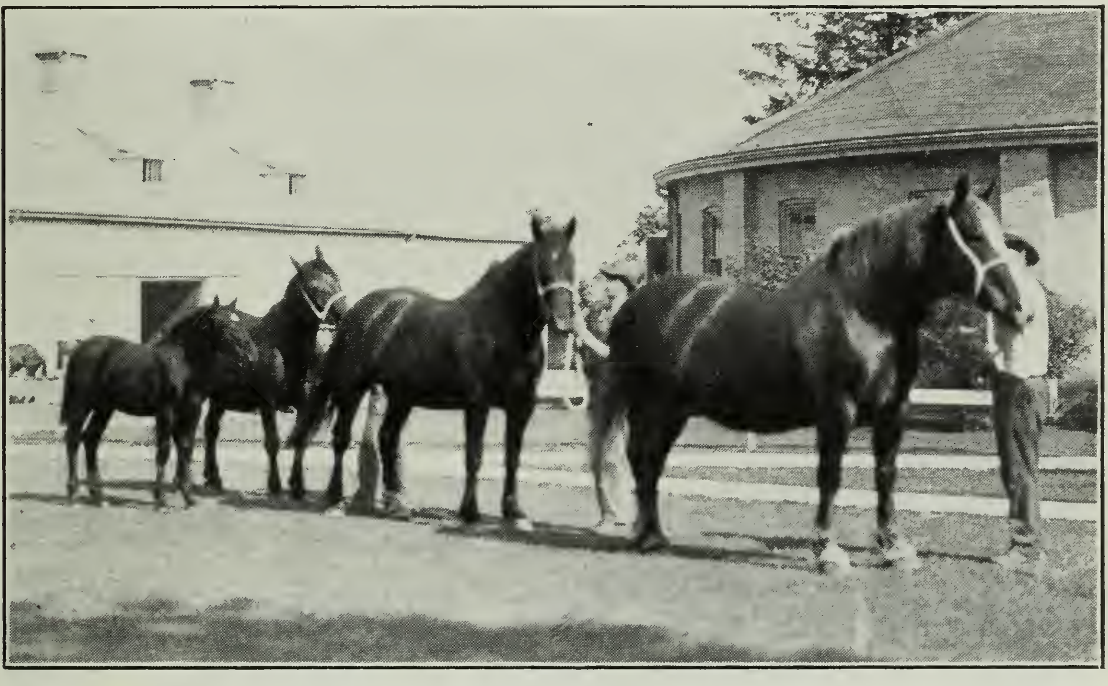
The breeding of draft horses is not a specialized business on the Ontario farm as was the case some years ago. It is rather a side line as there is not the same ready market in the lumber camps and in the cities for all classes of draft horses. Transportation companies and dairies, as well as some other business organizations continue to use the draft horse. Their demand, however, is only for the best quality. It is the market for the cheaper rougher classes of draft horses that no longer exists except for farm and, to a limited extent, bush work.

Horse breeding has not been profitable for the past few years in Ontario. Horses have been brought into the province and sold at prices lower than the Ontario farmer could raise them. This practice has lowered the standard of horses in this province. There are also a lot of aged horses at the present time which must be replaced in the next few years so that there is very indication of a better market for good draft horses in the near future.

Draft Type

The draft horse finds his particular field of usefulness in hauling heavy loads. He is a machine, the function of which is propulsion. To best perform this work he must be heavily and strongly built. Everything about him should be massive. The draft horse should be 16 to 17 hands high. This measurement is taken at the withers. The height should be due to depth of body instead of length of leg. A deep body indicates constitution, and capacity for food, which in turn indicates capacity for work.

The draft horse should weigh 1,600 lbs. or more. This weight should be largely due to massiveness of form, heavy frame and muscles, rather than to an excessive amount of fat. Depth and width of body, compactness, blockiness and heavy muscling are some o fthe things which indicate great weight and strength. Long legs, light bones and muscles, long body with small girth at the heart and flank, and a long back are some of the things which indicate that the horse is not heavy for his height and should cause you to discriminate against him.



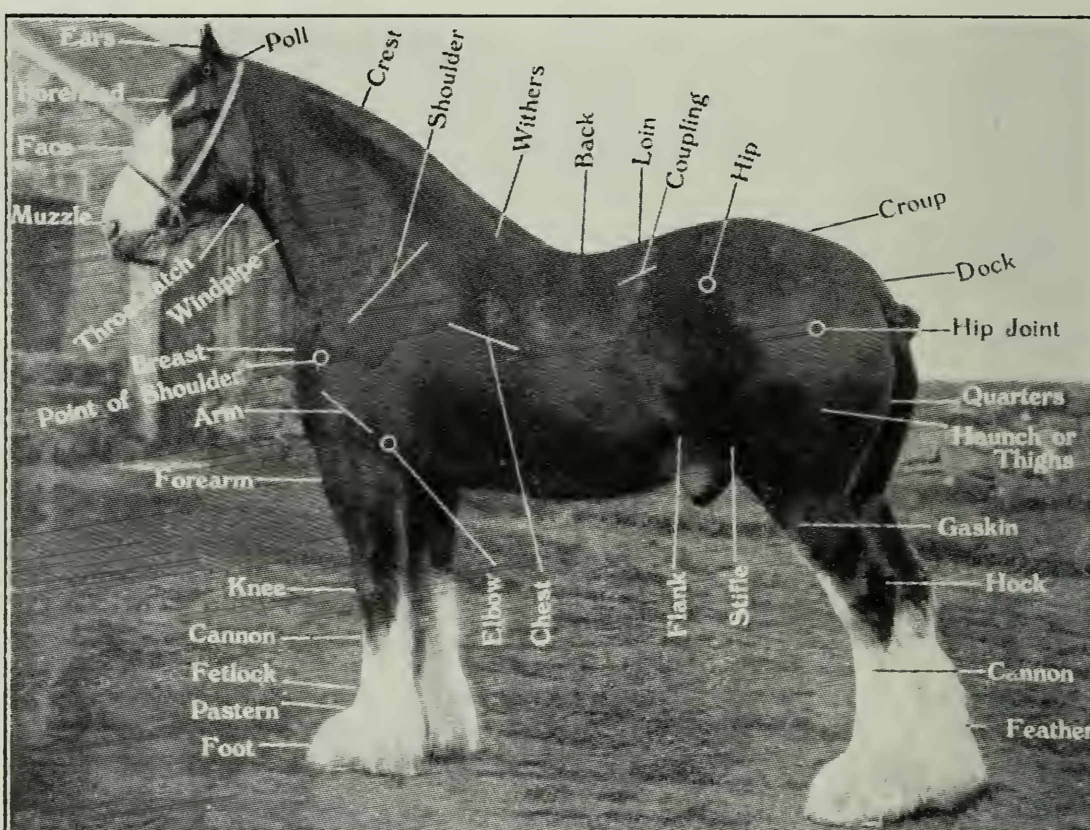
A family group of Percherons. Frances [9689] and three of her progeny, a foal, a three-year-old and a nine-year-old mare. All the Pure Bred Percherons on the College farm trace to this seventeen-year-old mare and her mate purchased in 1919.

The shoulder should be smooth and strong and should show an obliquity of about 45 degrees. The rough angular shoulder is more liable to become sore than the smooth snug one. It should lie well back into the body. The fore arm should show a clean flat appearance and should be heavily muscled. The knee should be large, straight and angular with the tendon standing out well to support the joints. The cannons should be short and clean with the tendon well defined at the back, giving the leg a flat appearance. The fetlock joints should be clean, straight and strong. The pasterns, viewed from the side, should show a slope of about 45 degrees, about the same slope as the shoulders. The foot should be attached to the leg so that it toes straight ahead. This position permits straight forward action. The feet should be large, even in size and, from the front view, should appear nearly circular at the line of contact with the ground. The heel should be deep and broad. The hoof wall should be free from cracks or breaks.

The fore ribs should be well sprung and long, giving the horse a broad back and a deep chest. The back should be short and heavily muscled, the coupling should be close and strong, the ribs roundly arched and the flank low.

The hips should be smooth and in keeping with the general width of the horse. The croup should be wide, level and heavily muscled. Deep, strongly muscled quarters and thighs are required for strength. The gaskin or lower thigh should be short and heavily muscled. The hock should be broad, clean and flat and strongly supported below. The juncture of the hock and cannon bone should be strong and should not appear cut in. From the rear, note the back and side of the joint which should be long from top to bottom, strong, angular and strongly supported by the back tendon and free from any puffiness. With the exception that the hind cannons are usually wider, pasterns and toes slightly shorter and feet less rounding the requirements are the same as for the fore legs.

Action is important. View the horse as he walks away from you. His feet should be lifted with a snap, the joints flexed so that the shoe shows plainly and carried forward in a straight line. The hocks should be carried fairly close together. As the horse walks towards you his feet should be lifted clear of the ground, brought forward straight and the heel and toe should meet the ground at the same time. This can be best determined when no dust or dirt is kicked forward by the impact. Viewed from the side, he should move with a quick, energetic, lengthy stride with a proper flexing of all the joints. The horse should then be trotted when the same observation should be made as before.



The names and location of the points of a draft horse.

SCALE OF POINTS

	Possible Score
HEAD—Ear of medium size and pointed; forehead broad and flat; eye full, prominent and mild; nasal bones straight; nostrils large, firm and flexible; muzzle rather small; mouth of medium depth; lips compact; muscles of cheek well developed and prominent; space between branches of lower jaw wide at angles	4
NECK—Of medium length, deep and full where it joins the body, being continuous with the withers without any line of demarcation; crest nicely arched; the whole neck to be well and prominently muscled, surmounted by a good full mane of good quality, and attached to the head in a graceful manner, not too thick and heavy at the throat	4

WITHERS AND BACK—Withers in line with the upper border of the neck, fairly high, broad and well muscled; back straight and short; loins broad, strong and heavily muscled	6
CROUP—Long, level, well and prominently muscled, dock coming out fairly well up and well clothed with straight and not too coarse hair	3
CHEST—Ribs long and well sprung with well marked angles; false ribs long, deep through girth; breast broad and well muscled	8
SHOULDER—Oblique and heavily muscled; the muscles covering the blade thoroughly developed and prominent	4
ELBOW—Strong and muscular and fitting closely to chest	1
FOREARM—Large and strong; rarther short and well muscled	2
KNEE—Straight, deep, broad and strong	3
KNEE TO FOOT—Cannon bone short, broad, strong, flat and flinty; ligament and tendons well developed and not too much tied in below the knee. Fetlock joint large and strong; pastern of medium length and well marked obliquely. Hair, where present, straight, fine and silky	8
FOOT—Large, round, with strong and deep wall, frog well developed and strong; heels broad and strong and not too deep. There must be an absence of any appearance of hardening or thickening of the lateral cartilages. Feet must be of equal size	8
HAUNCH—Strong and heavily muscled, thick through thighs; quarters broad and strong	4
STIFLE—Strong, compact and well muscled	2
GASKIN—Strong and heavily muscled, bone large	3
HOCK—Large, deep, broad, clean-cut, and angular. Must stand with hocks fairly well together, but straight	4
HOCK TO FOOT—Cannon bone short, broad, flat and strong; ligament and tendons well developed and strong; and not pinched in below hock; fetlock joint large and strong; pasterns of medium length and well marked obliquity. Hair, where present, straight, fine and silky	8
FOOT—Smaller, narrower and more concave in sole than forefoot; wall strong and moderately deep; frog well developed and strong; heels broad and strong, and not too deep. Feet must be of equal size	8
TEMPERAMENT—Energetic, docile, not nervous	4
STYLE AND ACTION—General appearance attractive, movements bold, straight, true and snappy, must be a good walker, all joints moving freely; knees and pasterns and hocks and pasterns well flexed, showing the soles of the feet quite plainly, must not wing or paddle with the fore feet, must not go wide at the hocks, nor yet close enough with the feet to interfere	10
WEIGHT AND HEIGHT—Say 1,600 pounds and upwards and say 15½ hands up	6
TOTAL	100

NOTE: Colour varies in different breeds. It may be bay, chestnut, brown, black, roan or gray in Clydesdales and Shires, or it may be black, gray, bay or brown in Percherons, or chestnut, roan or bay in Belgians, etc. All horses should show a good coat of fine, silky hair, and a soft, smooth skin.

The Draft Breeds

There are only five breeds of draft horses found on this Continent. They are the Clydesdale, the Percheron, the Belgian, the Shire and the Suffolk. The Clydesdale is still the leading breed in Ontario. The Percheron is becoming more popular and has been gaining on the Clydesdale the last few years. There are a few Belgians in the province at the present time and they rank third in popularity. The Shire, at one time, was quite popular but at the present time is seen only in a few sections. There have never been any large numbers of Suffolks in the province of Ontario.

The Clydesdale

The Clydesdale breed originated in Scotland. It takes its name from the river Clyde which flows through the district where Clydesdales originated. This country is rather rough and broken which accounts for the early improvers of the breed paying particular attention to feet and legs.

The origin of the modern Clydesdale traces back to about 1715. At this time, John Paterson of Lochlyoch, a tenant farmer in the County of Lanark, brought a Flemish stallion from England and bred him to the mares of that particular region. Other blood, such as the Shire, was also used in improving the horses of this district. One of the prominent early Clydesdale sires was Glancer (335) better known as "Thompson's Black Horse." He was foaled about 1810 and is believed to have carried some Lochlyoch blood. From this horse most of our present-day Clydesdales are descended.

Carbrook Bucklyvie [22039] a noted Clydesdale sire in Ontario in the last twenty-five years. He has a long list of prize winners in Canada to his credit and before leaving Scotland, sired Jim Scott, afterwards champion gelding at the Highland Show.

Broomfield Champion (95) one of the Glancer line, travelled in Aberdeen one season where he was known as "Aberdeen Champion." He was taken back to Broomfield and there became the sire of several noted stallions besides a number of prize mares. To this horse, early breeders liked to be able to trace their stock and so with him a more careful noting of pedigrees originated. Breeders began to find it advantageous to use a superior strain of blood. With this new attention to breeding, a new era in the history of the breed commenced.

A few of the early sires were Lochfergus Champion (448), Samson (741), Sir Walter Scott (797) and General (322). One of these, Samson (741), was the sire of two mares that left their mark on the breed. These were Darling, the dam of Prince of Wales (673), and Keir Peggy, the dam of Darnley (222).

Prince of Wales (673), foaled in 1866, had a very remarkable career in the show yard. His victories attest to his individual merit and as a sire he was one of the greatest of the breed. Many of the show animals between 1871-1896 were sired by him.

Darnley (222) was one of the best bred Clydesdales of his time tracing to Broomfield Champion through both his sire and dam. Considerably more is known of his ancestry than that of Prince of Wales. Darnley was also a show horse. As a whole, his stock were marked by a strong family likeness, perhaps never more clearly exemplified than at the Highland show, Perth 1887, when his fillies carried almost everything before them. Darnley was the sire of some well known stallions including MacGregor, Flashwood and Top Gallant, and was also the sire of the dams of Prince of Albion, Prince of Kyle, Prince Alexander and others. These last named stallions were by Prince of Wales. It will thus be seen that not only was Darnley the great rival of Prince of Wales as a sire, but in many respects his needful complement. Nearly all present-day Clydesdales trace to either Darnley or Prince of Wales. A large percentage trace through Darnley's great grandson, Baron's Pride. This horse has been called the "Father of the Modern Clydesdale."

One of the chief characteristics of the Clydesdale is the excellent quality of bone which they possess. They probably have not the same width and compactness of body that other breeds have but good specimens of the breed have sufficient size for a draft horse. The bone is clean and fine and the conformation of the hocks is the most perfect of any of the draft breeds. The slope of pastern offers the greatest relief to concussion so that the breed is particularly adapted for wear on city streets. The feet are of good size and texture. They have considerably more feather than some of our draft breeds. This should be fine in quality and not too abundant in the present day Clydesdales. In action, they are characterized by straightness of stride and sprightliness of movement. They carry their hocks close together whether walking or trotting. While many of the breed do not measure up to the standard for weight, a fair standard would be 2,000 pounds for the stallion and 1,600 pounds for the mare. The standard colour markings are bay or brown with a white star or stripe in the face, with all or part of the legs up to the knees and hocks white. There are also blacks, roans or chestnuts with white markings.

The introduction of this breed of horses to Canada dates back to the first half of the 19th century. One of the earliest importations occurred in 1842 and was made by Archibald Ward of Markham who imported Gray Clyde in that year. The same year R. Johnston of Scarboro imported Sovereign. Cumberland was imported by David Rowntree of Weston in 1845. In 1851 George Buchanan was imported by John Wilson of Oshawa and Bay Wallace by William Cochrane in 1854. Since that time importations have been made almost annually and many Canadian-bred and imported Clydesdales have found their way into the United States to lay the foundation of the breed there.

The Clydesdale Horse Association of Canada was organized in 1886 and up to the present time they have recorded 81,063 pedigrees and issued 32 stud books.

It is possible to register Clydesdale mares with four top crosses of registered Clydesdale breeding. In the case of stallions five top crosses of pure breeding are required.

The Percheron

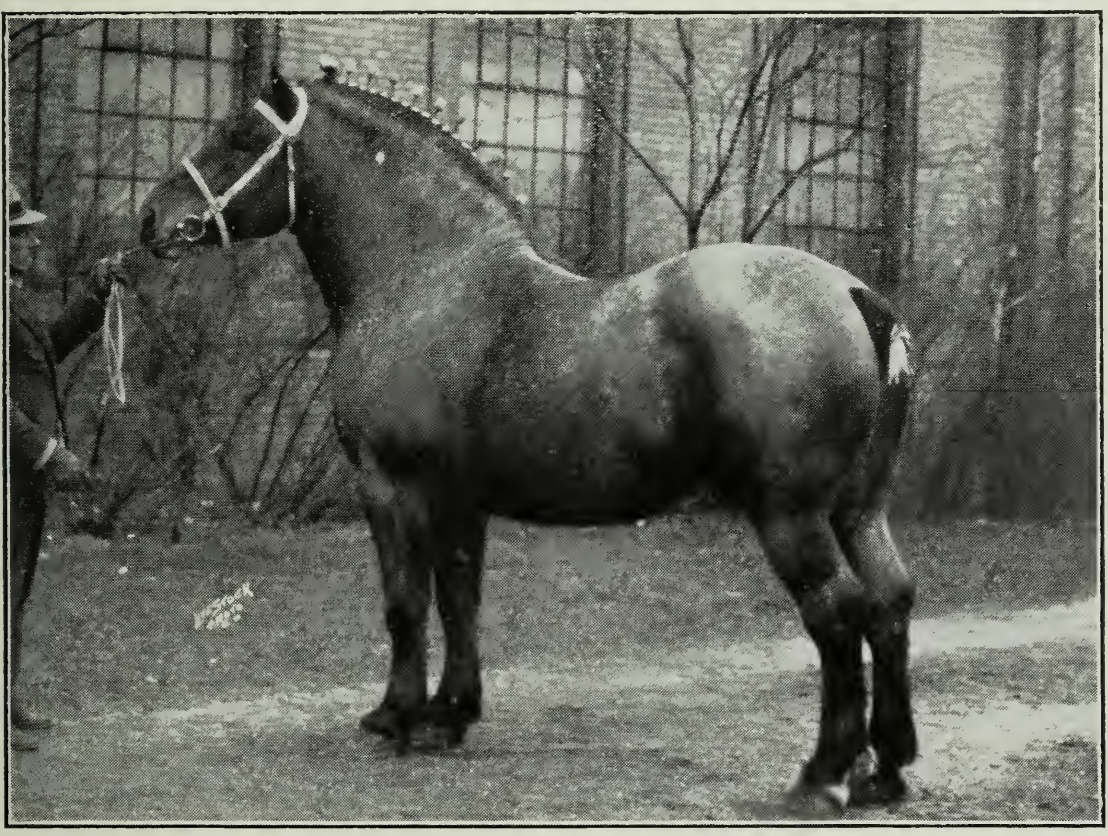
The Percheron originated in the province of La Perche in Northwestern France. This district has for many centuries been famous as a horse breeding area. The early horses of this district differed very little from other horses in Europe. The earliest improvers of the breed used Arab and Barb horses which were brought from the East. In their early development they were used a great deal for stage coach work. The horse breeders of La Perche specialized in this type of horse and their success marked the beginning of Percheron popularity. After the advent of the railroads they were developed as agricultural and draft horses.

Monarch [10386], prize-winning Percheron Stallion and the sire of a number of show animals including the Grand Champion Stallion at 1931 C.N.E., and first prize get of sire at the Royal, 1931.

About 1820 an effort was made to add size and weight to this breed. This was accomplished by the following methods: (1) The selection for breeding purposes of the largest animals within the breed. (2) Better care and management. (3) The possible introduction and use of Flemish stallions from Belgium.

Possibly with this breed less attention has been paid to blood lines than to individual merit. There are, however, a number of well known strains or families. The Brilliant strain rests on two horses, Brilliant 3rd and his grandsire Brilliant 1271. Carnot 66666, foaled in France in 1905 was an intensely bred Brilliant. He was imported in 1909 and has been one of the most successful show and breeding stallions ever used in the United States. Jalap, Lagos, Jasmine, Dragon, Laet and Etudiant are only a few of the well known sires belonging to the Brilliant family. Along with the Brilliant family should be listed the Coco, Favori and Picador families. These four families have left their mark on the breed in the United States and Canada.

The body of the Percheron is compact and blocky in form, full in the chest and with a broad back. Horses of this breed have often been criticized for having short rumps with rather low tail settings. The legs and feet are quite distinctive of the breed. The feet are well developed, the bone of the leg is usually of good quality while probably not so flat and flinty as the Clydesdale, and they have less feather. Percheron action is reasonably true and snappy and is usually better than any of the other breeds of draft horses except the Clydesdale. Gray and black are the predominating colours but bays, browns and chestnuts occasionally occur.



Carmen Dale [3503], a well known Belgian Stallion, grandson of Farceur, an outstanding breeding and show sire in the United States.

Percheron horses in Canada date back to the early part of the 19th century and no doubt the first representatives of the breed arrived with the French settlers in the province of Quebec. They have never been as popular in Canada as in the United States where they are wide spread and may be looked upon as the leading breed of draft horses. The weight of the mature stallion usually ranges from 1700 to 2000 pounds and mares from 1500 to 1800 pounds.

The Canadian Percheron Horse Association was organized in 1907 and since that time have issued 30,046 pedigrees and published 7 volumes of the Percheron Stud book. In order that Percherons may be registered it is necessary that the sires and dams be registered in the Canadian, American or French Stud books.

The Belgian

The Belgian is one of the oldest breeds of draft horses in existence. It originated in the same territory as the old Flanders horse. These animals differ a great deal from the old Flemish stock as their legs show an absence of hair and very little of the black colour of the old Flemish breed.

The Belgian horse is one of the most massive of all draft horses. He has short legs, a very compact body, is wide, muscular and deep. The neck is short and very heavily crested. Roans and chestnuts are the predominating colours though bay, brown, grey and black may appear. In many animals the feet are small with rather poor quality bone but great improvement has been made in this regard during the past few years. They are not usually as true in action as the Percheron or Clydesdale but good representatives of the breed show excellent action.

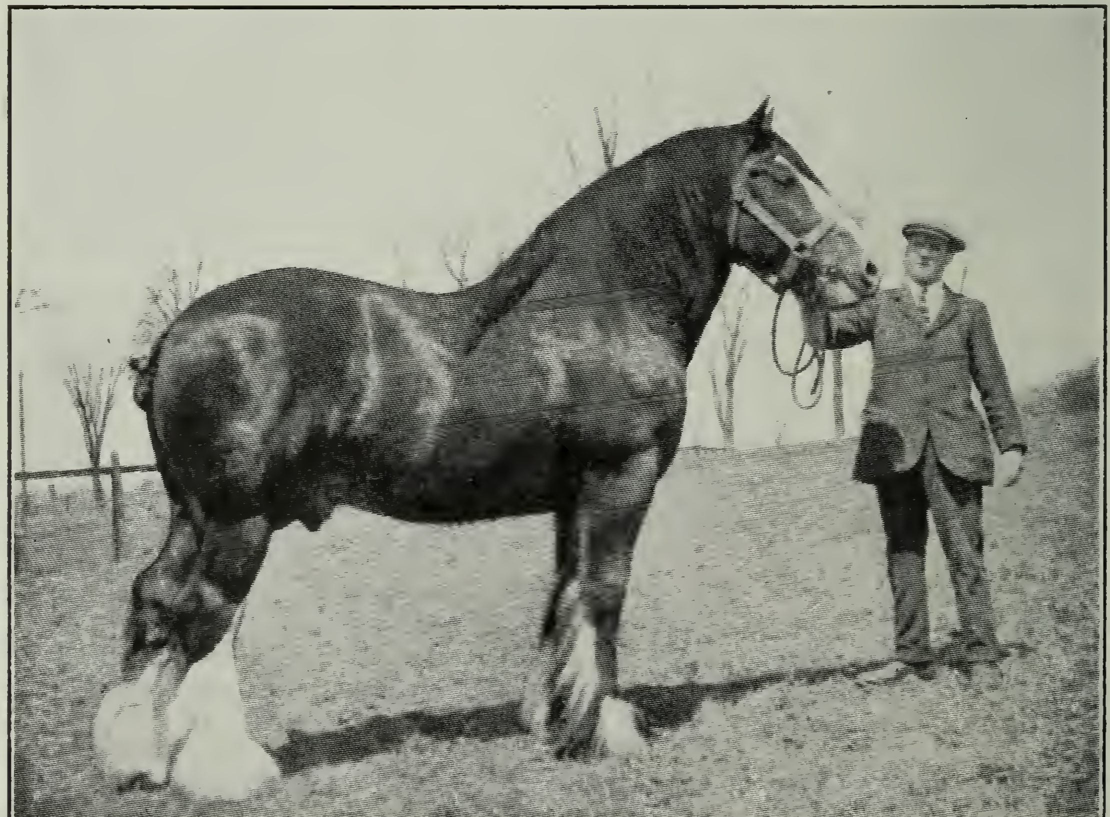
The Belgian horse made its appearance in the United States during the last half of the 19th century. In Canada the breed has not been quite so popular and it is only during the 20th century that they have made much progress. They are probably more popular in Western Canada than they are in Ontario.

The Canadian Belgian Draft Horse Association was organized in 1907 and up to the present time have issued 4,531 pedigrees and published 1 volume of the Stud Book.

No grading up for registration is permitted. The sire and dam must be recorded in the Canadian Belgian Draft Horse Stud Book.

THE SHIRE

The Shire is probably the oldest of our draft breeds as it dates its origin back to the days of the Roman Conquest. During the period when armour was worn it was necessary for horses to be of good size as they were called upon to carry a man with heavy armour which amounted to around 400 pounds. For this reason, a very large horse was developed, which, no doubt, was the foundation of the Shire breed of today.

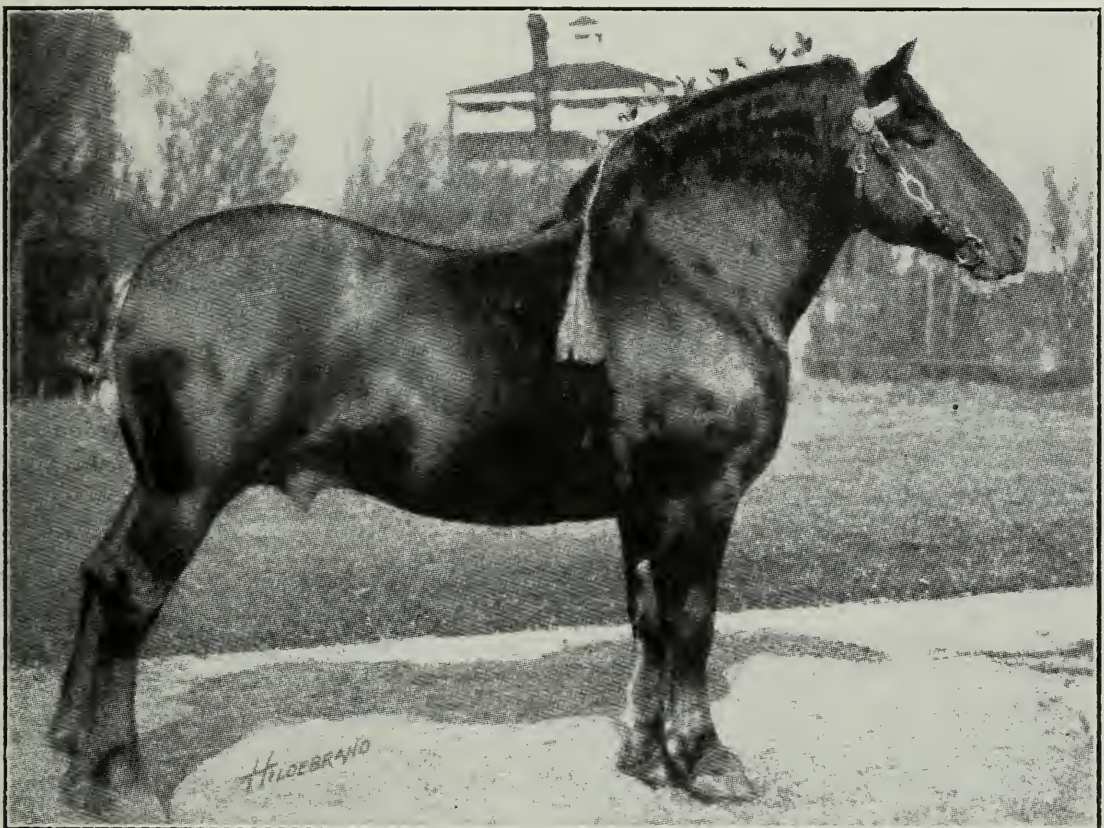


A typical Shire Stallion, "Snelston Topper."

The Shire is one of the largest breeds of draft horses, having very massive bodies but they are rather inclined to carry a little too much feather for popularity in this country. They have not the same quality, action and flat bone that the Clydesdales have and have not made very much headway in this province. They are of interest from the historical standpoint as the blood of this breed was used in developing the Clydesdale. They were first imported into Canada early in the 19th century.

The Canadian Shire Horse Association was first organized in 1888 and since that time have recorded 3,303 pedigrees and published 3 volumes of the Stud Book.

It is possible to register Shire mares with four top crosses of sires recorded in the Shire Stud Book of Canada. In case of a stallion, five top crosses are required.



A typical Suffolk Stallion, "Westview Chieftan."

The Suffolk

The Suffolk breed is commonly known as the Suffolk Punch and originated in Suffolk County in the Eastern part of England. This is one of the smaller of the draft breeds and is not widely known in Canada. The breed itself dates back to the beginning of the 18th century and it is supposed that Normandy horses played some part in the origination of the breed. It is believed that the Suffolk surpasses other breeds in Great Britain for purity of blood as there has not been very much crossing with other breeds. They are blocky and thick of body but are a little inclined to be rather light in the bone for a draft horse. They have not made very much headway in either Canada or the United States and are rarely seen in the Canadian show ring. The characteristic colour of this breed is chestnut.

The Canadian Suffolk Horse Society was organized in 1910 and have since then recorded 566 pedigrees.

No grading up for registration is permitted. The sire and dam must be recorded in the Canadian Suffolk Horse Stud Book.

FEEDS FOR HORSES

Fortunately in this country we grow excellent feeds for developing horses. No feeds excel oats, bran, mixed hays and roots for horse feeding. Oats are the safest and best of the grains. The proteins are excellent for bone and muscle development and the hull is an added advantage since it makes bulk. In Ontario there is a tendency to regard oats as the only safe grain for horses but in some countries other grains are used as substitutes for oats. The Arab horses, known for their speed and endurance, are fed largely on barley. This grain is also fed to horses in Northern Europe. Corn largely replaces oats in the corn belt sections of the United States.

Bran, on account of its bulky nature, mild laxative properties and high mineral content is especially valuable for feeding brood mares and colts. It contains phosphorus necessary for bone and muscle development. Bran forms a large part of the grain ration for show horses being maintained in high condition.

Oilcake is often fed when conditioning horses for work or sale. Of this feed one half pound per day is the usual amount for a heavy draft horse, and never more than one pound per day should be fed.

Flax seed or ground flax may be fed to horses but should be either boiled or steamed. According to some authorities raw flax seed may contain a compound which, when acted upon by an enzyme in the seed, yields the poison—prussic acid. Heating, however, will destroy this enzyme and make boiled or cooked flax a safe feed.

Of the hays, timothy has long been considered standard for the work horse. It is easily cured and for this reason free from dust, but it has also a slightly constipating effect. Mixed hays have a much higher feeding value and mineral content, being especially high in calcium. Farm horses should get these rather than timothy. In the past some horsemen have been prejudiced against alfalfa and clover hays. Possibly this has been caused by feeding these rich roughages in excess or by the poor quality of hay used. The legume hays are not quite so easily cured. In a feeding trial with United States Artillery horses it was found that the alfalfa-fed horses getting two pounds less grain and four pounds less hay per day than those fed timothy showed no shortness of wind, softness, or lack of endurance and gained in weight while the others lost.

Of the succulent feeds possibly field carrots, while not so commonly grown on Ontario farms, are slightly better than either mangels or turnips.

GENERAL HINTS ON CARING FOR HORSES

There has been considerable discussion as to the proper order of giving grain, hay and water to horses in order to secure the best results. Experimentation seems to show that the practice of giving the water first and the feed afterwards is correct. Watering after feeding may tend to disturb the normal arrangement of feed in the stomach and may wash considerable feed into the intestines before proper stomach digestion has been completed. *Water, hay and oats* would seem to be corect, but the successful English practice is water, oats and hay. The digestive processes in the horse have been worked out largely by experimental feeding and killing the horses at specific intervals of time after feeding. No churning of the contents takes place in the stomach of the horse and the successive feeds are arranged in order of their arrival. The average capacity of a horse's stomach when fully distended is three to four gallons and the organ is under the best physiological conditions for digestion when about two thirds full i.e. containing two or two and one half gallons, and in fact rarely contains more than this amount. Keeping these facts in mind one must conclude it is a mistake to overfeed a work horse with hay.

Salt is absolutely essential to all animals digesting roughage. It should be kept before horses at all times.

Variety is quite all right but avoid all sudden changes. A quick change from old to new hay or old to new oats will often result in colic. Wilted grass is more dangerous to feed than fresh grass.

MOULDY AND DUSTY FEEDS MUST BE AVOIDED. Mouldy feeds will usually cause poisoning when fed to horses and dusty feeds may cause heaves.

Occasionally the teeth require attention. In case a horse is not doing well with good care and feed, it would be advisable to have the teeth examined by a qualified veterinarian. In buying a horse some attention should also be paid to the mouth. Usually in the case of a cribber or wind sucker the outer edge of the teeth will be somewhat broken, due to the habit of grabbing the manger.

If a horse goes lame it is necessary to locate the cause. In locating lameness it should be borne in mind that it is the sound limb that the horse puts down with most confidence and when the ailing leg comes to the ground an effort to ease it is made by throwing the head up. When a horse shows lameness in the front legs, if the trouble is in the shoulder, the leg will usually be flexed at the knee when standing at ease. When the lameness is below the knee the affected limb will be extended forward.

The correct fitting of the collars and the proper care of the horses' shoulders are essential if maximum work is to be obtained. Steady hard work in hot weather is very hard on the shoulders and it is difficult even with good care to always keep them in good condition. Besides, ill-fitting collars may prove a distinct handicap when a horse is pulling a heavy load. A collar that is too short interferes with normal breathing and may be the cause of a horse holding back or even quitting because he cannot breathe properly. When collars are too long or too wide the point of draft may not come on the correct part of the shoulder and again a horse's efficiency is lowered. *Poorly fitting collars are usually the cause of sore necks and shoulders.*

A horse at hard work sweats considerably and when this evaporates a certain amount of solid waste material is left on the animal's coat. Careful grooming is necessary to remove the body waste thereby keeping the pores open and the skin healthy. It is best to groom the work horse at night so that he may rest more comfortably. Grooming should be thorough but a dull currycomb is preferable to a sharp one, and only a brush should be used on the head and legs.

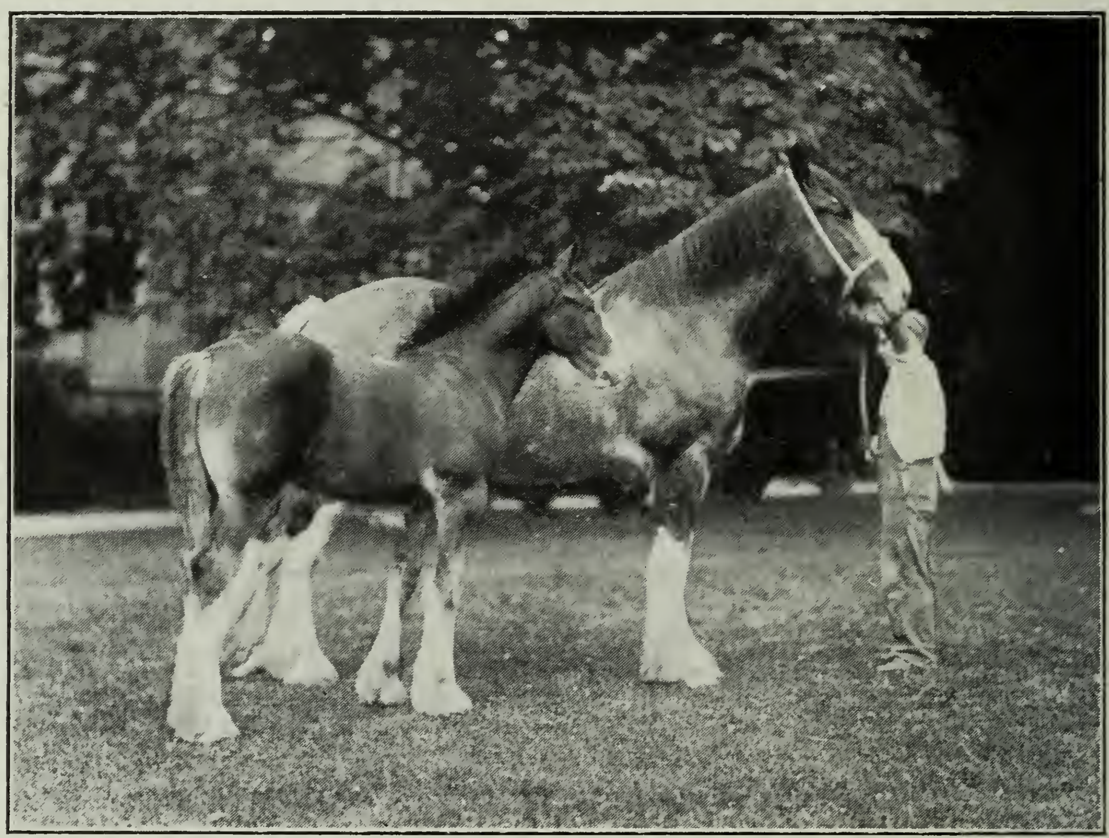
It is doubtful if the farm horse should be clipped. Usually he is not worked sufficiently to cause excessive heating and the coat of hair serves as a protection from the cold. In any case the chest should be left unclipped.

THE BROOD MARE

Probably not more than half the mares bred each year produce living foals. From this one must conclude that the care and management of the brood mare is not all it should be. At least a part of this loss may be prevented by proper feeding and management. The gestation period of the mare is approximately eleven months or 340 days.

To have a successful brood mare it is best to breed her as a three-year-old and keep her breeding regularly. Mares kept excessively fat are often very difficult to get in foal especially when not bred until five or six years of age or older. There is also more risk of losing the mare or foal.

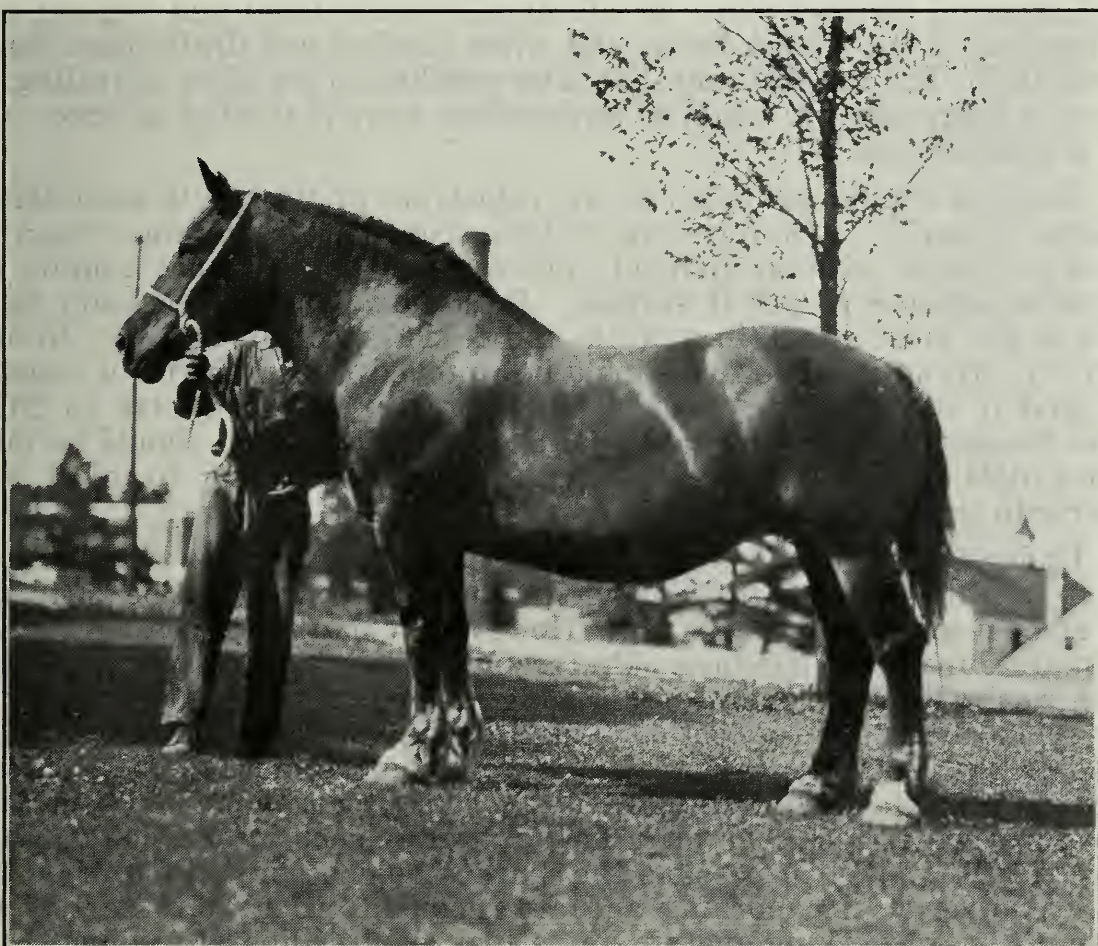
The importance of exercise for in-foal mares cannot be over emphasized. It should be regular throughout the entire gestation period. The working of brood mares is to be recommended. Not only is it good for the mare but it also reduces the cost of the foal. The man who works her should use good judgment. There is a difference between working and abusing. Pulling too hard, backing heavy loads, wading through deep mud or snow or over-exertion must be avoided. Preferably she should not be worked for one week previous to foaling, but there are plenty of cases where mares have been worked even up to the day of foaling without harm.



Maude Mark [50177] and her colt foal sired by Precedence [24623]. Photo taken at eight years; weight 1750 lbs.

The feeding of a brood mare that is doing some work is much simpler than is the case with an idle one. The chief essential is a well balanced ration containing plenty of protein, the muscle forming nutrients, and minerals, chiefly calcium (lime) and phosphorus, for development of bone. For the most part these are well supplied by home grown feeds. Legume or mixed hays, oats, bran and roots are satisfactory feeds for in-foal mares. The amounts fed during the winter and spring months will depend very largely on the condition of the mares, the age and amount of work being done. Young growing mares will require heavier feeding than the mature mares. In-foal mares during the winter months should receive daily from one-quarter to three-quarters of a pound of grain (3 of oats to 1 of bran) and about one pound of hay per 100 pounds of live weight. Some years hay may be scarce and grain cheap. It might be more economical to feed slightly more grain and replace part of the hay with good clean straw. On the other hand if hay be plentiful slightly more hay could be fed and a little less grain. Two mangels or turnips daily make a very satisfactory succulent feed. We dissolve $\frac{1}{8}$ of an ounce (level teaspoonful) of potassium iodide in the drinking water of the in-foal mare on the first and the fifteenth of the month, commencing this treatment in October for the mare that has been bred during the summer months. We believe this treatment tends to produce a healthier foal less apt to develop joint ill and also serves to prevent simple goitre and other undesirable conditions.

A mare at foaling time should be kept in a well lighted, roomy box stall, that has previously been cleaned and disinfected. Plenty of fresh clean straw free from dust and chaff makes a very satisfactory bedding. The formation of wax on the teats indicates that the foal may be expected within a few days. Usually the foal is born within twenty four hours after the appearance of the wax. This is only one of the many indications that foaling is near at hand, for sometimes there is a filling of the udder and teats and no wax formation. Someone should be present to render any necessary assistance and if necessary call a qualified veterinarian. When conditions are favourable and normal, the act of foaling usually occupies less than half an hour.



College Rosamond [13253], one of the Percheron brood mares at the O.A.C. Photo taken at nine years; weight 1950 lbs.

For the first day or two after foaling the chill should be taken off the drinking water in cold weather. As soon as the mare is on her feet she should be given a half pail. A warm bran mash (about 1 gallon) is very satisfactory for the first feed. In fact, on account of its laxative effect, bran should form one half the grain ration for the first week. It is well to feed the mare rather sparingly for a few days. This is especially true of mares that have been well fed previous to foaling. Such mares, if fed too heavily immediately after foaling may have an over supply of milk, causing digestive troubles in the foal. On the other hand, some dams do not have sufficient milk and it may be necessary to provide feed that will stimulate the milk flow.

When a mare foals on grass the feeding and management is much simpler. The aim should be to see that the mare gets considerable grass before and after foaling. The number of hours she may be kept out will depend largely on the weather as the very young foal should not be allowed to lie around on cold ground. On the other hand, foals born in late summer may suffer from too much exposure to the sun.

THE FOAL

With the young foal cleanliness is necessary. The navel should be disinfected with any reliable disinfectant according to directions. We apply a 2½% iodine solution at birth and daily until the navel is healed. Care should be taken not to spill any iodine on the colt's body as it may cause a mild irritation or blister. It is not a good practice to tie the colt's navel unless it bleeds freely. It will usually break itself and will not bleed so freely as if cut with a knife, and when healing will drain more readily than if tied. The navel stump should be watched to see if its is healing. In case of a leaky navel it would be advisable to have it treated at once. Consult a veterinarian.

The foal should get some of the colostrum or first milk soon after it is born. Usually it will have one or two sleeps before nursing. As a rule a foal will nurse without difficulty but at other times it may require considerable patience to get it started. Occassionally it is necessary to get some of the mare's milk in a bottle and feed the colt in this way in order to give it strength. The foal should be watched for any signs of constipation and if the digestive tract is not operating within twelve to fifteen hours he should be given a tablespoon of castor oil which should be mixed with a little of the mare's milk. Also it may be necessary to inject warm water into the rectum.

Under farm conditions it is often possible to allow the brood mare to run to pasture with the foal during the summer months and begin to work her at harvest time or early fall. However, it may be necessary to work the mare during the summer. Preferably she should not be worked from three weeks to one month after foaling. When the mare is working the foal should be kept in a cool dark stall during the day and turned out at night to pasture with its dam. It is very important that an overheated mare should not be allowed with the foal until part of the milk has been drawn by hand. Too much milk from a mare in such a condition will often cause scouring. When possible the mare should be brought to the stable in the middle of the morning and afternoon in order that the foal may nurse. A mare working and nursing a foal requires liberal feeding.

The foal should be taught to eat as soon as possible. This may be done by placing the feed box low and allowing the colt to nibble at the grain when the mare is eating. It will soon acquire a taste for grain. A mixture of three parts oats to one part bran is very satisfactory. It is more desirable to have oats crushed rather than whole for a colt of this age. It is doubtful, except for colts and old horses, whether the crushing of grain pays. Some horses are inclined to bolt whole grain but a little clean clover or alfalfa chaff mixed with it will make them eat more slowly.

FALL FOALING

Occasionally it may be necessary to have a foal born in the fall, preferably October or November before cold weather begins. This may be advisable, especially when a mare is required to do a heavy summer's work. Mares nursing foals during the winter months require a little extra feeding. Also it is necessary to allow the foal access to water. He will usually begin to drink about the same time as he learns to eat.

WEANING

The foal should be weaned at from four to six months of age. If he has been taught to eat while with the dam, weaning may be done without any serious set back. Since a colt makes half its growth the first year it is most important that it be properly fed. Bone and muscle-forming rather than fattening feeds are necessary. The ordinary home grown feeds including mixed hay, oats, bran and mangels or turnips are very suitable. In order to grow a colt rapidly without excess grain feeding a half pail of sweet skim milk may be fed twice daily. This is quite desirable when it has been necessary to wean at four or five months of age.

Regular exercise is equally important as the feeding. At the Ontario Agricultural College the colts are kept in a loose box stall at one of the barns. They are turned out nearly every day during the winter for four or five hours. They grow a heavy coat of hair which protects them from the cold and the exercise develops muscle and keeps the leg right. Colts that are turned out daily are also less apt to develop stable vices such as cribbing, than are those kept in with nothing to do.

What legume or mixed hay they will eat and from four to seven pounds of grain made up of three parts crushed oats to one part bran is fed daily. At the beginning of the winter they get about four pounds of this mixture and by spring this will have been gradually increased to seven pounds. Also one mangel or turnip per foal daily makes a very satisfactory succulent feed. This may be slightly heavier grain feeding than is common but it must be kept in mind that this is for April or May foals.

During the second winter the same practice is followed. The colts are turned out during the day and get what hay they will eat without wasting any and from seven to ten pounds of grain (oats and bran) daily. Also two mangels or turnips are fed daily.

RAISING THE ORPHAN

Occasionally a mare dies or has no milk and it is necessary to raise the foal on cow's milk. This may be done but requires considerable patience and care. Choose the milk from a fresh cow giving a low percentage of butter fat. To a tablespoonful of brown sugar add warm water to dissolve it, then 3 to 5 tablespoonsful of lime water and enough fresh milk to make a pint. Feed about one-fourth pint every hour for the first few days, always warming to blood heat. An ordinary nursing bottle and nipple is quite satisfactory. After a few days six feedings will be all right and later on four. At three to four weeks the sugar may be stopped but the lime water should be continued. In five or six weeks sweet skim milk may gradually replace the whole milk. At three months of age the foal may be given all it will drink three times daily. The foal should be taught to eat as soon as possible such feeds as crushed oats, bran and legume hay.

Lime water may be made by dissolving lime in water and allowing it to stand for several hours. Pour off and use only the clear liquid from the top of the container. This should be kept in bottles that are tightly corked as the lime water will gradually lose strength when exposed to the air.

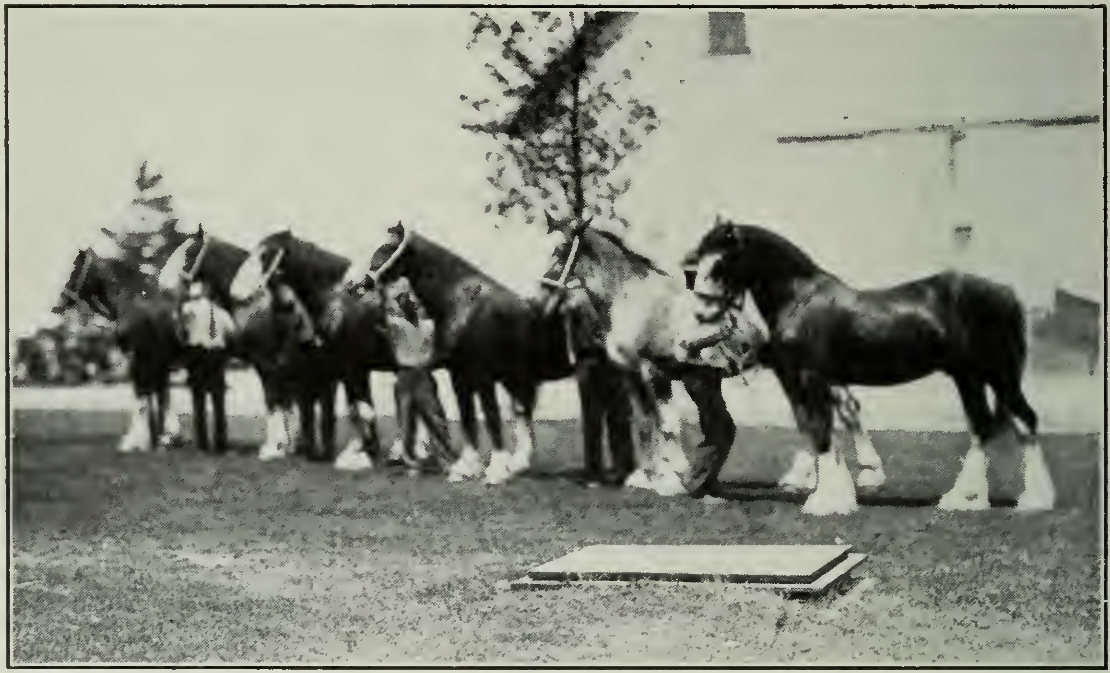
AGE TO CASTRATE

Colts not intended for breeding purposes should be castrated the spring that they are one year old. If done before this there is usually a lack of development of the fore quarters. However, it is seldom advisable to leave them entire more than one year as they often become troublesome. It is best to have it done at grass time and before the flies get bad.

SUMMER MANAGEMENT

The yearling and two-year-old colts are turned to grass early in the spring. Fresh water and salt are before them at all times. No grain is fed while the colts are on grass. By doing this we believe we get a horse with better feet and legs and a digestive tract that is not burned out with grain before the colt is mature.

On the College Farm with this treatment Clydesdales and Percherons rising three years old have weighed 1500 pounds and more.



A group of young Clydesdales bred and owned by the Ontario Agricultural College. They are sired by Baron Bobs [21952] one of the last sons of Baron's Pride.

CARE OF THE FEET AND LEGS

The statement has been made "that seventy percent of a horse is his feet and legs." The whole feeding and management should tend to produce not only a good body but feet and legs with the proper wearing qualities. The regular trimming of the colt's feet will influence, to a certain extent, the kind of feet he will have as a mature horse. Care should be taken to keep the heels as wide as possible. On soft ground or in a loose box stall a colt's feet may develop too much toe without sufficient width. It is a good practice to look over the colt's feet about once a month. The handling of the feet should begin when the colt is young and the trimming will be a simple matter. Under ordinary circumstances the frog should not be touched.

Sometimes there is a tendency to feed horses in racks or high mangers. In as far as possible colts should be fed hay out of a very low manger. A colt that is inclined to be weak in the knees will often strengthen when fed this way, and the trouble is only aggravated when he is compelled to reach up for his feed.

TRAINING THE COLT

The foal should be halter broken before weaning. A few lessons then will be much better and easier than as a two or three year old. It is a comparatively simple matter to break a colt that has been properly halter broken. Many good horsemen allow the colt to stand in the stable with the bridle and harness on a short time daily for a few days previous to hitching. He gradually loses his fear and will be less apt to kick. It is best to hitch him with a fast walking even tempered horse. The usual practice is to break him during the third winter getting his shoulders hardened ready for spring's work. A colt that has been properly fed should do considerable work as a three-year-old.

THE STALLION

The feeding and care of the stallion has a great deal to do with his success at the stud. He must be kept in good condition, but will not give best results if over-fat. Careful feeding and plenty of exercise, regular and sufficient grooming and sensible regulation of services are essential to success.

The ration of the stallion at heavy service will be quite similar to a horse at hard work. Oats, bran and mixed hays are very suitable. The total amount of feed required will depend very largely on his temperament and the exercise he gets. It is advisable during the breeding season to feed four times daily instead of three but giving the same total amount of feed. A warm bran mash may very well replace the last grain feed on Saturday night, especially during the breeding season. His care and management for the two or three months previous to the breeding season will have a very marked effect on his power to beget foals.

Regular exercise is most important. This may be done by leading a certain distance daily, or by paddocks or in off season by working.

AGE TO BREED

A well grown two-year-old stallion may be bred to a limited number of mares, not more than ten, and as a three-year-old not more than fifty mares. More services than these may impair his usefulness for life. The number that may be bred of course will depend on the length of the breeding season. Usually, however, it only lasts eight or ten weeks. It is almost impossible to lay down any hard and fast rules re. the number of services for a mature stallion. The stallion owner should remember that the reputation of his horse rests not upon the number and quality of mares he gets, but upon the number and quality of foals he leaves. Eighty to one hundred mares is generally considered a fairly heavy season.

FEEDING THE WORK HORSE

There are a number of points to be considered in feeding work horses. The ration will depend on the size and age of the animal and the severity of the work. There is a tendency among some farmers to overfeed work horses with hay and underfeed with grain. This makes the ration too bulky and indigestion may result.

Young and old horses require a slightly larger grain allowance than horses that are in their prime. A rule (Henry and Morrison) usually followed in making horse rations is 2—2.5 lbs. hay and grain per 100 lbs. live weight. The work performed will govern the amount of grain to be fed. Farm horses at hard work should receive daily about one pound of hay and one pound of grain per 100 pounds live weight. A common practice is to feed one-third of the grain at each feed but slightly more hay at the night feed. The pasturing of horses on idle days and at night will help keep down the cost of feeding. However, this is not always possible.

On idle days horses should be fed less grain. The character and amount of the ration should be modified to meet each change of work. The stocking or swelling of legs of horses receiving too much grain on Sundays and holidays is so common that it is often called "Monday morning disease." A safe plan is to cut down the oats in the ration and substitute about one-third bran. We give only two feeds of grain on Sundays and holidays rather than three.

Idle horses may be wintered almost entirely on roughages such as good hays and straw. The average farm horse usually does some work and should receive a small grain allowance. Horses should be fed grain at least one month previous to spring's work. Two mangels or turnips daily make a very satisfactory succulent feed for the farm work horse.

SHOW RING HINTS

In leading a colt one should always be on the left side. Keep to the outside when turning as there is less danger of being tramped or kicked leading him this way. No colt that has not been properly halter broken should be taken to a fair. The place to school him is at home.

Some showmen seem to think that a horse is not correctly shown unless he is prancing and taking short choppy strides. It should be kept in mind that the draft horse is required to do most of his work at the walk. For this reason a judge prefers to see a horse move with a long free easy stride. Also at the trot the mistake is often made of urging him beyond his speed. Others are not sufficiently careful when turning the horse before the judge. The horse is turned in a semi-circle and no attempt is made to move him straight from the judge. This may give the wrong impression of action. A good showman usually turns the horse and then stops before leading him away.

Occasionally the appearance of the draft foal is marred by the clipping of the fore top and mane.

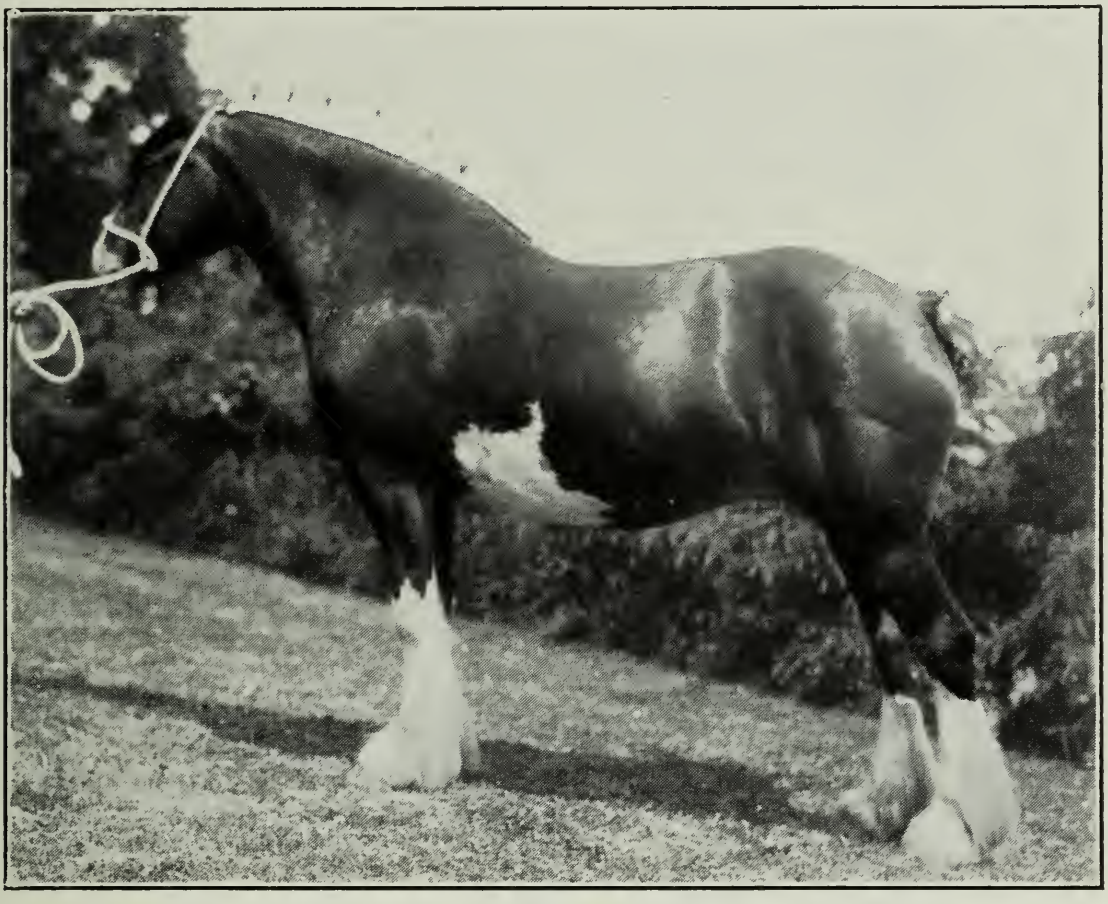
The age of a horse is computed to the first of January. This means a foal born in the fall must be shown the following year in the yearling class although he may not be one year old at the time of showing.

A brood mare is required to show with her foal by her side. In the Pure Bred classes the prize list usually states "Brood mare with her foal of the same breed by her side."

A Yeld mare is simply a dry mare four years of age or over. She need not necessarily have ever raised a foal or she may have shown in the brood mare class in former years.

At some shows one sometimes finds a man showing the same horse in the Heavy Draft and Agricultural classes. Such should not be permitted because it is at once apparent that the same horse cannot be both heavy draft and agricultural. Some horses are just on the line so far as weight and type are concerned and might be shown in either heavy draft or agricultural, but not both.

In judging draft horses it is usually not necessary to know the exact height of the horse as is the case in some light horse classes where this forms a basis for classification. The height is measured at the highest point of the withers and is stated in hands and inches. A hand is four inches. In taking the height a horse should stand on a perfectly level floor. The forelegs and hindlegs should be as perpendicular to the floor and as parallel to each other as the conformation of the horse permits. Also the head of the horse at the poll should be in line with the withers. It should be noted that the spirit level in the cross bar of the standard should indicate that it is being held properly.



Rose Glad Eye [50064]. She has raised four foals. Photo taken at seven years; weight 1900 lbs.

ESTIMATING THE AGE OF HORSES BY THEIR TEETH

The economic value of the horse depends to a great extent on his age, and it is useful to know how to determine this in order to estimate his worth. The teeth are a fair indication of the age of a horse. The indications become fairly satisfactory to those who have proven them many times by personal observation and experience in noting the differences that exist. It must be remembered that feeds have a marked influence on the wear of the teeth, and make differences not entirely due to age. Pasturing on sandy soils may also cause the teeth to wear more rapidly than when horses are pastured on other types of soil. Liberal feeding favours early maturity and may hasten the arrival of the incisors, but usually not more than a few months.

Order of Appearance of Incisors

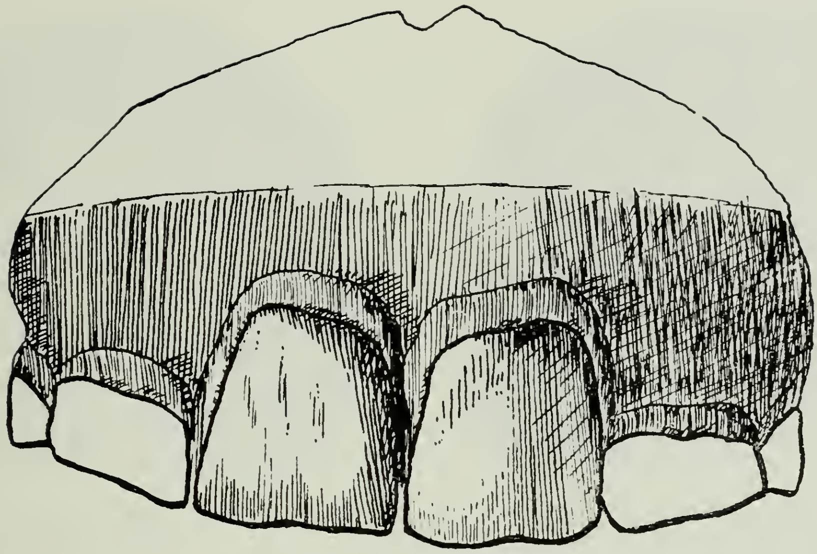
It is important in estimating the age of a horse to know the difference between temporary and permanent incisors. In the majority of cases the foal at birth has no teeth but it is not long before the temporary teeth begin to appear. The first pair usually appear at about ten days, the second pair toward the thirtieth day, and the corners at six to ten months. The temporary incisors or milk teeth as they are often called, are slender, narrow and very white, while the permanent incisors are broader, thicker and usually of a light yellowish or straw colour. In a general way the replacing of a temporary incisor by a permanent one last six months.

Since the permanent incisors of both the upper and lower jaws appear at the same time, it is only necessary to refer to the upper. There are six permanent incisors in each jaw in the full mouth and these make their appearance in pairs. The pair in the centre are the first to appear and have displaced the temporary pair and are full grown when the colt is from 2½ to 3 years old. The second pair are fully grown at 3½ to 4 years, and the third pair have displaced the two corner temporary incisors at 4½ to 5 years of age. At this time the horse is said to have a full mouth.

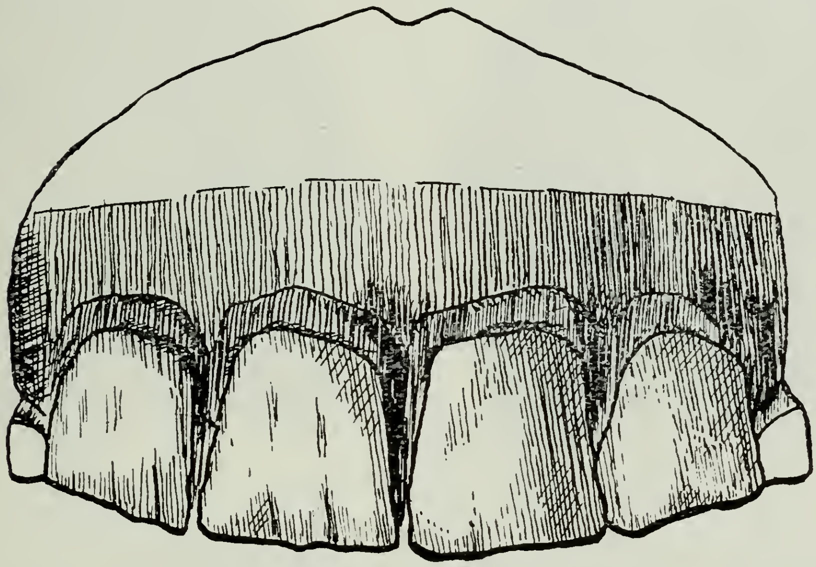
Disappearance of the Tables

The best indications of the age from five to eleven years is the order of the disappearance of the tables or marks in the incisors. At five years the tables in the central pair of incisors of the lower jaw show some wear but it is not until the horse is about six years old that they have almost disappeared. At seven years of age the two incisors next to the central pair lose almost all traces of their tables through wear, and at eight years the corner incisors or outside pair are so worn as to be almost free from any appearance of having tables. At nine years of age the tables have disappeared from the central pair of incisors in the upper jaw; at ten the marks in the next pair in the upper jaw are about worn out, and when eleven is reached the tables have almost disappeared from the corner pair of the upper row of incisors.

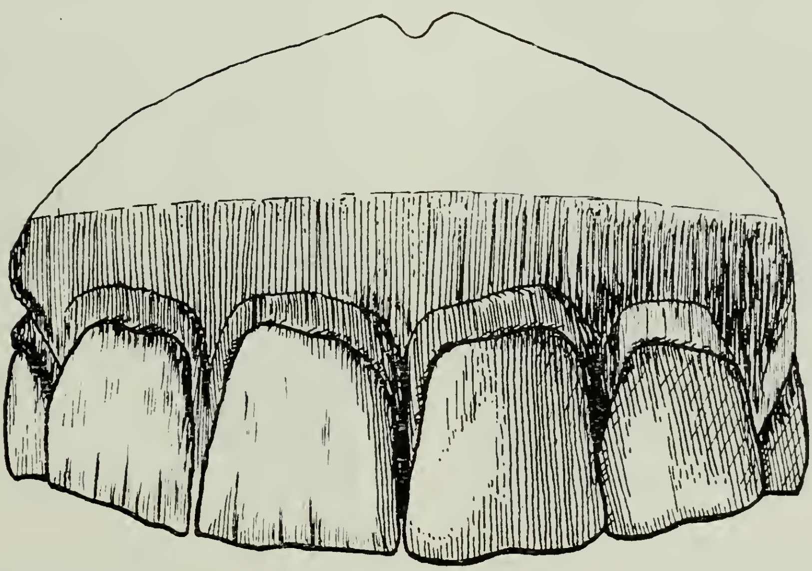
After a horse passes beyond eleven years of age it is more difficult to estimate the age with any degree of certainty. With advancing age the upper surface of the incisors appear more triangular and the teeth spring from the jaw with a greater slope. This is clearly illustrated in the sketch showing the mouth of the seventeen-year-old Percheron mare "Frances."



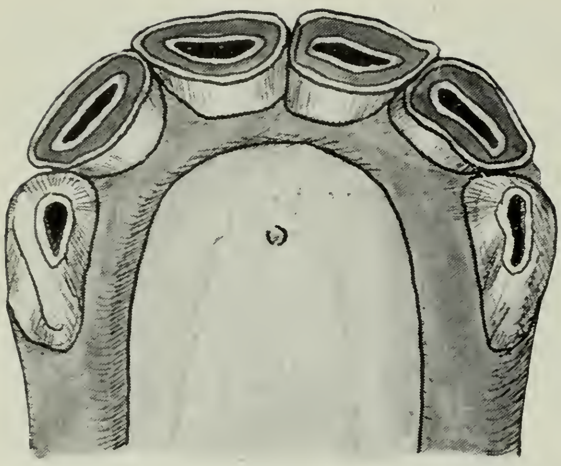
Three-year-old mouth showing first pair of permanent incisors.



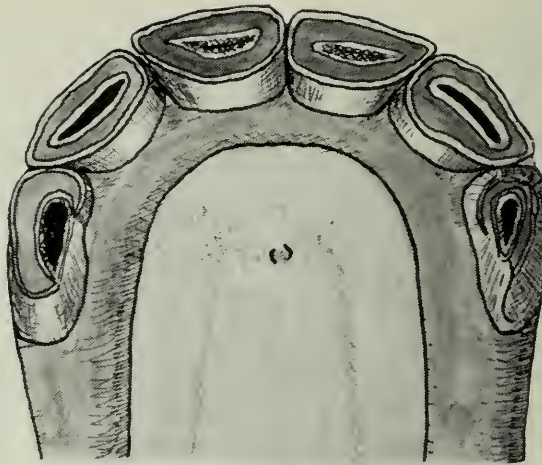
Four-year-old mouth. The second pair of permanent incisors are in place.



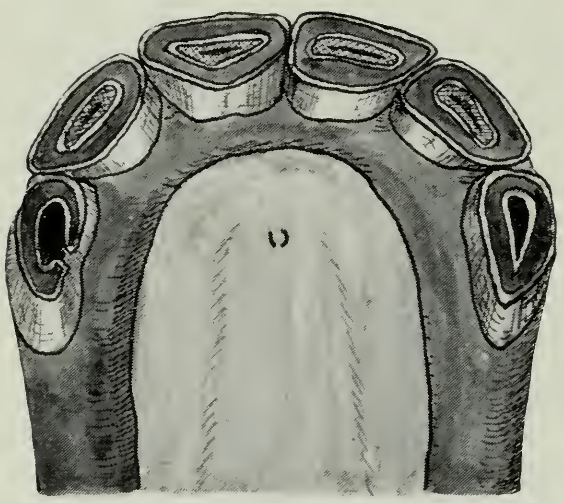
Five-year-old mouth. The horse has now a full mouth, or all his permanent incisors.



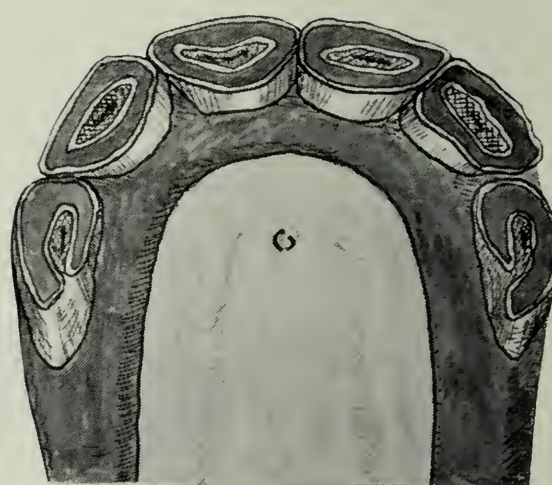
Five Years
Lower Incisors



Six Years
Lower Incisors

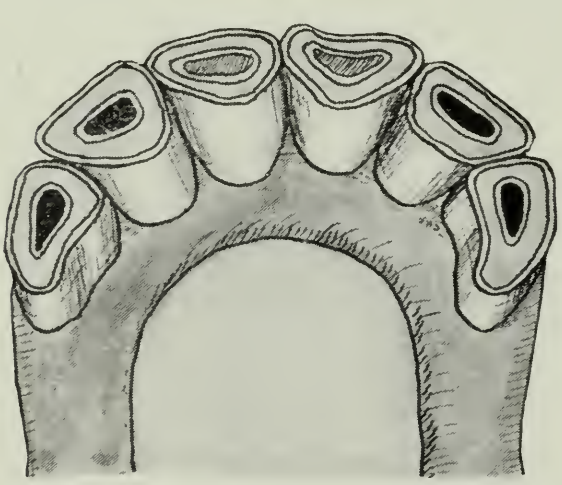


Seven Years
Lower Incisors

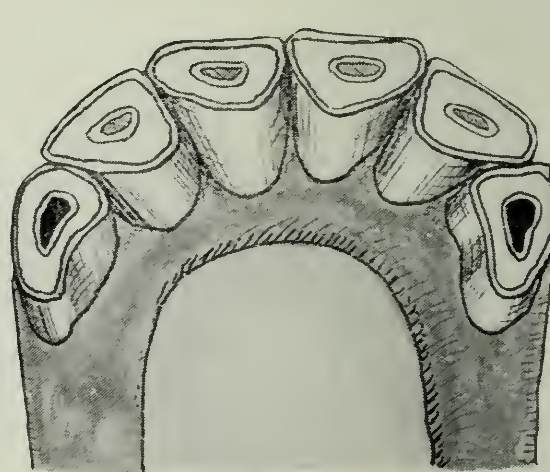


Eight Years
Lower Incisors

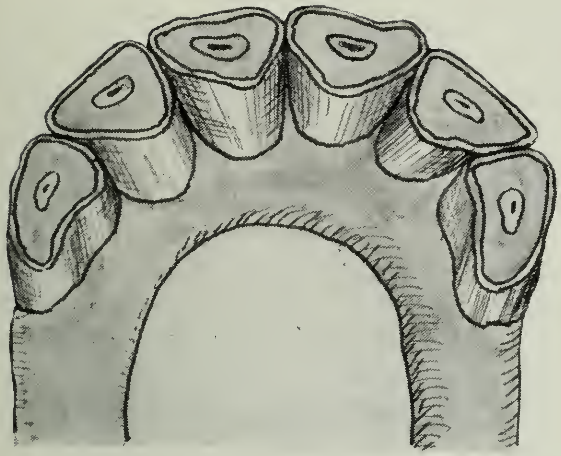
At five years the marks are quite distinct and the tables show practically no wear in any of the incisors. At six years the tables in the centre pair of the lower jaw show some wear, the marks becoming smaller. At seven years the second pair have nearly lost their marks, and at eight the corner pair show considerable wear.



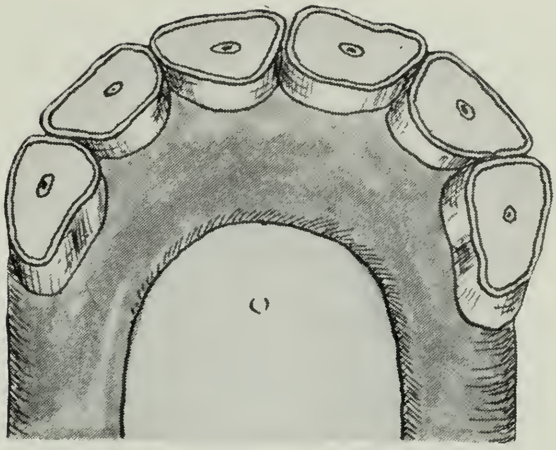
Nine Years
Upper Incisors



Ten Years
Upper Incisors

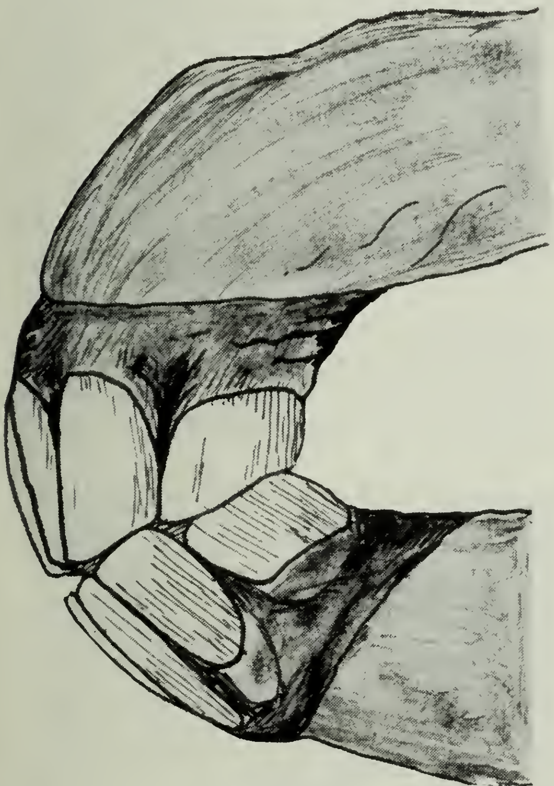


Eleven Years
Upper Incisors

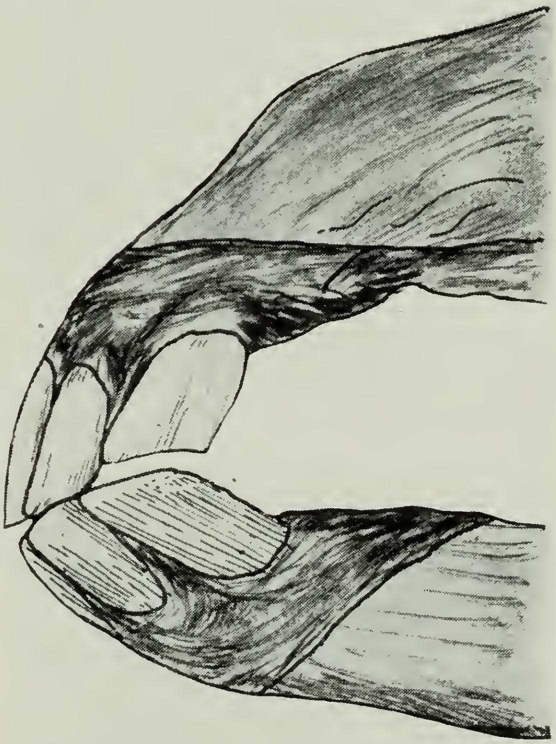


Seventeen Years
Lower Incisors

At nine years the central pair of permanent incisors in the upper jaw have almost lost their marks. At ten years the second pair have reached the same condition, and at eleven years the marks have gone from all of the permanent incisors.



Five Years



Seventeen Years

Comparison of a five-year-old mouth with that of a seventeen-year-old, showing the difference in shape as age advances. The teeth spring from the jaw with a much greater slope. The sketch showing the seventeen-year-old mouth is that of "Frances," one of the two imported Percheron mares brought to the College in 1919.

The prints of the horses' teeth were made by a student under the direction of the authors. In as far as possible these sketches were made from horses' mouths, but it was also necessary to use models which were loaned by the Ontario Veterinary College.

UNSOUNDNESS IN HORSES

An unsoundness is generally considered any disease or malformation which lessens the usefulness of the horse, but a blemish may depreciate the value without interfering with his usefulness. Such injuries as wire cuts may properly be called blemishes. Careful observation and much practice is necessary to determine unsoundnesses except in acute cases. It might be in order to explain the unsoundnesses listed in "The Ontario Stallion Enrolment Act," 1927. The act states:

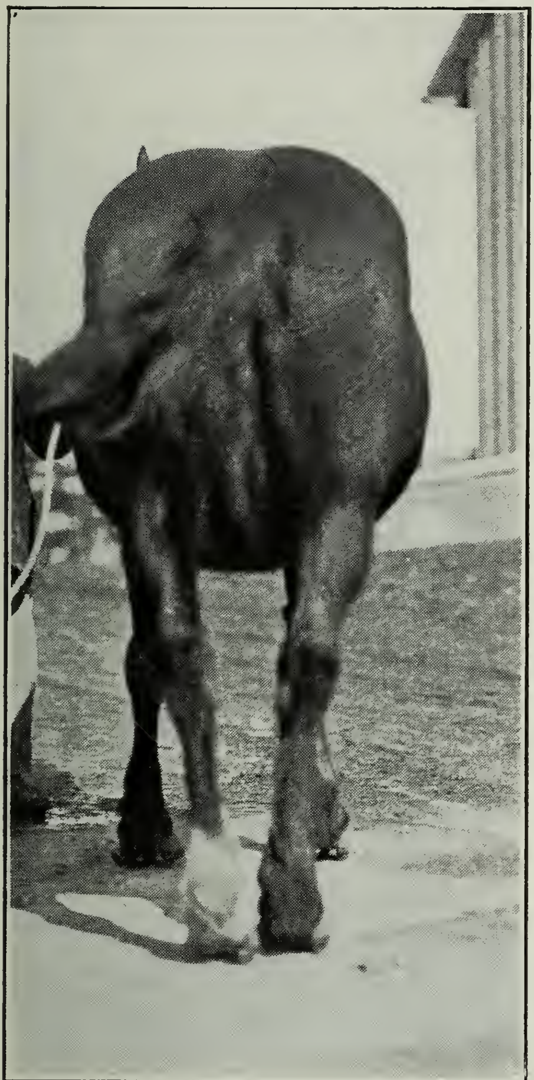
"The following shall be considered diseases or malformations, as the case may be, under these regulations: Bone spavin; curb, when associated with a formation of hock which predisposes to curb; bog spavin, when associated with a formation of hock which predisposes to bog spavin; ring bone; string-halt; side bone; roaring or whistling; periodic ophthalmia; navicular disease; and radical defect or defects or general defectiveness of conformation rendering the stallion unsuitable for use in the stud."

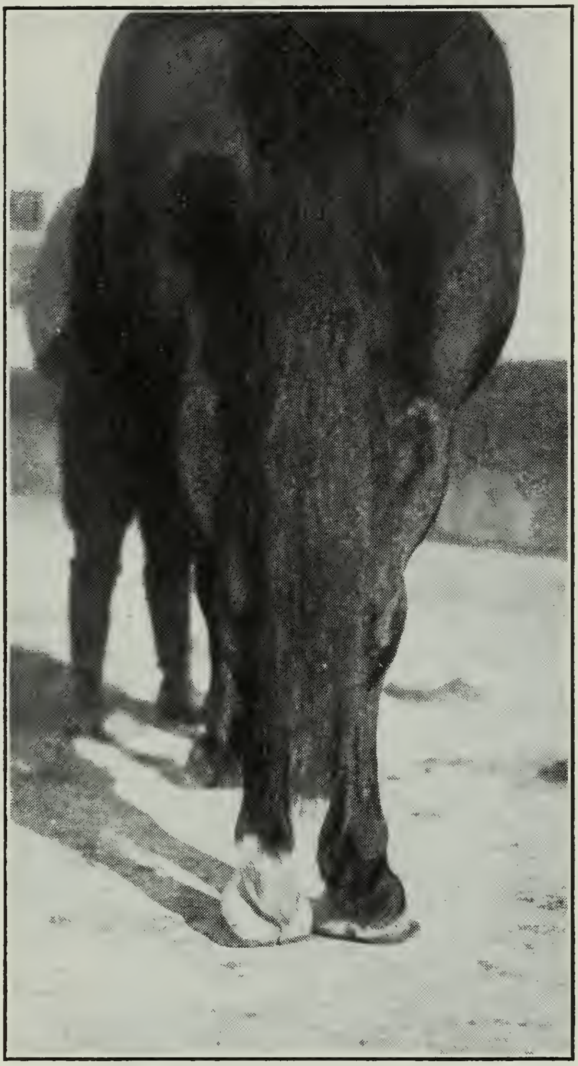
BONE SPAVIN—The hock should be carefully examined because this is likely to be the hardest worked joint of the body. The most common trouble and worst of all is the bone spavin, frequently called jack spavin. Bone spavin may be caused by anything that produces inflammation, for example, FAULTY CONFORMATION and mechanical injuries of the hock, either from blows or kicks or from too rapid and hard work on paved streets. To detect a spavin it is best to stand in front of the horse so that one is able to see the inner outline of the hock. Bone spavin consists of a bony deposit which nature has thrown out to strengthen an otherwise weak joint and when it has developed it ties the joint so that it interferes with the proper action of the horse. The hind leg instead of coming down on the heel as it should in a sound limb, is thrown forward so that the toe reaches the ground first and the stride is unnaturally shortened and lameness frequently results.

Occult spavin is very hard to determine since the deposit is not apparent to the eye but hidden in the joints. The horse, however, will go lame on being taken from the stable. The lameness may disappear after considerable exercising.

A well developed bone spavin. The photo at the left shows a rear view and the one at the right a side view. Also a thoroughpin has developed on the right hock. Note the short round conformation of the hocks which predisposes to unsoundnesses.

CURB—A curb is found just below the hock and to the rear. It is a thickening of the ligaments or tendons in that region. By looking at the leg from the side it may be easily seen as it is a variation from the straight line which normally extends from the point of the hock to the fetlock. Narrow tied-in hocks are more subject to curbs than those that are broad.





The photo (left) shows a mare standing incorrectly being wide at the hocks and narrow at the ground—base narrow. This is only a faulty conformation but frequently results in unsoundnesses. Compare this with the photo (right) showing the mare standing with the hocks well under.

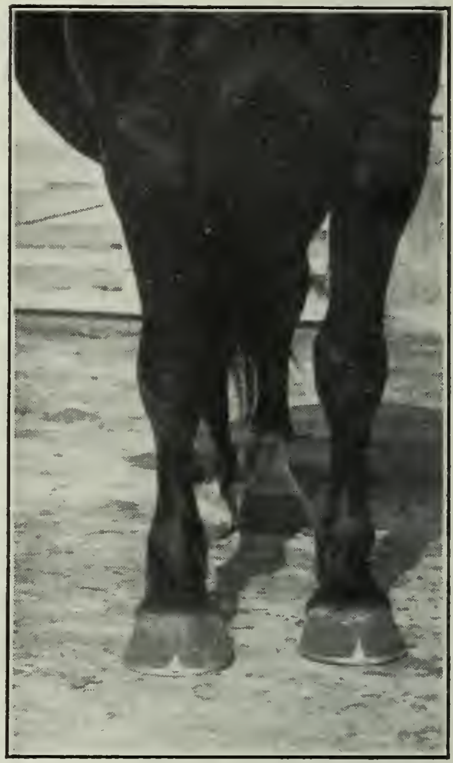
BOG SPAVIN—Bog spavin is found in the natural depression that occurs in the inner and front part of the hock. The oil from the joint accumulates and forms a soft swelling commonly known as bog spavin. It is usually associated with a short round hock.

RING BONES—These are located on the pasterns and are more common to the fore limb. Short upright pasterns are predisposed to ring bone formation. Pasterns that are too straight on young mature horses usually become more upright with advancing age and the action depreciates in proportion. There are two forms called the high and low ring bone, depending on the location. Usually it is situated at the hoof head where the foot joins the pastern. Because of the prominence in most cases it may be readily seen but occasionally it is necessary to pass the hand over the joint to detect a small form.

STRING HALT—This is a spasmodic jerking up of one or both hind legs. It is most evident when a horse is walking, turning or backing.

SIDE BONES—Side bones are common to the front feet. By pressing the thumb and fore finger around the hind quarter of the front foot this unsoundness may be detected. They are small, hard prominences that were originally cartilages but have hardened, often causing pain and lameness when the horse is driven on hard roads.

Some horses have coarse cartilages which are soft and pliable and should be distinguished from side bones.

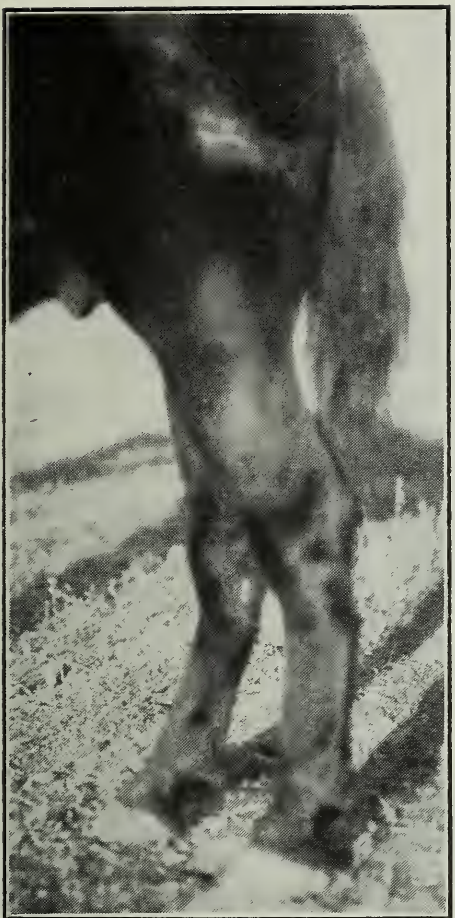
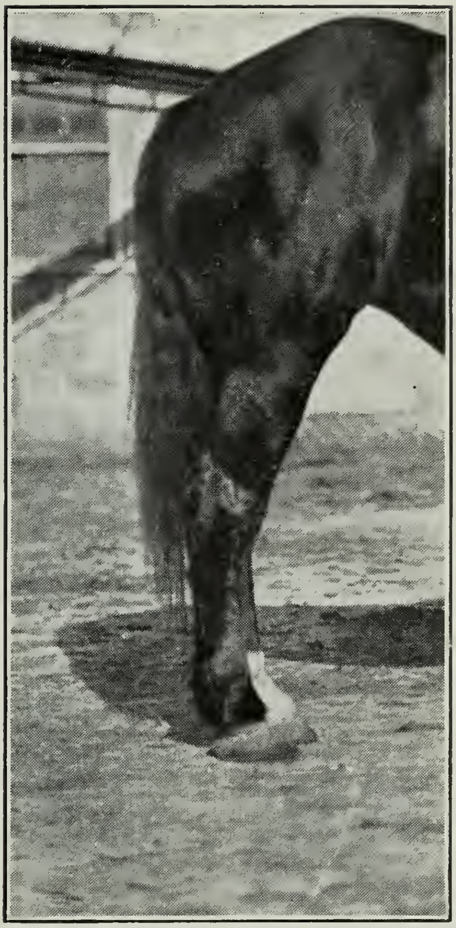


The photo (left) shows an undesirable pair of front feet with two well developed side bones, and (right), clean cut sloping pasterns and broad spreading feet. Note the coarseness and lack of quality of the feet and legs of the former .

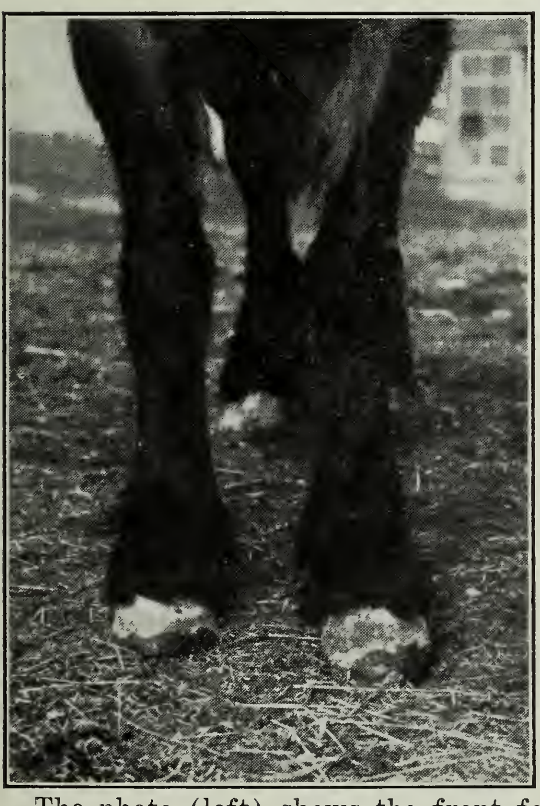
ROARING OR WHISTLING—The chief symptom is a roaring or whistling sound following a brisk trot or heavy work. This sound in severe cases may be heard some distance away. It is one of the diseases which prevents a stallion from standing for public service in France.

PERIODIC OPHTHALMIA—This disease is characterized by periodically occurring attacks of inflammation of the eye. Finally the animal becomes blind. The natural shape of the pupil of the eye is elliptical and a horse that has been attacked with this disease usually has a somewhat spherical pupil. Also the eyelid may be shrunken. A horse by its action will usually indicate if the eye sight is good. Stepping inordinately high or an inclination to shy usually indicates defective vision. By moving the hand slowly in front of the eye, blindness may be detected. If the hand be moved too rapidly the influence of the air on the eye may induce the horse to shut it though it may not have seen the motion of the hand.

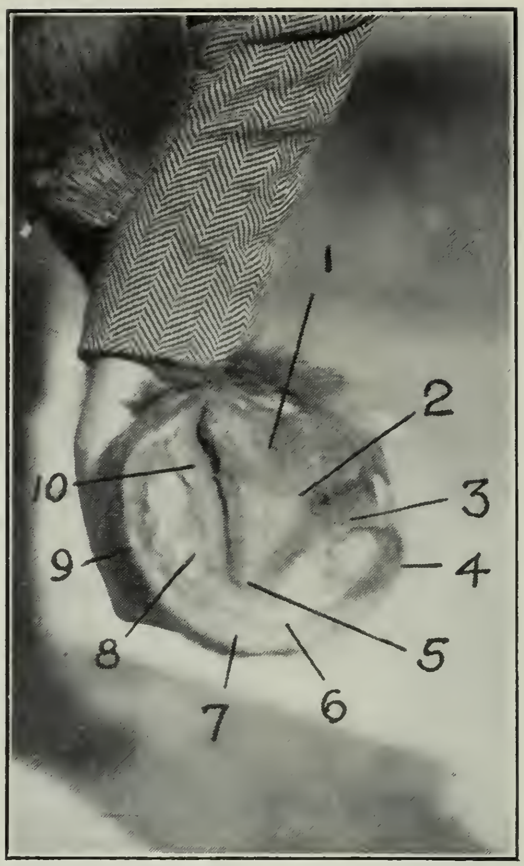
NAVICULAR DISEASE—In advanced cases the heels contract, the hoof becomes hard and dry, the frog dries up and in bringing the foot to the ground the toe strikes the ground first. At first the symptoms are scarcely noticeable. Without warning the horse may limp but after a few steps goes sound. According to some authorities navicular disease occurs almost exclusively in harness horses.

The photo (left) shows weakly supported hocks predisposed to curbs and other unsoundnesses. The hind legs of this horse indicate a lack of strength. Contrast this with a normal pair of hind legs (right).




The photo (left) shows the front feet of a horse affected with navicular disease. They have a narrow contracted appearance. The bottom of the foot (right) of the same horse shows a narrow contracted heel and a shrunken frog.



A photo of the bottom of a healthy foot. Note the clear outline of the parts in direct contrast with the diseased foot. The foot has a better shape, a wider heel and a larger frog.

1. Central furrow.
2. Lateral Ridge of frog.
3. Bar.
4. Outer Quarter.
5. Apex of Frog.
6. White Line.
7. Ground Border of Wall of Toe.
8. Sole.
9. Inner Quarter.
10. Lateral Furrow between Frog and Toe

Horses' feet need constant care in order to keep them in good condition. Feet that are regularly trimmed seldom have quarter cracks nor do they cause much trouble.

The frog is soft and spongy in texture and acts as a spring in relieving concussion, when the foot comes in contact with the ground. In order to keep this organ in a healthy condition, the horse should be shod so that the frog comes in contact with the ground at every step, and should not be mutilated by whittling or burning. It is sufficient to remove any ragged portion as this organ sheds of itself. In cases where horses are compelled to stand in filthy stables, we frequently have a disease develop in the cleft of the frog, known as thrush.

The sole is made of a hard, horny substance and acts as a protection to the lower surface of the foot. It is thickest at the toe, gradually becoming thinner toward the heel. It should not be burned or whittled in shoeing. The sole should be concave not convex.

Occasionally, the feet become dry and hard. In such cases it is a good practice to pack the shoes at night with a little moistened blue clay or, in severe cases, have the horse stand in it for several hours. Hoof ointments also serve to keep the feet in good condition. Some paint the horse's feet with the waste oil drained from cars. This, however, contains some gasoline which may have a drying and hardening effect on the feet. In fact it may do more harm than good.

THE HORSE BARN

Occasionally it may be necessary to remodel a horse barn or build a new one. The following points should be considered:

(1) Width
(2) Ceiling height
(3) Windows
(4) Alleys
(5) Standing stalls
(6) Box stalls
(7) Harness room
(8) Stall construction
(9) Floors

WIDTH—One row of stalls requires about 18 feet for alley, stall, manger and walk.

CEILING HEIGHT—The distance from the floor to the under side of the ceiling joists should be at least 8 feet and 8½ or 9 feet is preferable. Low ceilings are usually associated with dark, stuffy stables and there is some danger of injury to stock. Provide at least 800 cubic feet or more air space per horse.

WINDOW SPACE—In as far as possible the windows should be at the rear of the horses, and there should be about five square feet per horse.

ALLEYS—Feed alleys are made from 3 to 4 feet wide. The litter alleys at the wall should be 5½ to 6 feet wide.

STANDING STALLS—The standing stalls for work animals may be single or double. If space permits, it is better to have single stalls. A single stall for a draft horse should be 5 feet wide from centre to centre of partition and the length at least 9 feet in all. The top of the manger is 2 feet wide and the standing platform 7 feet long. The standing stall should be wide enough for a horse to lie down in comfort but not wide enough to encourage him to roll.

BOX STALLS—A box stall should be provided wherever more than three or four horses are kept. It is essential for sick animals, colts or mares at foaling time, and should be at least 12′ x 12′. The box stall should have a feed box and manger of a type that takes up as little room as possible and with no projecting corners.

HARNESS ROOM—The harness room should be about the length of the stall and from 5 to 8 feet wide. The life of a harness is lengthened by affording it protection from stable air. Also washing and oiling the harness twice a year will greatly increase its length of usefulness.

STALL CONSTRUCTION—In horse stable construction everything should be solid and permanent. Stalls should be made tight to a height of about 4 feet and above this there should be a guard at the front of the stall partitions about 3 feet high.

The manger is built to a height of 4 feet on alley side and 3½ feet on stall side. The manger should be about 2 feet wide at the top and 12 inches at the bottom, the whole manger being 12 inches from the floor. A slatted bottom allows dirt and chaff to drop on the stall floor.

The materials used in stall construction are wood, concrete and steel. Wood is the most common material used and should be of 2″ plank such as rock elm or any other tough durable timber. Supporting posts should be 6″ x 6″, preferably oak.

FLOORS—The most satisfactory floor is concrete with the standing stalls overlaid with 2″ plank. The stall floor is sloped 1″ in its length toward the gutter. The gutter should consist of a slight depression rather than a distinct gutter.

Another method of securing drainage is to make a gutter 8 inches deep and 6 inches wide and cover it loosely with a plank set flush with the floor.

MULTIPLE HORSE HITCHES

For several years there has been considerable interest in working larger horse units, particularly on the plough. The four and five-horse tandem hitches have a place on most Ontario farms and in some cases the six-horse hitch may be used to advantage. There is less crowding and tramping of feet, the horses are cooler, and no horse is required to walk on the ploughed ground. However, with implements such as the disc or harrow, when four horses are used, it is quite satisfactory to work them abreast.

The four-horse hitch illustrated in Fig. 1 is almost self explanatory. In many cases this is all the horse-power necessary to operate a two-furrow riding plough. Most Ontario farms have at least this number of horses.

The five-horse hitch, Fig. 2, is very workable and practicable for Ontario conditions. This method of hitching is to have three horses in the lead and two on the wheel. In this hitch the nigh horse of the wheel team has about eighteen inches more neck yoke than his furrow mate. It will thus be seen that the wheelers are kept at a considerable distance away from the draw chain and also get more air. The nigh horse of the wheel team makes a very suitable place for working a brood mare or colt. Also, with this hitch, the driver has a full view of his horses and there is less interference in turning.

The Six-Horse Hitch demonstrated by the Animal Husbandry Department at the 1930 International Plowing Match. The horses are working efficiently hitched to a tractor disc. They were owned by the Corporation of the City of Stratford. The off horse of the lead three was seventeen years old and had worked nine years on the city streets. What machine can give better service than this? Photo by courtesy of the Farmer's Advocate.

The six-horse hitch is illustrated in Fig. 3. The lead three are hitched in the same manner as in the five-horse hitch but the rear eveners are proportioned differently and the regular neck yoke is used.

Special attention is called to the fact that only the lead horses are driven. The wheelers are tied in and bucked back. The tie or lead strap is snapped into the bit or halter ring. Fastening to the halter ring is preferable because it is easier on the horse's mouth. When the wheel horse is in the proper position the other end of the tie chain is fastened to the single tree of one of the lead horses at an angle that will keep the rear horse walking straight ahead and keep him in place while turning. It should be fastened at a distance that will allow six to eight inches slack when the horse is working in a comfortable position or with enough slack to permit the front single trees to lie on the ground without bearing down on the heads of the rear horses.

In bucking horses back, a buck rope or strap is used. This snaps across the withers from one bit ring to the other. The longer section goes on the outside and crosses over the horse's withers. From the short connecting chain a single strap or rope runs downward and fastens into the draw chain just back of the horse's hind leg; that is, where the horse is next the draw chain. If the horse is not next the draw chain his buck strap fastens to the tug of the horse which has already been bucked back to the draw chain. This latter arrangement will only be necessary when six horses are driven.

When starting an outfit notice whether any of the horses show a tendency to walk to one side or the other. If one does, simply snap the rear section of the buck strap into the correct link of the short chain between the front checks. This shortens or lengthens the two front checks the desired amount so the pressure on the bit will cause him to walk straight ahead. If the horse wants to head out, shorten the inside check, and if he crowds in, lengthen it.

The lengths of the buck straps are as follows: outside check, 54 inches; inside check, 48 inches; short connecting chain, 10 inches; and the part of the buck strap which fastens to the draw chain, 6 feet. On each end of this strap bolt snaps should be used as it is much easier to fasten and unfasten them to the chains. The buck straps—rope or leather, tie chain, spreader, and neck yoke for the five-horse hitch are illustrated in Fig. 4. The eveners for any of these hitches may be made from 2-inch plank of any tough durable wood.

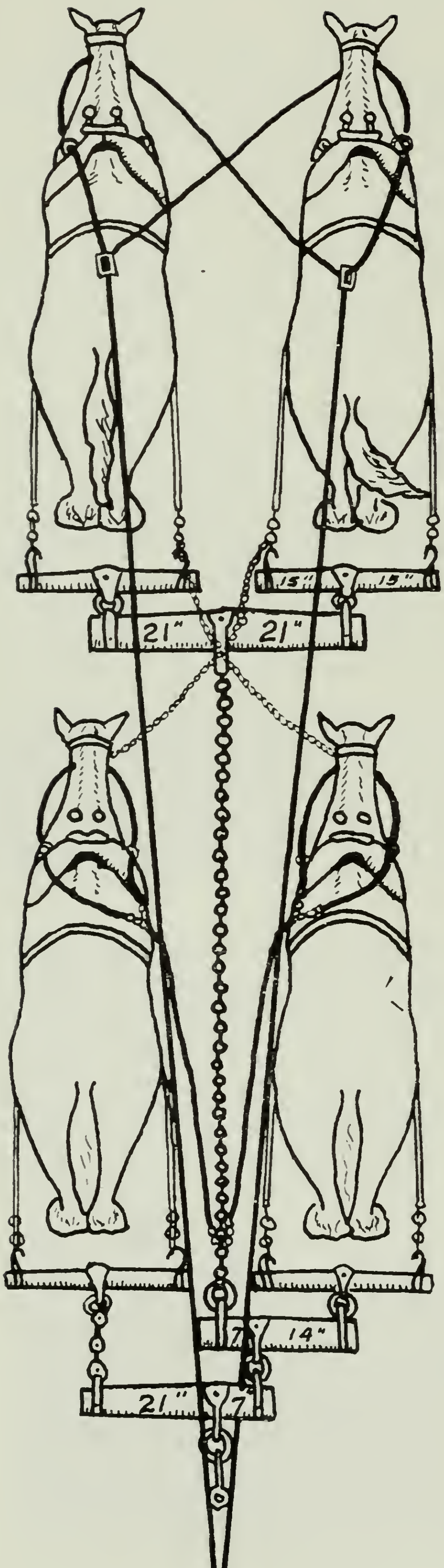


Fig. 1. The Four-Horse Hitch.

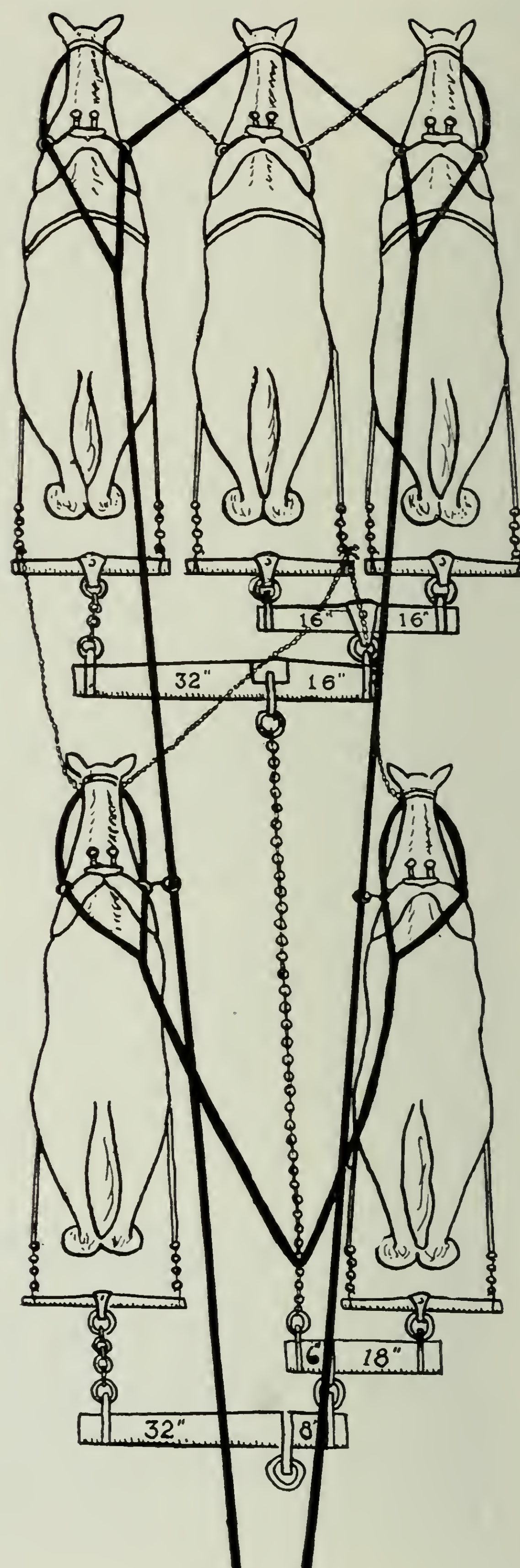


Fig. 2. The Five-Horse Hitch.

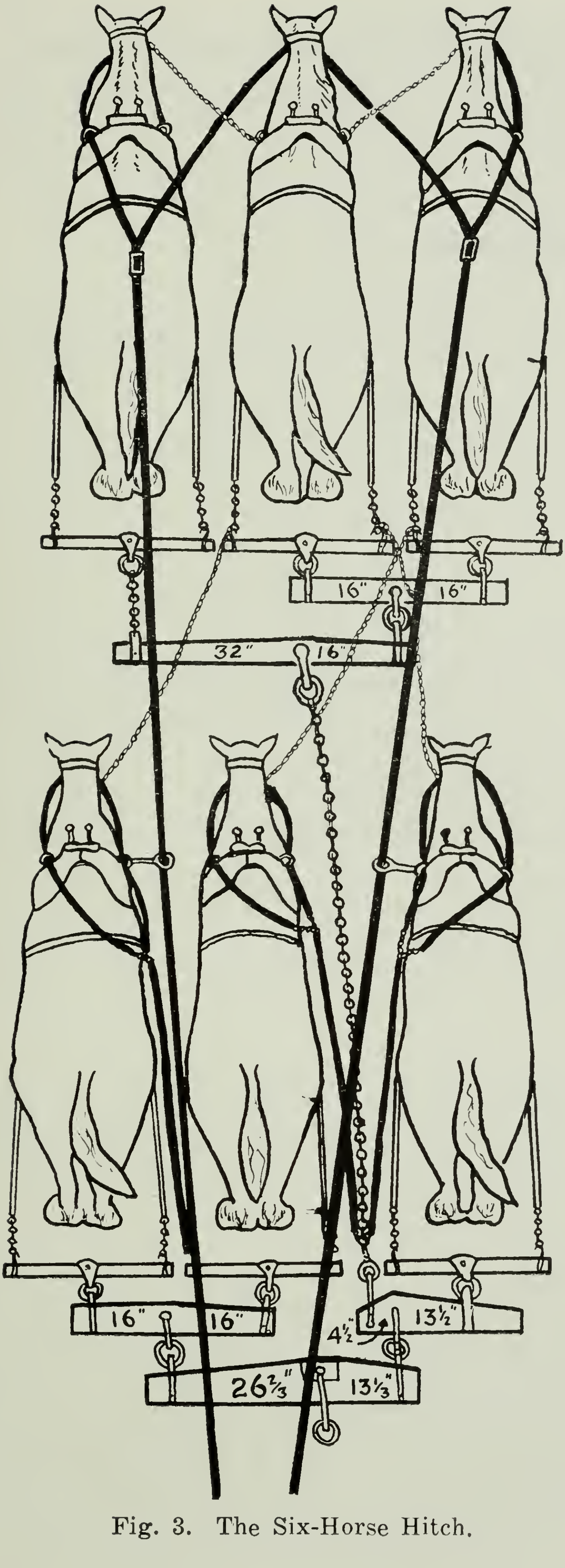


Fig. 3. The Six-Horse Hitch.

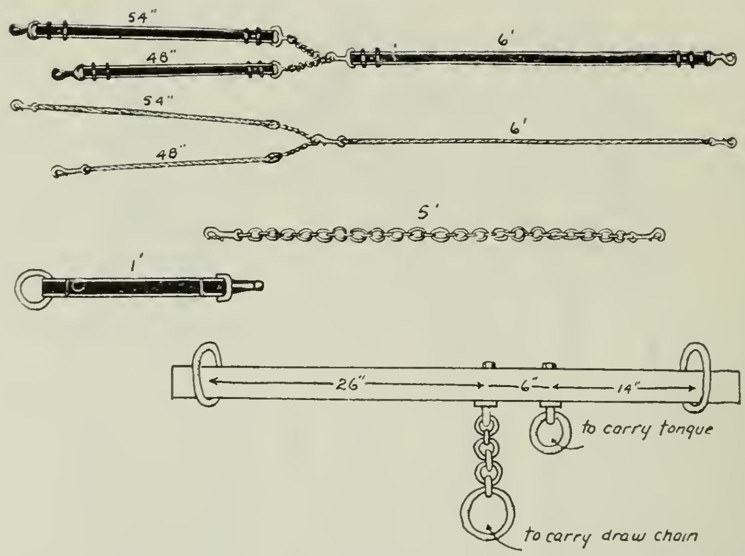


Fig. 4. Showing buckstraps—rope or leather; tie chain; spreader; and neck yoke for five-horse hitch.

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Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE, GUELPH

SOYBEANS IN ONTARIO

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DEPARTMENT OF FIELD HUSBANDRY

ORIGIN AND IMPORTANCE

The soy, soja or Japanese Bean (Glycine hispida) is the great legume of the Orient. The people of China and Japan have cultivated this crop for centuries, used it in various forms for food and fed it to live-stock.

This crop was introduced into the United States shortly after the year 1800 but only within the last two decades became a crop of major importance. Over three million acres of soybeans are now grown in that country.

Soybeans were first tested in the experimental plots at the Ontario Agricultural College in 1893 and first distributed for co-operative tests from the College to farmers in 1901. Experiments at the College, co-operative tests over the Province and recent field plot demonstrations, have increased the interest in this plant so that soybeans have now become an important crop in Ontario.

Soybeans on a twenty-one acre field in Peel County

Ripe Soybean plants grown at the Ontario Agricultural College.
Note the abundance of pods and their even distribution on the plants.

There are many purposes for which soybeans can be grown. As a supplementary hay crop they have an important place in Ontario. In yield and quality of fodder the crop ranks high and being a legume soybeans are beneficial to the land. The seed is the richest protein producing grain that can be grown in this Province. It also yields a large amount of oil which has a wide commercial use. The cake or meal obtained from the processing of soybeans to extract the oil is an excellent high protein concentrate which can be used with good results in balancing rations for livestock.

DESCRIPTION

The soybean is an erect growing, bushy, annual legume, having branching hairy stems and hairy leaves. The height of the stems varies from as low as one foot to as high as six feet, depending on variety, soil, and climatic conditions. The most suitable varieties for Ontario conditions average from two to three feet in height. The leaves vary much in size, shape and color. With many varieties the leaves begin to turn yellow as the pods begin to ripen and have usually all dropped off by the time the pods are ripe. In some varieties, however, the leaves remain on the plants and retain their green color, even to maturity.

The soybean has a strong tap root with many rootlets. Under suitable conditions and with the required bacteria present the roots of the soybean show a good supply of nodules, many of these being as large as good sized peas. The flowers are small and either white or purple in color and are usually self-fertilized.

The seeds which are produced in short pods show a great range in colors, yellow, olive yellow, olive green, brown and black being common. There is little loss due to immature seed as all the pods of the soybean ripen very evenly.

In experiments at the College, extending over a period of thirty-eight years, there has been very little damage by fungus or bacterial diseases to soybean varieties.

COMPOSITION

The soybean is richer in protein than any other farm crop grown in Ontario. In the table following will be found an analysis made by the Department of Chemistry of the Ontario Agricultural College of soybean grain and some of the other principal grain crops produced in the Province:—

Composition of the Grain of Soybeans and other Crops. Air Dry Basis—Average of Two Determinations—Checks.

Samples	Moisture	Ash	Protein	Fat	Nitrogen Free Extract	Fibre
Soybeans, O.A.C. No. 211 Wellington County	6.43	5.23	41.75	17.15	23.95	5.49
Soybeans, O.A.C. No. 211 Kent County	7.84	4.89	39.85	17.74	24.32	5.36
Soybeans, O.A.C. No. 211 Waterloo County	5.84	4.53	39.90	17.56	26.91	5.26
Soybeans, Early Yellow	6.39	4.75	38.70	17.66	28.22	4.28
Soybeans, Ogemaw	6.64	4.59	39.35	16.00	28.12	5.30
Soybeans, Black Ontario	6.27	4.81	42.25	17.60	24.14	4.93
Field Peas	9.59	2.58	25.30	1.41	55.50	5.62
Dent Corn	10.79	1.12	9.53	4.15	72.03	2.38
Oats	8.93	3.09	8.18	5.13	63.07	11.60
Barley	9.85	2.47	10.01	2.48	69.81	5.38

It will be noted that soybean grain differs from the grain of other crops in having a higher percentage of protein, a higher oil content, and an almost entire absence of starch. This high percentage of protein is a decided advantage when the crop is used with other field products for feeding to livestock. Animals are able to digest and utilize a high percentage of the protein, carbohydrates, and fat of the soybean.

CLIMATIC ADAPTATION

Soybeans require about the same temperature and the same length of growing season as corn. This crop is well adapted to growing in those states immediately south of the Great Lakes. When suitable varieties are sown, soybeans can be successfully grown for grain in Western and South-western Ontario and for fodder production over a greater part of Old Ontario. Soybeans are more resistant to dry weather and will also stand an excess of moisture better than the corn crop.

A good field of Soybeans in Welland County

ROTATION

The soybean seems best adapted to short rotations and can readily be included in most of the cropping systems of Old Ontario. The crop may be sown in the same rotational division as spring grain or that of hoed or cultivated crops. It can also be used as a catch crop following a total or partial failure of grasses and clovers or where winter wheat has badly winter killed.

SOIL AND SOIL PREPARATION

While the soybean is well adapted to growing on nearly all types of soil it gives best results on mellow, fertile, sandy loams or clay loams. Good corn land is well suited for growing soybeans. This crop often succeeds on land too wet to successfully grow corn and on soils too acid to produce good crops of clover.

Soybeans, like any other crop grown for seed or fodder, require a good seed bed. The land should be plowed in the fall or as early as possible in the spring and thoroughly worked by discing or cultivating and harrowing until a fine seed bed is prepared. A good seed bed preparation is the best means of inducing weed seeds to germinate and destroying weeds before the seed is sown. Good tilth also insures the highest germination of the soybean seed.

Soybeans in Dundas County - July 15th

MANURES AND FERTILIZERS

Good crops of soybeans have been produced in Ontario on land that was manured in the autumn or where barnyard manure was applied to the previous crop.

Commercial fertilizers have been used with soybeans to a very limited extent in Ontario. On soils that are low in fertility a good crop of soybeans could not be expected without an application of barnyard manure or commercial fertilizers.

VARIETIES

The importance of the soybean is evidenced by the large number of distinct varieties of this crop. More than one hundred varieties of soybeans have been tested for fodder and grain production by the Field Husbandry Department of the Ontario Agricultural College. Some of these varieties matured sufficiently early to be successfully grown in Ontario. Many, however, are too late for the climatic conditions of the Province and do not even reach the best fodder condition before the arrival of killing frost. It is, therefore, of first importance that the varieties selected should be adapted to local conditions and to the purpose for which the crop is grown. In the table below will be found the average results for six years in testing twenty-one varieties of soybeans for fodder by the Department of Field Husbandry at the College:

VARIETIES	Average of 6 Years' Tests.		
	Date of Cutting for hay	Average Height when cut for hay (Ins.)	Green Fodder per acre (Tons)
O.A.C. No. 211	Sept. 7	29	10.16
Habaro No. 20405 (Wash.)	Sept. 9	29	9.87
Ito San Soja	Sept. 10	31	9.66
Black Eyebrow (Jeffrey)	Sept. 6	32	9.61
North's	Sept. 4	28	9.54
Minnesota No. 167 (Exp. Sta., Minn.)	Sept. 9	32	9.49
Manchu	Sept. 6	32	9.25
Early Yellow (O.A.C. No. 111)	Sept. 5	29	9.18
Elton	Sept. 7	31	8.93
Medium Green (O.A.C.)	Sept. 15	31	8.41
Mandarin	Sept. 3	26	8.12
Chestnut	Sept. 5	26	8.10
Tsurunoko	Aug. 29	26	7.86
Oyaji	Aug. 30	26	7.58
Shiro Kotsubu	Sept. 10	27	7.46
Early Yellow	Aug. 28	26	7.40
Black Ontario	Aug. 30	25	7.10
Quebec No. 92	Aug. 30	23	7.06
Black Manchurian (Jeffrey)	Sept. 2	25	7.04
Brown	Aug. 30	24	6.75
Ogemaw	Aug. 22	17	4.77

The O.A.C. No. 211, which stands first with an average yield of 10.16 tons of green fodder per acre for the six year period, is a plant selected strain, developed by the Ontario Agricultural College, from the Habaro variety and is the only variety of soybeans eligible for registration in Canada. It will be noted that the O.A.C. No. 211 produced an average yield for the six year period of almost one ton of green fodder per acre more than the Manchu variety. The latter variety is one of the most prominent varieties grown in the soybean districts of the United States. The Brown and Ogemaw varieties, which reach the hay condition several days earlier than the O.A.C. No. 211, are small yielders and are not generally recommended for hay production in Ontario. The O.A.C. No. 211 outyielded the Early Yellow, a common commercial sort sold by seedsmen in Ontario, by 2.76 tons of green fodder per acre. The A.K. 2 variety, which has been under test in each of the last four years, reached the hay condition about a week later than the O.A.C. No. 211 and was surpassed in yield of green fodder per acre by this variety in three of the four years.

The above varieties were all cut for green fodder and hay at the best stage of growth, when the soybean pods had reached one-half their normal size.

Twenty-one varieties have been grown for grain production in the Department of Field Husbandry at the College for each of the last six years. In the table which follows will be found the average results for this period in weight of 1000 seeds in ounces; the height in inches when cut for grain; the time and stage of maturity at which varieties were cut for grain and the yield in bushels of grain per acre.

A twenty acre field of O. A. C. No. 211 Soybeans in Kent County

VARIETIES	Average 6 Years' Tests			
	Weight 1000 Seeds (Ounces)	Average Height when cut (Inches)	Date and Stage of Maturity when cut	Grain per acre (Bus.)
Black Ontario	5.72	25	Sept. 23— 99% Ripe	28.47
North's	6.38	28	Oct. 2— 97% "	28.42
O.A.C. No. 211	7.27	28	Oct. 9— 93% "	27.73
Black Manchurian (Jeffrey)	5.60	25	Sept. 23— 98% "	27.12
Early Yellow Soy No. 111	6.39	26	Oct. 8— 88% "	27.12
Manchu	7.28	31	Oct. 8— 88% "	27.03
Mandarin	7.46	25	Sept. 29— 96% "	27.02
Oyaji	8.56	25	Sept. 23— 81% "	26.75
Black Eyebrow (Jeffrey)	7.24	32	Oct. 8— 92% "	26.73
Tsurunoko	8.37	25	Sept. 23— 98% "	26.57
Chestnut	5.37	24	Oct. 3— 95% "	25.85
Early Yellow	8.56	24	Sept. 23— 97% "	25.50
Habaro (No. 20405) (Wash)	7.89	27	Oct. 10— 89% "	25.38
Minnesota No. 167	6.28	29	Oct. 7— 93% "	25.22
Elton	6.58	30	Oct. 7— 91% "	25.17
Quebec No. 92	7.86	18	Sept. 28— 97% "	23.83
Ito San Soja	6.07	26	Oct. 8— 86% "	23.27
Brown	7.93	21	Sept. 21—100% "	22.68
Shiro Kotsubu	5.18	24	Oct. 6— 89% "	22.43
Medium Green (O.A.C.)	4.98	33	Oct. 12— 14% "	17.33
Ogemaw	6.62	15	Sept. 10—100% "	16.77

It will be noticed that nineteen of the twenty-one varieties were at least 86 per cent. matured when cut for grain. A few plants of these varieties which were not ripe when cut completed the ripening process in the shock. The Black Ontario variety, which stands first in average yield of grain per acre, was received from a grower in the Manitoulin Island in 1924. It produces small black colored grain, and straw of medium length. This variety is not recommended for general cultivation in Ontario on account of its dark colored seed and light yield of green fodder and hay. The O.A.C. No. 211 has proven to be the best general purpose soybean tested at the College. It stands first in average yield of green fodder per acre over a six year period and third in average yield of grain per acre over the same period of time, being only slightly surpassed in grain yield by the Black Ontario and North's varieties. Grain produced by the O.A.C. No. 211 variety is of good size, and bright yellow in color. It is well suited to the manufacture of high grade soybean products where color is very important. Under average conditions the plants attain sufficient height to be easily harvested and the seed is not readily shattered. In the counties of south-western Ontario the O.A.C. No. 211 variety will ripen earlier than at Guelph.

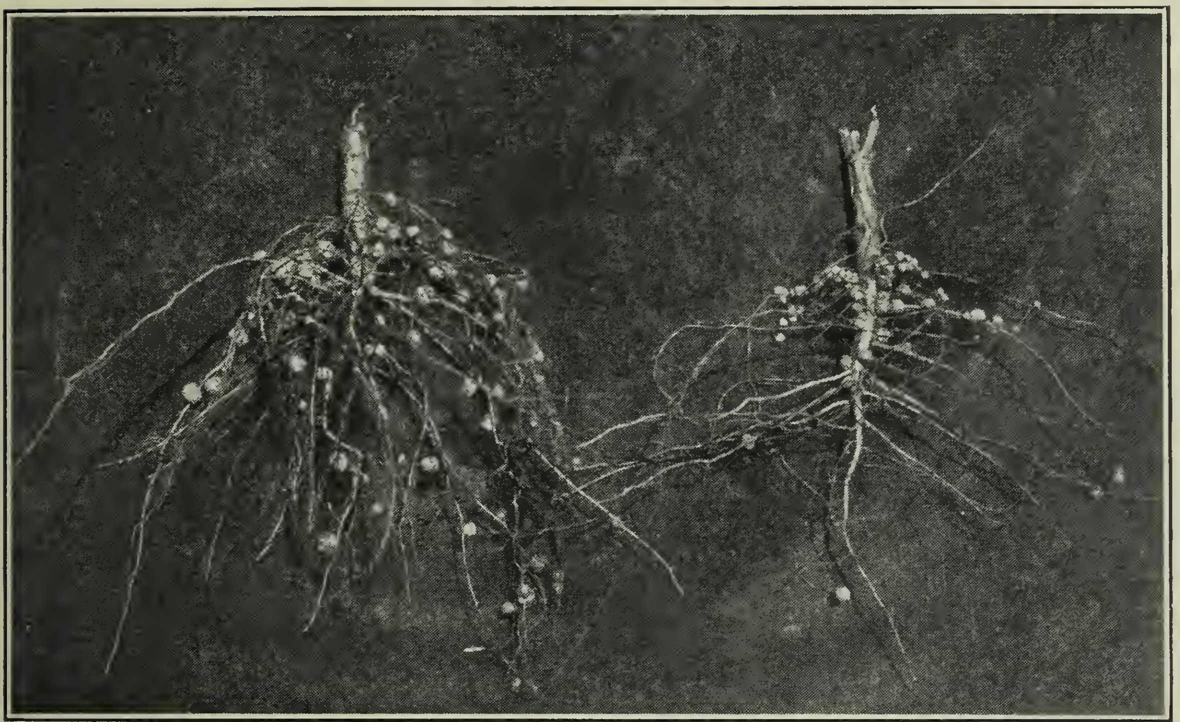
A successful crop of O.A.C. No. 211 Soybeans in Middlesex County

SEED SELECTION

It is just as important to sow only the best seed of soybean varieties as it is to sow only the best seed of varieties of any other field crop. Matured, sound, uniform seed of good size for the variety, produces best results. Soybean seed loses its vitality with age and it is not advisable to sow old seed.

INOCULATION

Like other leguminous plants soybeans are able to make use of the nitrogen of the air through the medium of bacteria which form nodules on the roots. Only the presence of these bacteria enable soybeans to produce the most satisfactory yields of green fodder and of grain. When the crop is being grown for the first time on a field the seed should be inoculated. This may be accomplished in several ways. The common method is to obtain pure soybean cultures from the Bacteriological Department of the Ontario Agricultural College, Guelph; the Bacteriological Division of the Central Experimental Farm, Ottawa; or from commercial firms handling this product. These cultures should be applied to the seed according to directions which are sent with them. Another method is to use soil from a field which has grown soybeans showing well developed nodules. Mix one gallon of the surface soil with an equal amount of water and stir thoroughly. Sprinkle the seed with this muddy water solution at the rate of about one pint to one bushel of seed. The muddy water solution should be about as thick as cream or paint. After treatment the seed may be spread out and allowed to dry in the shade.



Well developed nodules - the result of inoculation

DATE OF SEEDING

Inexperienced growers of soybeans frequently sow the crop too late for best results. Soybeans in this particular should not be confused with common field beans. They are much hardier than field beans, will stand earlier seeding, and suffer less from frost injury in the autumn. The results in the table which follows emphasizes the importance of early seeding:—

VARIETIES	Date of Seeding	Average Yield per Acre. (6 years)	
		Straw (Tons)	Grain (Bus.)
O.A.C. No. 211	April 30	2.13	26.66
	May 7	2.09	25.88
	" 15	2.06	24.94
	" 21	2.09	23.68
	" 28	2.07	22.33
Early Brown	April 30	1.28	22.97
	May 7	1.25	21.96
	" 15	1.21	21.80
	" 21	1.32	22.04
	" 28	1.26	20.54
Early Yellow	April 30	1.41	25.10
	May 7	1.27	22.68
	" 15	1.27	22.74
	" 21	1.50	22.48
	" 28	1.42	22.50

The largest average yield of grain per acre of each of the three varieties was produced from seed sown on the average date of April 30th. Seed of the O.A.C. No. 211 variety, sown on the average date of April 30th, produced an increased average yield per acre of 4.33 bushels over seed sown on the average date of May 28th. Seed of the Early Brown variety, sown on the average date of April 30th, produced an increased average yield per acre of 2.43 bushels over seed sown on the average date of May 28th. Seed of the Early Yellow variety, sown on the average date of April 30th, produced an increased average yield per acre of 2.60 bushels over seed sown on the average date of May 28th. There was little difference in the average total yield of straw from the seed sown at different dates. The greatest average weight per measured bushel was obtained from the early seedings.

METHODS AND RATES OF SEEDING

Three methods of seeding have each been carefully tested in the experiments at the College for a period of six years: sowing in cultivated rows 26-2/5 inches apart, sowing solid with the grain drill and sowing broadcast. In experiments indicated here five rates of seeding were used with each of two varieties, namely, one-half, one, one and one-half, two and two and a half bushels per acre. The following table gives the average yield of grain per acre in bushels of the three methods for a period of six years:—

Methods of Seeding	Average Yield of Grain per acre in Bushels (6 years, 60 tests.)
Sown in Cultivated Rows 26-2/5 inches apart	24.7
Sown Solid Like Small Grains	24.9
Sown Broadcast	22.5

Sowing solid with the grain drill in the same manner in which an oat or barley crop would be sown produced slightly larger yields of grain per acre than sowing in cultivated rows 26-2/5 inches apart. Sowing in cultivated rows is a method to be recommended when fields are weedy. Sowing broadcast for grain production produced the smallest yields per acre of the three methods.

The amount of seed sown is not only regulated by the methods used but also by the size of the seed of the variety sown as well as by the purpose for which the crop is grown. Large seeded varieties require to be sown at a greater rate per acre than small seeded varieties. Growing soybeans for fodder purposes requires a heavier rate of seeding than when the crop is sown for seed. Such varieties as the O.A.C. No. 211, Early Yellow and Brown, when sown for grain production by the cultivated row method, require one-half to three-quarters of a bushel of seed to sow an acre and when sown solid with the grain drill about one bushel of seed per acre. Sowing solid with the grain drill seems to be the most suitable method for growing soybeans for green fodder or hay. The varieties mentioned above, when seeded by this method, will require about one and one-half bushels of seed per acre.

DEPTH OF PLANTING

Poor stands of soybeans have been caused by too deep planting. On well drained clay loams or good sandy loam types of soil the depth of planting should not exceed two inches. On light sandy loam types of soil soybeans have been planted to a depth of as great as three inches and produced good results.

SOYBEANS IN MIXTURES

An experiment was conducted in duplicate for a period of five years in which soybeans and the White Cap Yellow Dent variety of corn were grown separately and in combination. Soybeans were planted one-half link (practically four inches) apart and the corn ten inches apart in the rows throughout the experiment. The table below gives the average yield of green fodder per acre in tons for each of the five years and for the whole period:

CROPS	First Year	Second Year	Third Year	Fourth Year	Fifth Year	Average 5 Years
Soybeans	8.90	6.52	10.19	9.38	7.30	8.46
Dent Corn	13.29	13.75	18.05	14.45	18.15	15.54
Soybeans and Dent Corn	13.25	12.17	18.41	15.23	15.15	14.84

The White Cap Yellow Dent corn sown alone produced an average yield of 1,400 pounds more green fodder per acre than the soybean and dent corn combination. The 14.84 tons representing the average yield per annum of the soybean and dent corn mixture was composed of 11.46 tons corn and 3.38 tons of soybeans per acre. While the soybean and dent corn mixture did not yield quite as well per acre as the dent corn alone it produced a better balanced ration, the soybeans being high in protein content and the corn in carbohydrates.

In each of the last five years soybeans have been tested in mixtures for green fodder and hay production with Early Amber Sugar Sorghum, White Kaffir Corn, Sudan Grass, Japanese Panicle Millet, Japanese Barnyard Millet, Hungarian Grass Millet, and Teff Grass. In the table which follows will be found the average results of these mixture experiments:

MIXTURES	Average of 5 Years' Tests			
	Percentage when Harvested		Yield of Green Fodder (Tons)	Yield of Hay (Tons)
	Soybeans	Other Crops		
O.A.C. No. 211 Soybeans	100	....	11.20	3.84
O.A.C. No. 211 Soybeans and Early Amber Sugar Sorghum	50	50	16.99	6.61
O.A.C. No. 211 Soybeans and White Kaffir Corn	59	41	14.66	5.61
O.A.C. No. 211 Soybeans and Sudan Grass	32	68	11.76	4.24
O.A.C. No. 211 Soybeans and Japanese Panicle Millet	32	68	13.53	5.03
O.A.C. No. 211 Soybeans and Japanese Barnyard Millet	33	67	9.69	4.62
O.A.C. No. 211 Soybeans and Hungarian Grass Millet	24	76	9.02	3.45
O.A.C. No. 211 Soybeans and Teff Grass	60	40	10.30	3.89

In the different mixtures soybeans were sown at the rate of one bushel (sixty pounds) per acre and the other crops in one set at the rate of sixteen pounds of seed per acre and the other set at the rate of thirty-two pounds of seed per acre.

If cut with the binder for green fodder, soybeans along with Early Amber Sugar Sorghum, Kaffir Corn, or Sudan Grass, make satisfactory mixtures. The mixture of soybeans and Hungarian Grass Millet because of the fineness of material and ease of curing is one of the most satisfactory mixtures tested for hay.

CULTIVATION

The soybean crop on reasonably clean land does not require a great amount of cultivation. Some attention, however, at the proper time will stimulate growth and help to destroy any weeds that may be present. It is always wise to

A dense stand of Soybeans ready to cut for hay

sow enough seed to allow for a few plants being pulled up during cultivation. The best implements to use where the crop is in rows or drilled solid, are the Weeder, Rotary Hoe, and light Harrow. It is usually advisable to go over a field of soybeans with one of these implements before the plants appear above the ground or after they are well up. If a crust has formed cultivation will do much to assist the plants in breaking through. Weeds that have just started to grow can be killed at this time. It is not advisable to harrow soybeans as they are breaking through the ground but after the plants have made a start. The amount of harrowing to be given will depend on the type of soil, kind of harrow, and condition of crop. Where soybeans are in rows they should receive additional cultivation with a scuffler or other type of cultivator.

The Rotary Hoe - A useful implement for cultivating Soybeans.

HARVESTING

Soybeans cut at the right stage of growth and properly cured make excellent hay of high feeding value which is readily eaten by farm animals. This hay, which is rich in protein, can be produced on the farm to balance other feeds for milch cows or growing stock and will lessen the quantity of high priced concentrates which the farmer has to purchase. To produce soybean hay of the greatest palatability, greatest digestibility, and highest yield, the crop should be cut when the pods are well developed—have reached at least one-half their normal growth. At this period the lower leaves will have begun to turn yellow. When cutting of the crop is delayed stems become woody and lose much of their feeding value. Late cutting also results in a heavy loss of leaves. Experienced growers find little trouble in curing soybeans for hay. Cutting should commence as soon as the dew is off. The cut material is allowed to lie in the swath until thoroughly wilted and raked into windrows before the leaves become brittle. It usually lies in the windrow a day or two, depending on weather. Three or four days in the coil is usually sufficient to complete the curing of soybean hay.

Soybeans may be cut for grain with the grain binder, shocked in the field, and handled like any other grain crop. The Self Rake Reaper, Pea Harvester, Corn Binder, and Combine, are all used in the harvesting of this crop for grain. If cut with the mower some seed is likely to be lost from tramping. The best period to cut for grain is when the pods are nearly ripe which with most varieties will be when about ninety-five per cent. of the leaves have fallen. Small sheaves in small shocks will hasten the drying process.

A Soybean crop ready to cut for seed.

THRESHING

The ordinary grain thresher will successfully thresh soybeans, provided the speed of the cylinder is reduced by means of pulleys to about one-half of that required to thresh cereal grains and the speed of the remainder of the threshing machine maintained. The ordinary bean thresher is also fairly well equipped to thresh soybeans. One of the principal objects of the operator should be to thresh soybeans without splitting or otherwise causing injury to the seed.

USES OF THE CROP

Hay. One of the fine features about the soybean is its ability to produce a crop of legume hay in a single season. Farmers sometimes find on looking over their hay prospects in the month of May that a previous dry summer or severe winter has left them short of roughage for livestock. Soybeans in less than four months will produce hay that is greatly relished by farm animals. Being high in protein it can be used to balance up grains, grasses and ensilage. Best results are obtained when soybeans are fed along with other kinds of hay. Farmers who have grown and fed soybean hay claim that it has a feeding value equal to alfalfa.

As A Soiling Crop. Soybeans make a satisfactory soiling crop to be cut and fed green in midsummer. They are useful for feeding to animals that have to be kept in the stable and for the dairy herd when pasture becomes short.

Ensilage. Soybeans alone do not make the best ensilage but in combination with corn they furnish feed of high quality. Some farmers sow one part soybeans and three parts of corn. A mixture of this kind, however, is not so easily harvested as a straight crop of corn. It is better to grow the two crops separately and mix them as they are put into the silo in the proportion of one part soybeans to three parts corn.

Pasture. The soybean is sometimes used as pasture. Sheep or cattle will make good gains on it. There is less wastage from tramping when the crop is sown in rows. Other annual pasture crops, oats and sweet clover for instance, will give earlier pasture, stand tramping better and come along faster under close grazing.

Soil Improvement. The soybean like clovers and other legumes is able by means of bacteria on the roots to gather nitrogen from the air and leave it in the soil for the benefit of crops that follow. It must be remembered, however, that the best results can only be obtained when the soybeans are well inoculated and some part of the plants left on the land. After a seed crop of soybeans there is considerable organic matter in the way of leaves and stubble to be turned under.

Ripe Seed. The mature soybean seed, either whole or ground, provides an excellent protein feed to use with oats and barley for all kinds of livestock, except market hogs. Soybeans contain a large amount of oil and when fed to hogs in even small quantities the quality of pork is lowered. It is, therefore, recommended that farmers refrain from using the whole soybean for feeding to growing hogs. Brood sows can be wintered nicely and will produce healthy litters when fed on a ration containing a proportion of soybeans. As a source of protein for dairy cattle and to keep the cows in good condition the soybean is excellent when fed in conjunction with other grains.

Straw. Soybean plants lose most of their leaves before the crop is ready to harvest for seed and the threshed straw consists mainly of stems and pods. This material, however, will give very satisfactory results when fed in combination with other roughages to sheep, horses, and young cattle.

Soybean Oil. Soybean seed is rich in oil, averaging about 18 per cent. This oil is used in the manufacture of soap, paints, rubber substitutes, printer's ink and other articles. It is also used as a salad oil and as a substitute for butter and lard. Many mills use a screw type of expeller to extract the oil from soybeans which have been cleaned, heated, and ground. Other means of extraction include the ordinary press and the solvent method where benzol or other materials are used.

Meal. Soybean meal from which the oil has been extracted provides a high protein concentrate which gives excellent results when used in rations for livestock. The protein may run as high as 44 per cent. A small amount of this meal added to ground oats and barley will balance the ration and help to keep animals thrifty.

Other Products. In China and Japan soybeans are used in many ways as human food. The green pods, dried seed cakes, soy sauce and soybean milk, all have their place. In America soybean flour is made into cakes, biscuits, muffins, and being low in starch it has a special place as a diabetic food.

A co-operative test of Soybeans on a Southern Ontario Farm.

WHAT FARMERS THINK OF SOYBEANS

(Extracts from reports by men who have grown and fed the crop.)

Durham. "I cut part of the soybean hay crop for green feed for the cows to help the short pasture. All kinds of stock ate it and did well on it. I like it for hay as it will produce much more tonnage than any other emergency hay crop."

Dundas. "I think the soybean is a wonderful milk producing feed."

Brant. "All the stable stuff seemed fond of the beans. We intend to sow a large field next season."

Elgin. "Soybean hay certainly made the cows milk better."

Elgin. "The soybean is a sure crop, more so than hay has been in the last few years."

Frontenac. "I think the soybean should be grown on every farm to supply a concentrate to mix with other grain feeds."

Grenville. "Just started to feed cows soybean hay and they are taking to it very well. Horses seem to like it too."

Halton. "We cut the soybean for hay and fed it to the cows night and morning as an extra feed The cows kept up in their milk remarkably well."

Hastings. "We liked the hay very much as feed for cattle and considering the yield we do not see why it should not be a profitable crop to grow."

Kent "I believe that soybeans are a splendid crop being easy to grow and harvest, and of great feeding value in all forms."

Kent. "For dairy cows they are second to none and we are sorry they are finished. We gave one small feed each day and could see an advance in the milk flow and it also improved the coats of the cows."

Lambton. "I am feeding soybean hay at the present time to my milking cows. They eat it readily, seem to relish it and are doing well at the pail."

Lincoln. "Cattle will leave very good mixed hay and eat the soybean hay. I believe they are a good crop to grow especially when the clover seems so hard to get a crop from."

Middlesex. "We found that soybean hay seemed to satisfy our cows and the milk flow increased considerably. When it was finished we used mixed clover and timothy and had to add mangels to the ration in order to keep the milk flow up."

Middlesex. "I think my seed yield, 27½ bushels, would have been larger still if it had not been so wet."

Middlesex. "The results of this year's crop are satisfactory enough that I intend to sow them again."

Oxford. "Cows fed this hay seemed to relish it and do well on it."

Perth. "The lambs do better on it I believe than on any other hay we have ever fed. It seems to be ideal feed for stock."

Simcoe. "Soybeans for hay are a splendid crop as everything we have fed it to are very fond of the feed. Small calves will eat it before second cut alfalfa and seem to do well on it. We are using soybeans to mix with the dry mash for hens and they are laying extra well for this time of the year. I think soybeans will have a place on every farm shortly."

Welland. "Both sheep and cattle seemed to relish the hay."

Wellington. "Dairy cows relish the soybean hay and they milk very well when getting it."

A Soybean Field Meeting in Lincoln County

BULLETIN 367] [JULY, 1932

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

PORK ON THE FARM

E. C. Stillwell, M.S., Lecturer in Animal Husbandry.

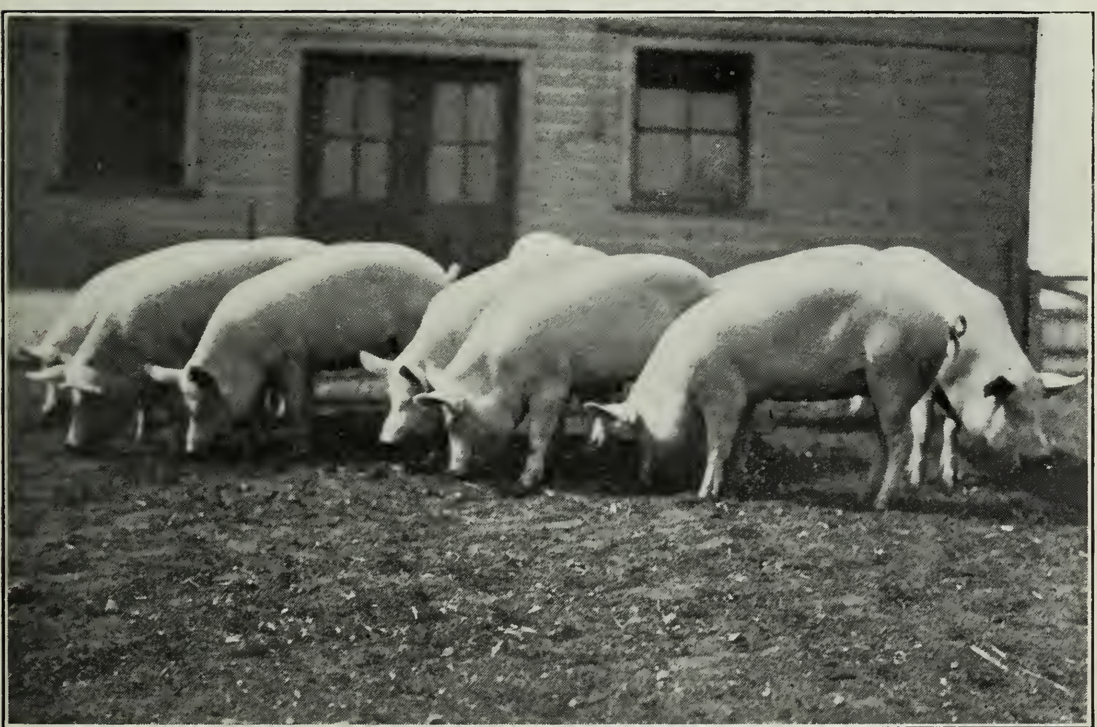


ILLUSTRATION No. 1
A group of finished bacon hogs bred and fed at the Ontario Agricultural College.

PORK ON THE FARM

Since pioneer days hogs have been raised, killed, and the pork cured on the farms of this country. The methods used were satisfactory and a high-class product was obtained. In some cases to-day, however, difficulty is experienced, especially with the beginner, and it is hoped that the directions which are given in this bulletin will prove helpful. There are numerous methods of processing pork, but those described in the following pages are easy to follow and since there is nothing mysterious about the curing of pork a good product is possible.

Selection of Hogs for Butchering

High-class cured pork cannot be produced from inferior live hogs. The ideal type is the pig which brings the highest price on foot. Too often the farmer sends all the best hogs to market and expects to get a high quality cured product from the inferior hogs which he thinks is economy to kill and use for home use.

It is needless to say that pigs showing disease or unthriftiness will yield an inferior product.

Condition is a matter for the individual to decide. Some demand lean meat while others want excessive fat, but for real high quality cured pork the bacon type hog weighing around 200 pounds is ideal.

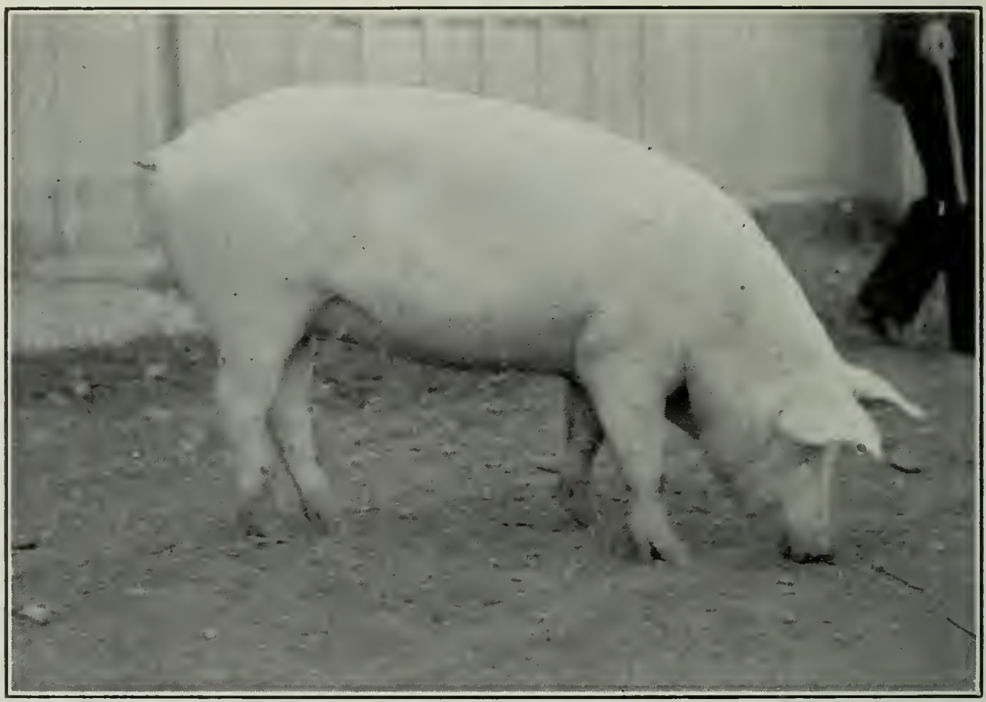


Illustration No. 2

The ideal market pig is balanced, smooth, trim and is firmly fleshed. He has a slightly arched top, a long flat side, and full tapering hams.

Before Killing

Hogs should be kept off feed from 18 to 24 hours before killing but they should have all the fresh water they require. This empties the stomach and intestines, which makes the removing of these organs much easier and aids greatly in their cleaning.

Hogs should never be beaten, chased or excited before killing as this tends to raise the body temperature.

Killing and Dressing

The tools necessary for killing are shown in Illustration No. 3.

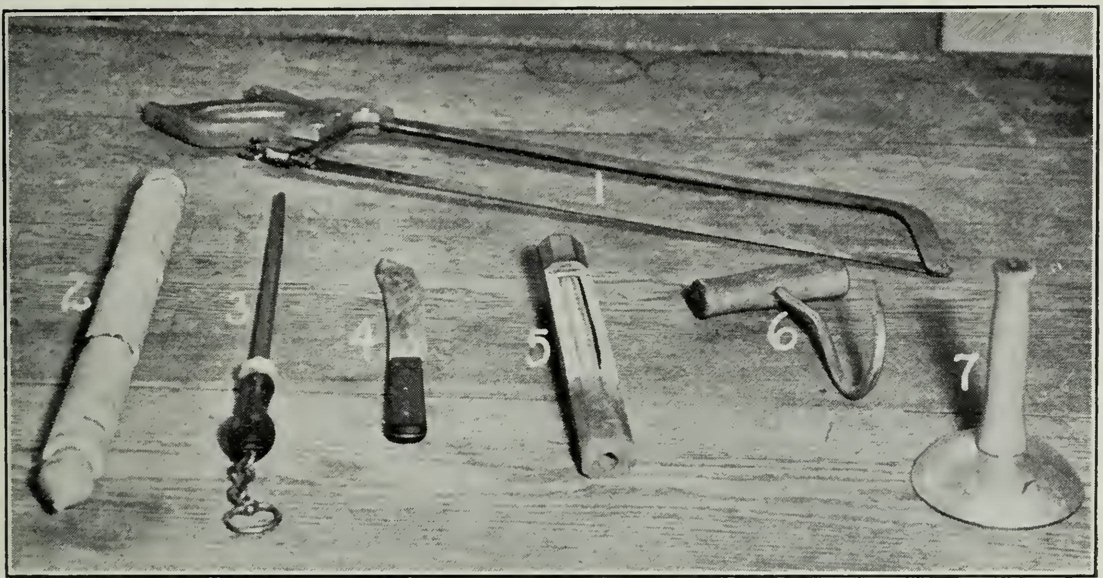


Illustration No. 3
Tools for Butchering—1, meat saw; 2, wooden gambrel; 3, steel; 4, 6″ butcher knife; 5, thermometer; 6, hog hook; 7, bell-shaped scraper.

A table or a sleigh platform with a barrel leaning at an angle of about 45 degrees will be necessary for the scalding and scraping equipment.

There are numerous appliances for hanging up carcasses. A notched rail leaning against a building, a ladder in a similar position, a scantling 2″ x 4″ nailed to posts; any of these will do but they should be placed in a solid position and strongly built to avoid accidents.

Killing

Before the hogs are killed the equipment should be in readiness, knives sharp, and the water for scalding at the correct temperature.

Illustration No. 4 shows the blood vessels and the positions of the knife in cutting these.

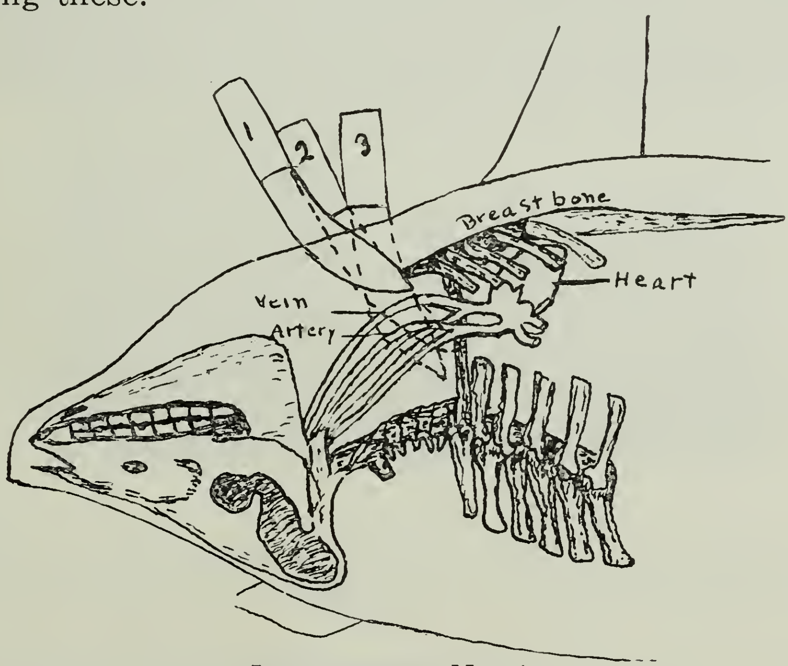


Illustration No. 4
The Position of the Blood Vessels—(Courtesy of Nebraska Experiment Station.)

Any one of the following methods may be used for killing:

1. Sticking.
2. Shooting and then sticking.
3. Stunning and then sticking.

STICKING

When this method is used the hog should be placed in a small pen. Two men are necessary although a third is useful. The two helpers reach under the pig and grasp the legs on the opposite side; by a quick pull the hog is thrown on his back. One helper stands astride the hog holding the front legs while the other holds the hind legs. The sticker presses down on the lower jaw of the hog with his left hand and with the knife in the right hand he makes an incision just at the breast bone, then pressing downwards he severs the veins and the arteries. Illustration No. 5 shows this method.

The hog is allowed to get up or with a block and tackle it may be pulled up by the hind leg to aid in bleeding.

A "stuck shoulder" may result when the pig is stunned and then stuck while lying on its side. Similar results may be seen if the pig is not held squarely on its back. A little thrust of the knife on either side of the breast bone will cause this condition.

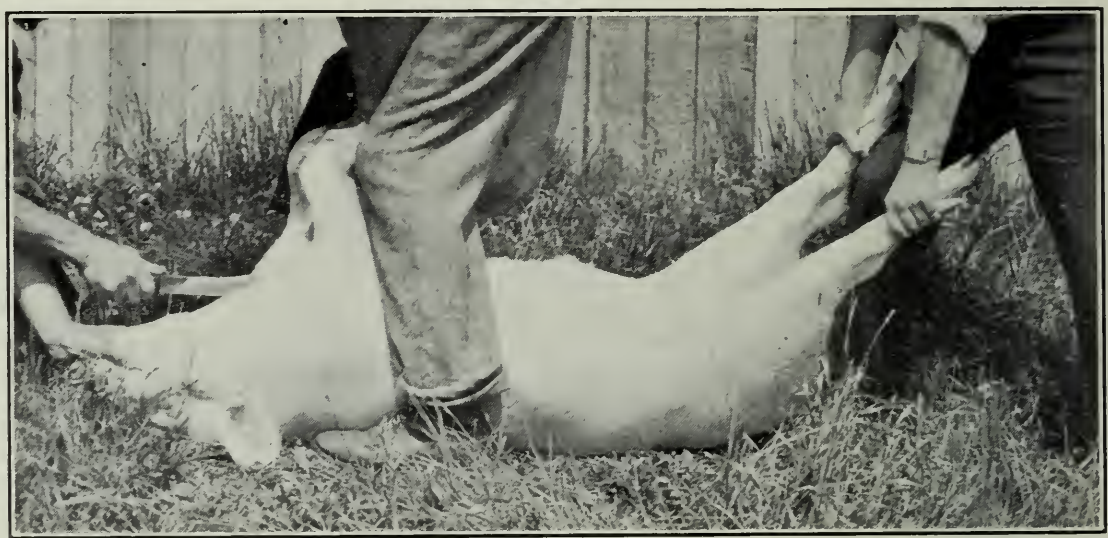


ILLUSTRATION No. 5
Sticking the Pig.

SHOOTING

Shooting is sometimes necessary with extremely wild hogs or when they are not confined in a small pen. Sometimes, however, the bullet is deflected and lodges in some part of the carcass, generally in the shoulder. This not only spoils the appearance of the part where the bullet lodges, but spoiling is liable to occur, in the opening made by the bullet, while in the cure.

STUNNING

Unless extreme speed and accuracy are exercised in stunning, it is useless, as the pig gets excited and runs about if the first blow is unsuccessful.

The method of killing which is most satisfactory is to hoist the hog up by the hind legs with a block and tackle, then stick. This allows quick and efficient bleeding.

Scalding

The temperature of the water should be 150° Fahrenheit. If it is too hot the hair is liable to set and if too cold it takes a longer time to loosen. For outside farm work in cold weather it is best to have the water 175° Fahrenheit or higher and, by the time it is dipped from the kettle to the barrel, the temperature will be about right. The thermometer is the only accurate way to test the water.

The addition of wood ashes, lye and other cleansing materials are helpful in obtaining a good clean job.

There are various ways of heating water for scalding purposes. Live steam may be forced into a tank or barrel from a boiler. Iron and stones are heated in a fire and placed in the water, or it may be heated in a large kettle and dipped from this to the barrel.

The hindquarters should be scalded first as it is the easiest part to scrape. Insert the hog hook in the lower jaw and lower the hog into the barrel. It should be raised occasionally to try the hair to see if it is slipping. Illustration No. 6 shows the position.

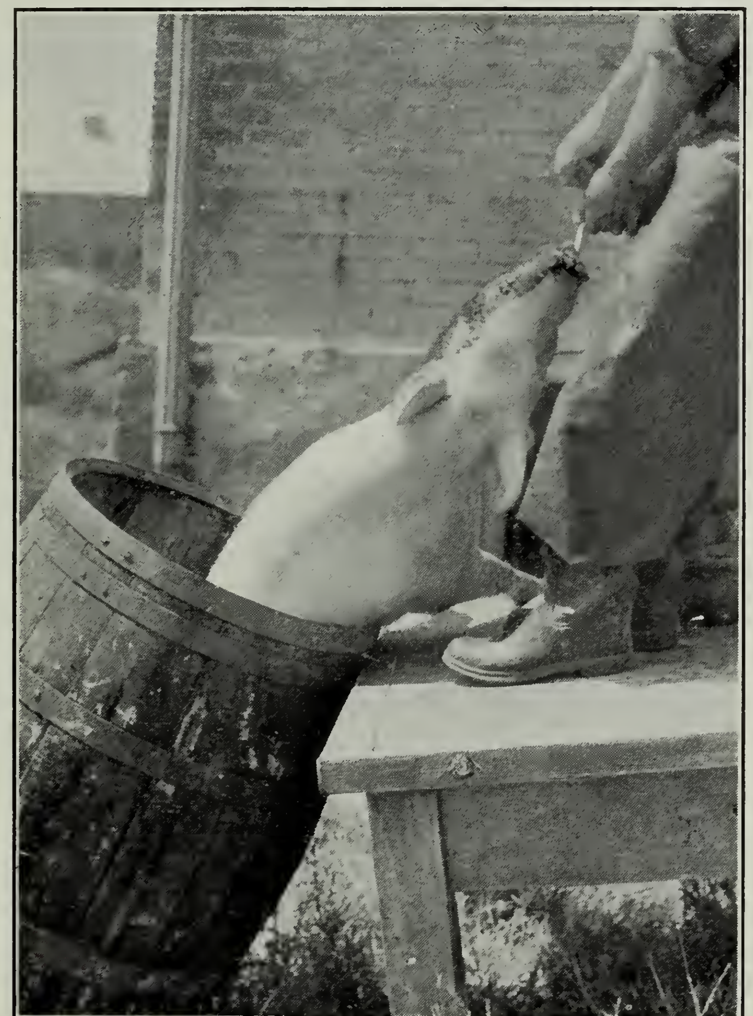


Illustration No. 6

Scalding the Hindquarters.

When the hair slips easily the hog is pulled out of the barrel and with a twisting motion the hair is pulled from the legs. Then with the scraper the hair is removed as in Illustration No. 7.

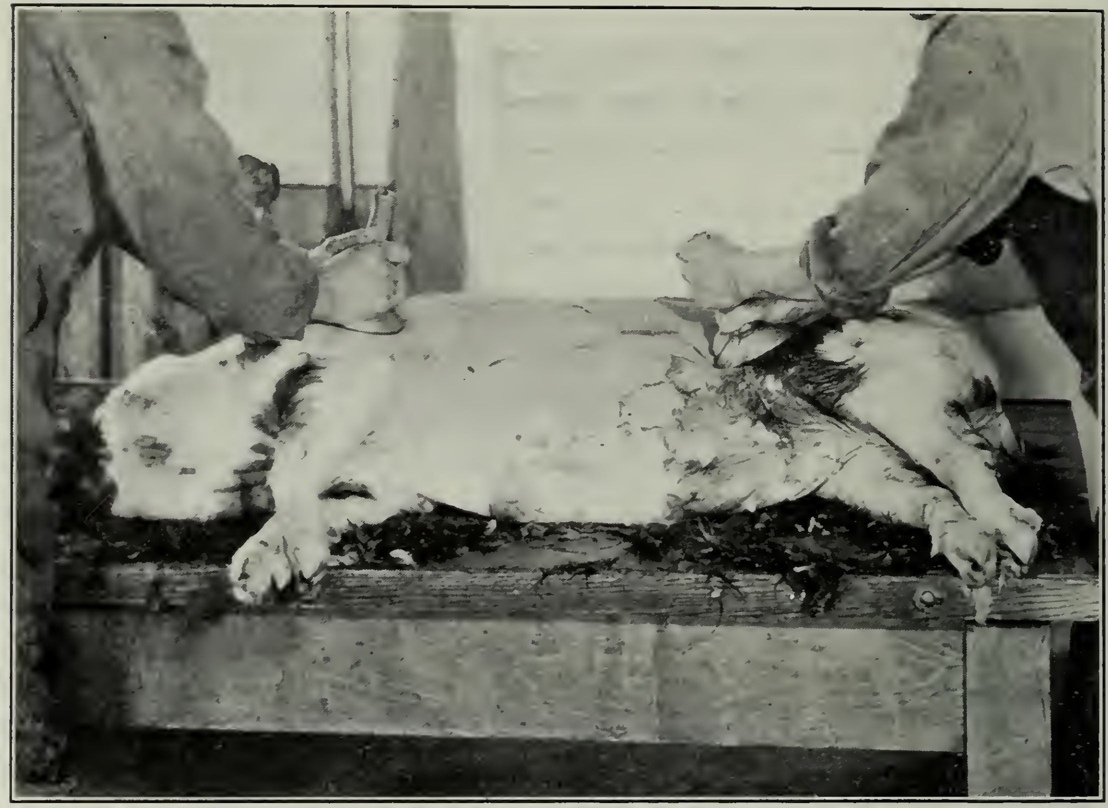


Illustration No. 7
Scraping.

By cutting on each side of the hind leg the cords are exposed so that the gambrel stick may be inserted as in Illustration No. 8.

Illustration No. 8
Cutting the Cords loose and inserting the Gambrel Stick.

Using the gambrel stick as a handle the fore part of the pig is placed in the barrel as in Illustration No. 9.

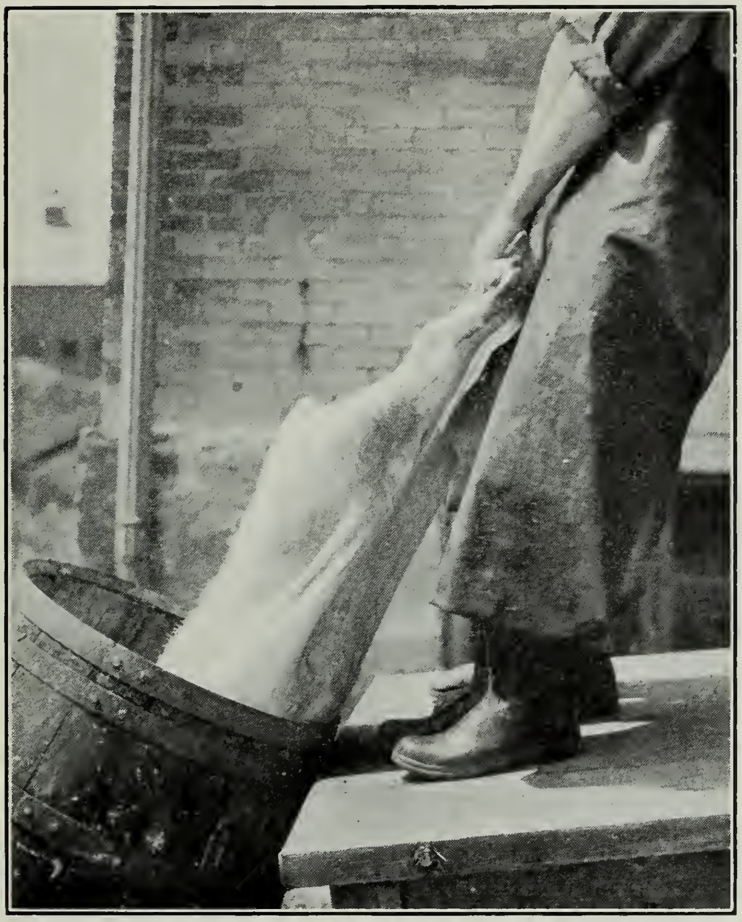


Illustration No. 9

Scalding the Fore Part.

When the hair slips freely the hog is pulled out on the table and the hair removed from the fore legs by a twisting motion. The hair may be pulled from the ears by the hands. The scraping continues until all the hair is taken off. A pail of hot water thrown over the carcass will help considerably in getting a clean job.

When the hair is scraped off hang the carcass up and pour hot water over it. Then scrape again and if necessary use the knife to shave off any hair which is hard to remove. Pour cold water over the carcass and scrape upward with the back of the knife. This drives the water out of the pores and gives a finish to the carcass. The hog hook may be used to remove the dew claws from the feet.

Removing the Entrails

Grasping the knife as in Illustration No. 10 cut down to the aitch or pelvic bones. With practice these bones may be separated with this first stroke of the knife, but for the beginner it is best to open these as in Illustration No. 11.

ILLUSTRATION No. 10

The first cut on the mid-line.

ILLUSTRATION No. 11

Separating the pelvic bones.

Loosen the bung gut and cut around the anus as in Illustration No. 12. It is best to tie a string around the gut to keep the carcass clean.

Illustration No. 12

Cutting out the bung.

From the opening already made cut down the mid line right to the throat just opening the skin. Then open the abdomen down to the breast bone as in Illustration No. 13.

Illustration No. 13

Opening the Abdomen.

Grasping the bung, very carefully pull and cut the connective tissue which holds the entrails in place. Care must be exercised in loosening the entrails so as to leave the kidneys in place.

The entrails are placed in a tub. The liver may be removed with them or taken out after.

Open the chest cavity as in Illustration No. 14. The knife is placed just a little to either side of the mid line of the breast bones, and with an upward pull the bones are separated.

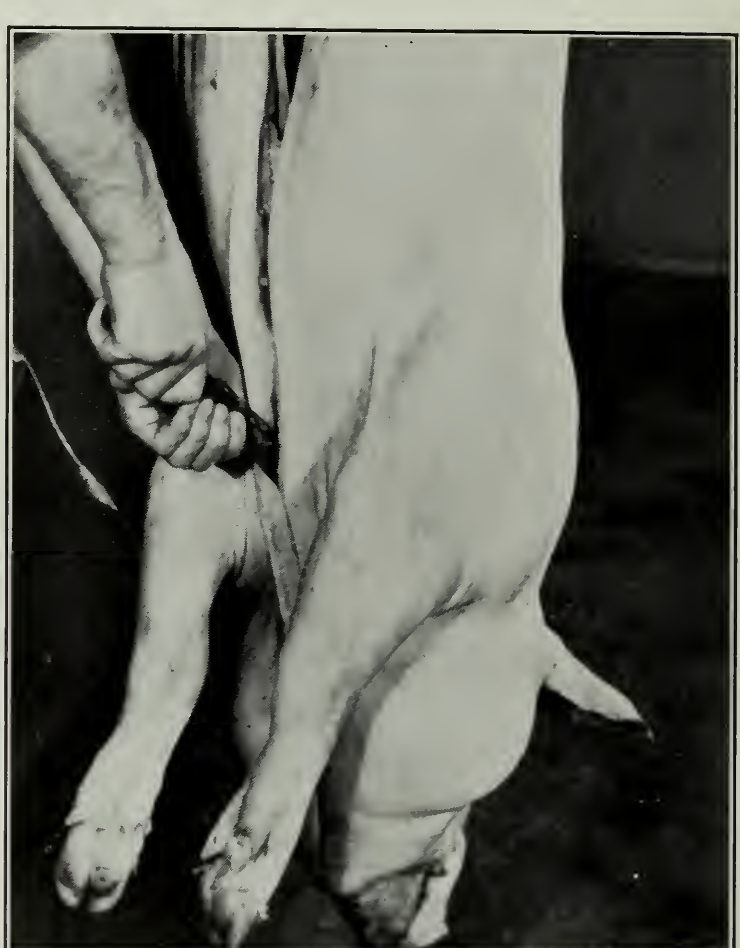


Illustration No. 14

Opening the Chest Cavity.

Cut around the meaty portion of the diaphragm, and remove the heart, lungs and windpipe. By pulling the windpipe and cutting on either side of it the tongue is loosened and removed as in Illustration No. 15.

ILLUSTRATION NO. 15
Removing the heart, lungs, windpipe and tongue.

The leaf lard is loosened allowing it to hang from the upper end. It is much easier to loosen this while the carcass is warm and by so doing the carcass cools out much more rapidly.

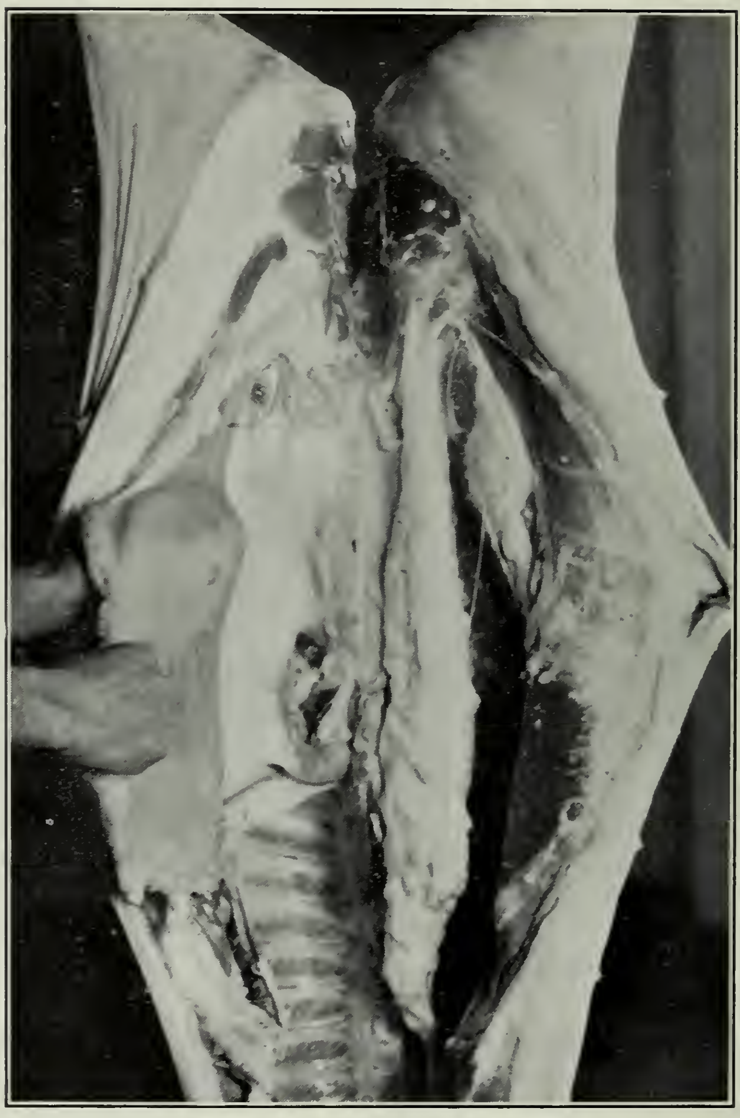


ILLUSTRATION No. 16
Loosening the leaf lard.

Illustration No. 17

Splitting the Carcass.

The carcass may be split while it is still warm. This is done by sawing down the centre of the spinal column. There are other methods of splitting but the saw does a neat and quick job.

The carcass should be cooled slowly at a temperature of 40° F. for a few hours to allow the animal heat to escape. A temperature of from 32° F. to 36° F. is ideal for keeping carcasses. They become firm and should be held at this temperature for at least twenty-four hours before cutting. Cutting warm carcasses will give, not only uneven cuts, but spoiling is more liable to start in meat which has not been thoroughly cooled.

The gaul bladder is removed from the liver as in Illustration No. 18. Care must be exercised to keep the gaul from getting on the carcass as it has a very bitter taste.

Illustration No. 18

Removing the gaul bladder from the liver.

The intestines should be stripped from the ruffle fat. Then they can be turned inside out and the lining scraped with a small smooth piece of wood or the back of a knife. When these have been thoroughly washed and cleaned they can be used as sausage casings. The heart and tongue should be cut loose, washed clean and put in a cool place.

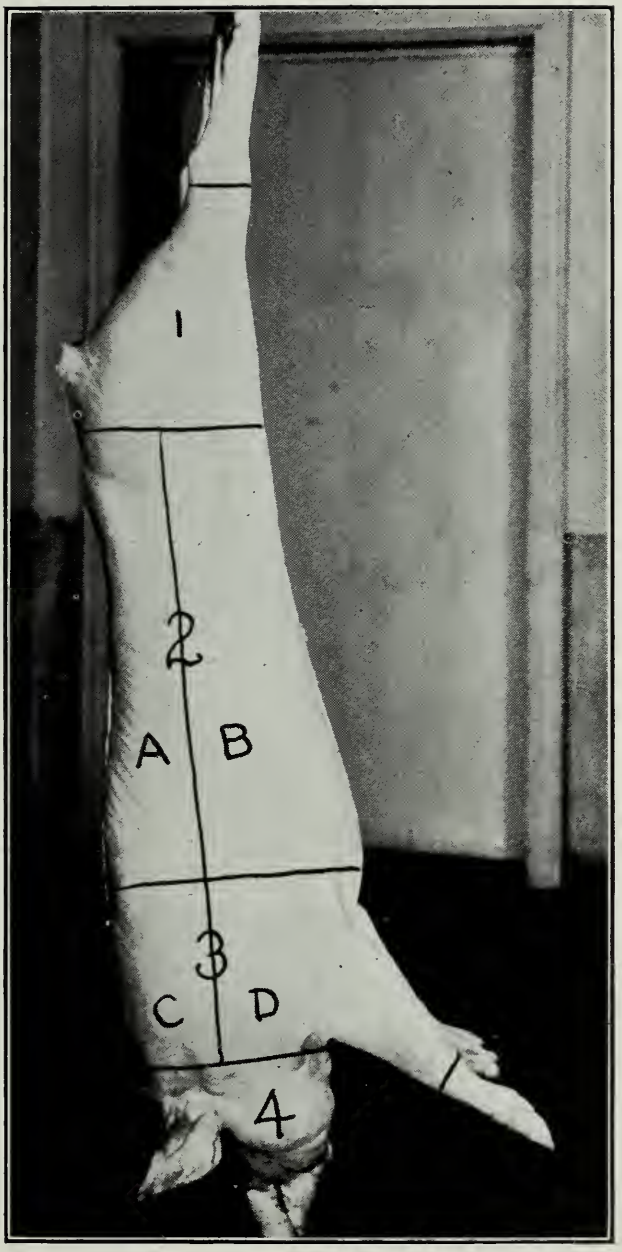


ILLUSTRATION No. 19

1.—Ham

2.—Middle piece { A—Back.
B—Belly

3.—Shoulder } C—Shoulder butt.
D—Picnic Shoulder

4.—Head.

The standard pork cuts are shown in Illustration No. 19. There are numerous ways of cutting pork but the standard cuts are easily handled and cured.

Illustration No. 20
Removing the head.

Illustration No. 21
Pulling the leaf lard out.

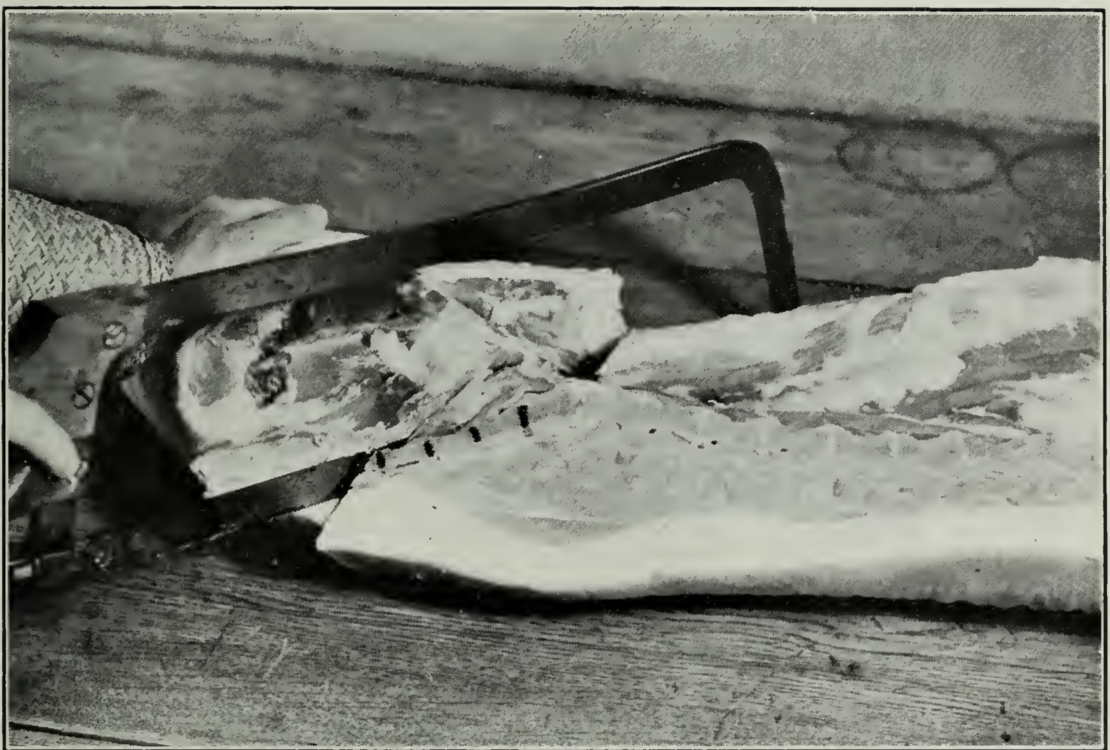


ILLUSTRATION NO. 22

Cutting off the Ham.

Counting backwards about four segments on the tail vertebrae and about two inches in front of the pelvic bone, a short cut ham is removed as in Illustration No. 22, so that the shank is perpendicular to the cut as in Illustration No. 23.

Illustration No. 23

Ham untrimmed and trimmed.
4. Ham untrimmed
3. Ham trimmed
2. Foot
1, 5 and 6—Trimmings.

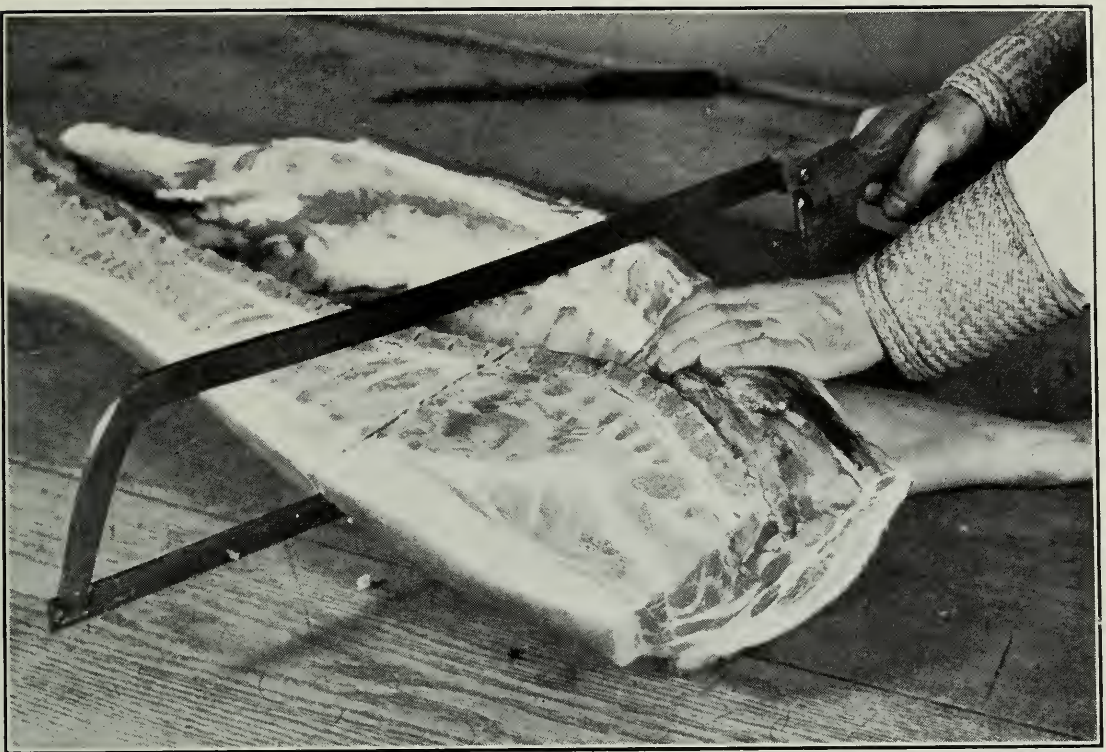


Illustration No. 24

Removing the Shoulder.

The shoulder is removed at the third rib. A cut is made, not parallel with the ribs, but parallel with the cut which removed the head, so that the shoulder has a more or less square appearance.

Illustration No. 25

Removing the Neck Bones.

First the neck bones are removed. Then the shoulder is cut into the various parts as in Illustration No. 26.

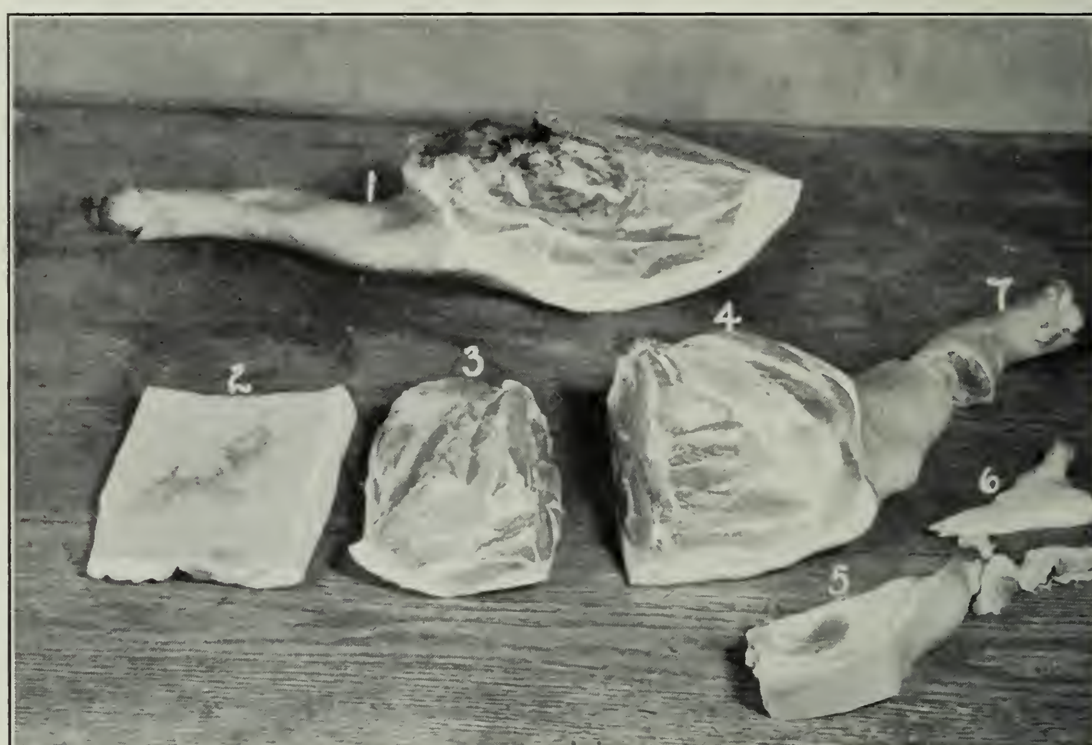


ILLUSTRATION NO. 26

Shoulder Cuts .

1. Shoulder untrimmed
2. Clear Plate } Shoulder Butt
3. Boston Butt }
4. Picnic Shoulder
5. and 6. Trimmings
7. Foot

Illustration No. 27

Cutting middle piece into back and belly.
1. Belly 2. Back

With the edge of the tenderloin muscle as one mark and a point at the lower edge of the back bone at the shoulder end as the other point, the middle piece is divided into back and belly.

Illustration No. 28

Cutting out the spare ribs.

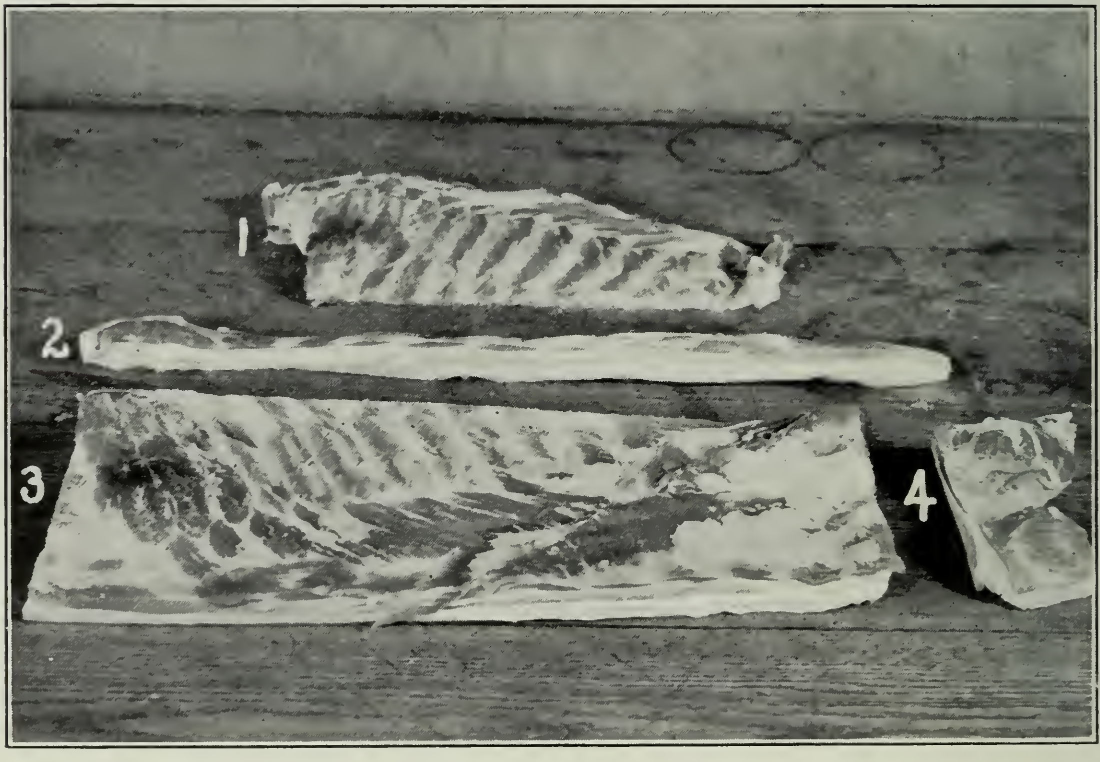


Illustration No. 29

Belly Cuts

1. Spare ribs
2 and 4. Trimmings
3. Bacon trimmed.

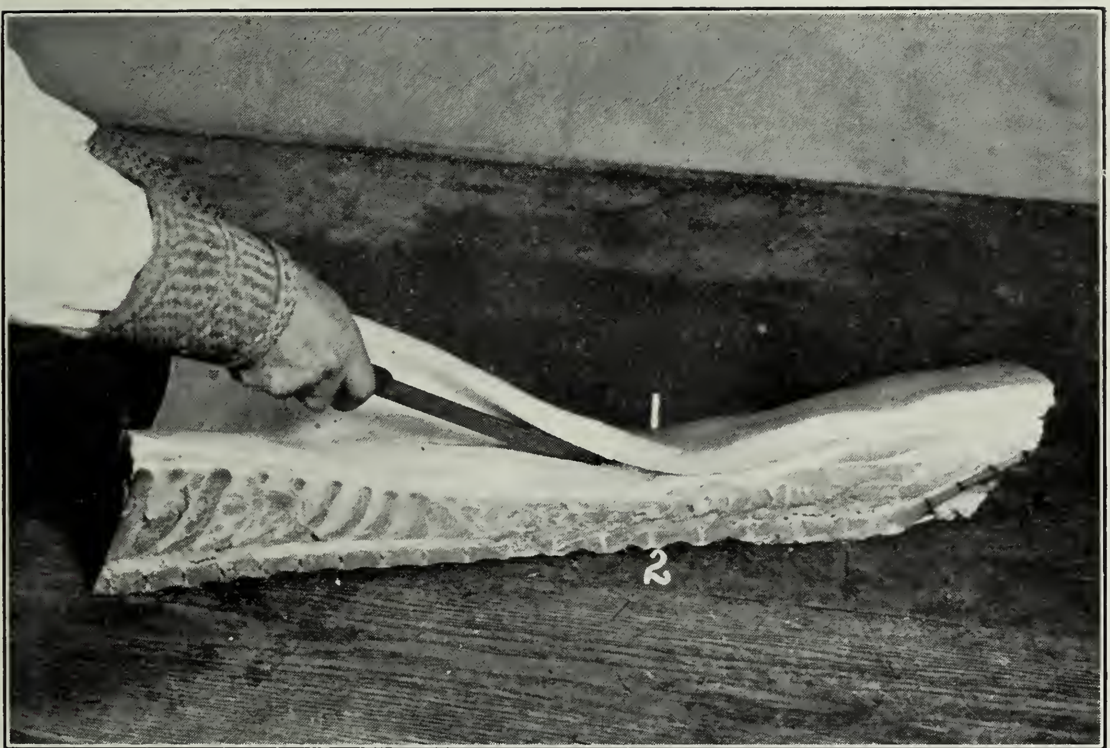


ILLUSTRATION NO. 30

Cutting the back into fat back and loin
1. Fat back. 2. Loin

This practice is seldom followed in cutting bacon carcasses as the fat on the back is just about right for proper cooking. With heavy hogs, however, the fat back is removed and rendered down for lard.

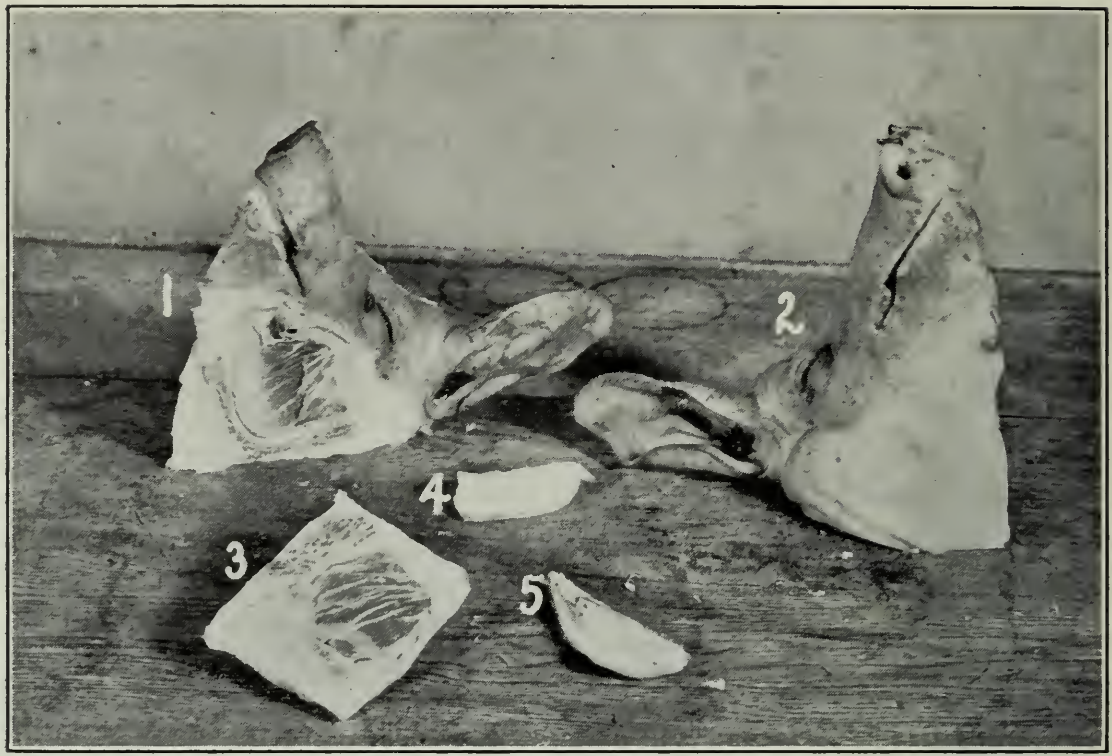


ILLUSTRATION No. 31

Head
1. Trimmed
2. Untrimmed
3. Jowl or Dixie square
4. and 5. Trimmings

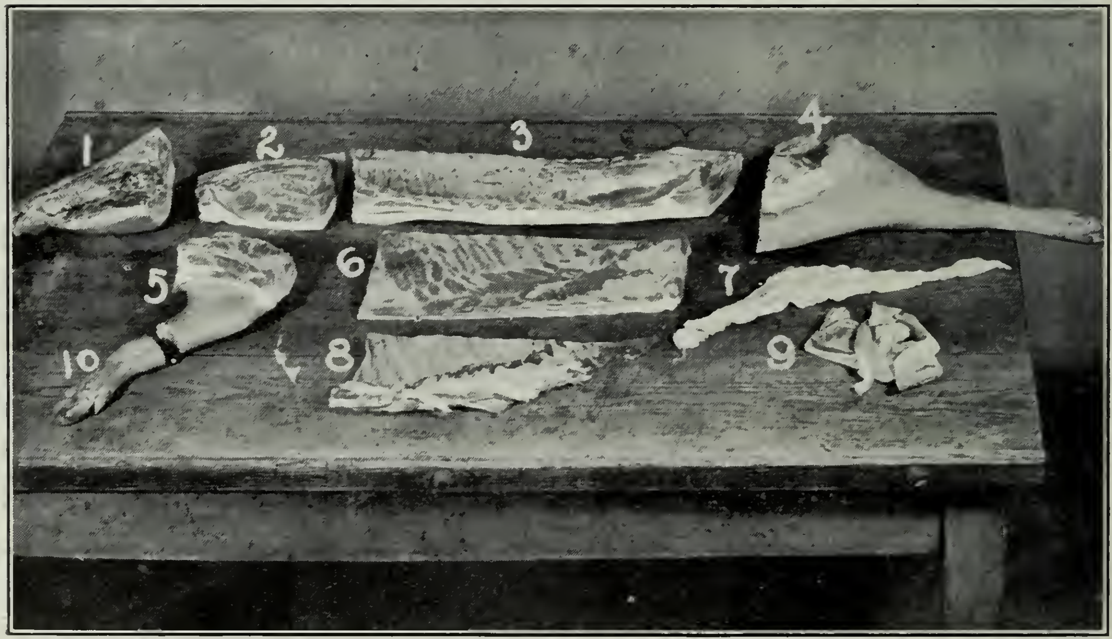


ILLUSTRATION No. 32

1. Head
2. Shoulder butt
3. Back
4. Ham
5. Picnic shoulder
6. Bacon
7. Leaf lard
8. Spare ribs
9. Trimmings
10. Foot

Sausage Making

It is possible to make the whole pork carcass into sausage but generally just the trimmings and a few of the smaller cuts are ground up for that purpose.

Pork sausage should be about three-quarters lean meat and one-quarter fat. However, the quantity of fat put into this process can be regulated by the appetite of the consumer.

The meat should be thoroughly ground and mixed, being careful to see that no bits of cartilage, bone or skin are left in it.

With every 50 pounds of meat add 12 ounces of salt and 2½ ounces of pepper. Other seasoning can be added to suit the taste. About 3 ounces of sage may be used. The above are about the maximum quantities to use and for a milder flavour slightly smaller quantities can be put in the mix.

The sausage meat may be stuffed into casings or packed in cotton sacks. Another method is to cook the sausage and pack in a crock and cover with hot grease.

Curing Pork

Numerous ingredients may be used in the curing of pork but the three main ones are Salt, Sugar and Saltpetre. Salt is a strong preservative and may be used alone, but the addition of other ingredients add to the flavour and appearance of the meat. Sugar adds flavour to the meat and helps to soften the hardening tendency caused by the Salt. Brown or White sugar may be used, or an equal quantity of Molasses may be used as a substitute for Sugar. Saltpetre is a strong preservative and is only used in very limited quantities. Its chief use is to keep the natural colour of the meat. Other ingredients may be added to suit the taste or fancy of the individual.

There are great numbers of recipes for the curing of pork and if directions are followed carefully as to the weight of meat used and the quantities of curing agents required, a desirable product will result.

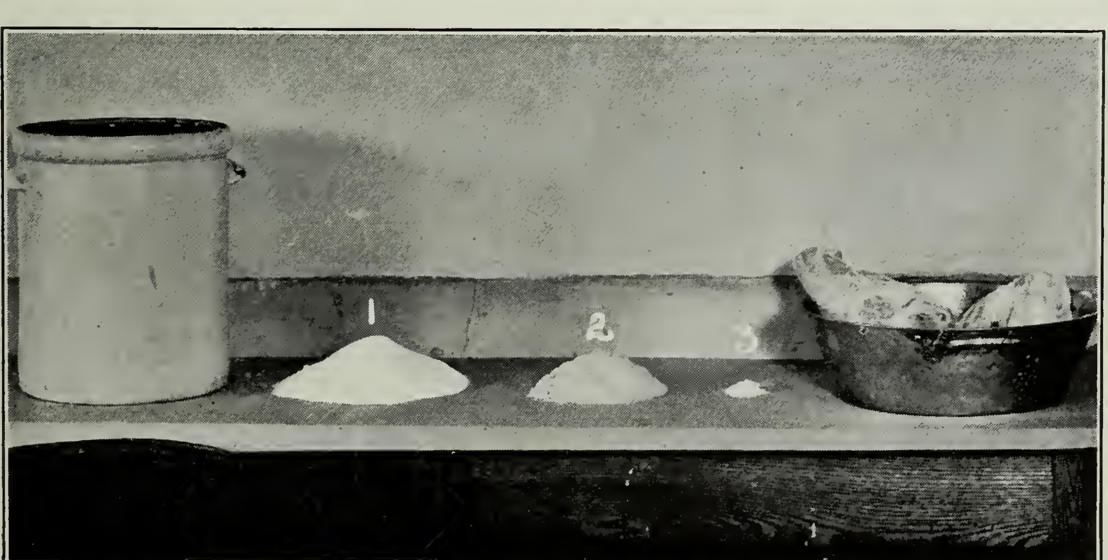


Illustration No. 33

Proportions for 100 pounds of Meat
1. 10 pounds Salt
2. 3 pounds Sugar
3. 2 ounces Saltpetre

Under farm conditions a cool, dry, well ventilated cellar will be a satisfactory place for curing.

The vessels for curing should be clean hardwood barrels or earthenware crocks. Molasses barrels are satisfactory but vinegar barrels should be charred before putting meat in them.

All meat should be properly cooled at a temperature above freezing. A neat job of cutting will add to the attractiveness of the finished product. It is well to remember that small cuts not over twelve or fourteen pounds will be more quickly and thoroughly cured than large cuts of twenty pounds or more.

Brine or Sweet Pickle Cure

For each 100 pounds of meat use:
- 10 pounds Salt
- 3 pounds Sugar *or* Molasses
- 2 ounces Saltpetre
- 6 gallons Water

Mix the above mentioned ingredients thoroughly and rub some of the mixture on the meat, packing it skin side down in the barrel, except the top layer, which should be packed skin side up. Weigh this down with a piece of hardwood board and good clean bricks. Iron or limestone will cause trouble if used as weights. Dissolve the remainder of the mixture left after rubbing on the meat in six gallons of water which has been boiled. Cool and pour over the meat in the barrel so that it covers the meat two or three inches. Repack the meat at the end of seven days and take out any small pieces, such as jowls. Pour the brine back on the remaining meat and leave it: hams, three days to the pound; shoulders, two and one-half days to the pound, and bacons, two days to the pound. When the meat is taken out of the cure soak it in warm water for fifteeen minutes, then soak in cold water. The length of time the meat is left in the water will depend on the desired flavour. If a mild salt flavour is desired leave the meat in water in some cases for an hour or more, and if a strong salt flavour is desired the meat may be hung up to dry after it comes out of the warm water. It is good practice to look at the meat frequently as occasionally in warm weather the brine may become thick and ropey. When this occurs wash off the meat in warm water, scald the barrel and make up a new cure. The strength of the new cure will depend on the length of time the meat has been in the cure. The longer the time in the cure the weaker the new solution. The brine cure is best for cooler weather.

The Dry Cure

For every 100 pounds of meat use:
- 8 pounds fine Salt
- 3 pounds Sugar
- 3 ounces Saltpetre

Mix thoroughly and rub one-half the mixture on the meat. Pack skin down on a clean table. In seven days rub the rest of the mixture on the meat and repack. Leave in the cure three days to the pound. When removed from the cure wash in warm water and soak in cold until the desired flavour is obtained. This may seem rather indefinite but experience will teach just what time is required for these processes. If the meat is packed in a crock or barrel it should be repacked frequently, as the bottom layer will be in the liquor which collects at the bottom of the crock. In order to get a uniform cure keep changing the meat. This cure is best for warmer weather but the shrinkage in this method is much greater than in the brine cure.

After the meat has been soaked, hang it up to dry for at least twenty-four hours. The meat should be hung up with clean strong cord. Wire, tar rope, etc. are objectionable and do not improve the appearance or flavour of the meat.

Smoking

When the meat is dry it may be smoked. The method will depend on the equipment, but in a building large enough the meat should be at least six feet away from the fire. It is best to keep the temperature of the smokehouse below 120° Fahrenheit. Small smouldering fires tended frequently will do the work. The length of time to get the desired colour will depend on the kind of smokehouse. From a few hours in a well built smokehouse to several days in a home-made up-turned barrel may be necessary.

Here again, experience will be the deciding point as to the desirable colour of the finished product. For meat which is to be used immediately a light amber colour is recommended, and for meat which is to be kept some length of time a dark colour indicates a thicker coating of the smoke by-products which not only help to flavour but preserve as well .

Kind of Fuel: Green hickory is the best wood to use to procure a nice colour and flavour. If this is not available green apple wood, maple or any hardwood will do. Corn cobs are also used, but never wood from evergreen trees, as a black sooty smoke results which gives an off flavour.

After Smoking: When the meat comes out of the smokehouse it should be wrapped in several thicknesses of paper and tied tightly. It may be hung up in any dry well ventilated place, but never in a damp place, as moulding will result. For further protection, place the meat in cotton sacks and hang in a dry room.

Yellow Wash

For 100 pounds of meat:

- 3 pounds Barium Sulphate
- 1 ounce dry Glue
- 1½ ounces Chrome Yellow
- 6 ounces Flour

Mix six ounces flour in half a pail of water; mix the Chrome Yellow in one quart of water and add the glue, then pour this mixture into the flour and water. Place this solution on the fire and bring slowly to a boil adding the Barium Sulphate. Stir constantly. When this has reached the boiling point, remove and cool. Make this solution up the day before it is to be used. Apply with a brush to the cotton sacks in which the meat is packed.—*Bulletin* 186, *U.S. Dept. of Agriculture.*

Illustration No. 34

Cured and Smoked.
1. Bacon
2. Ham
3. Shoulder
4. Back Bacon

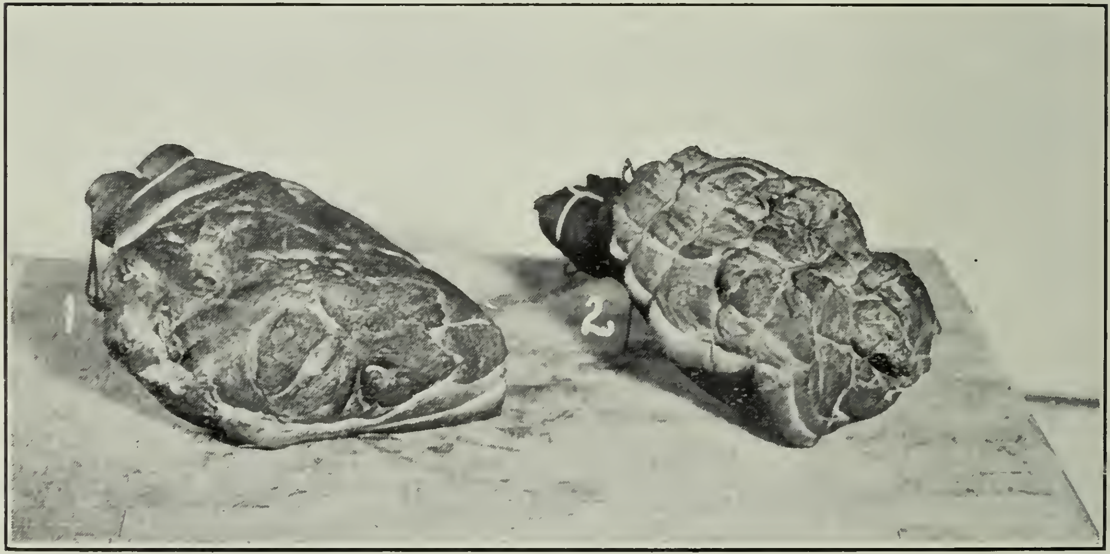


Illustration No. 35

Shoulders cured and smoked.
1. Trimmed shoulder
2. Boned and rolled

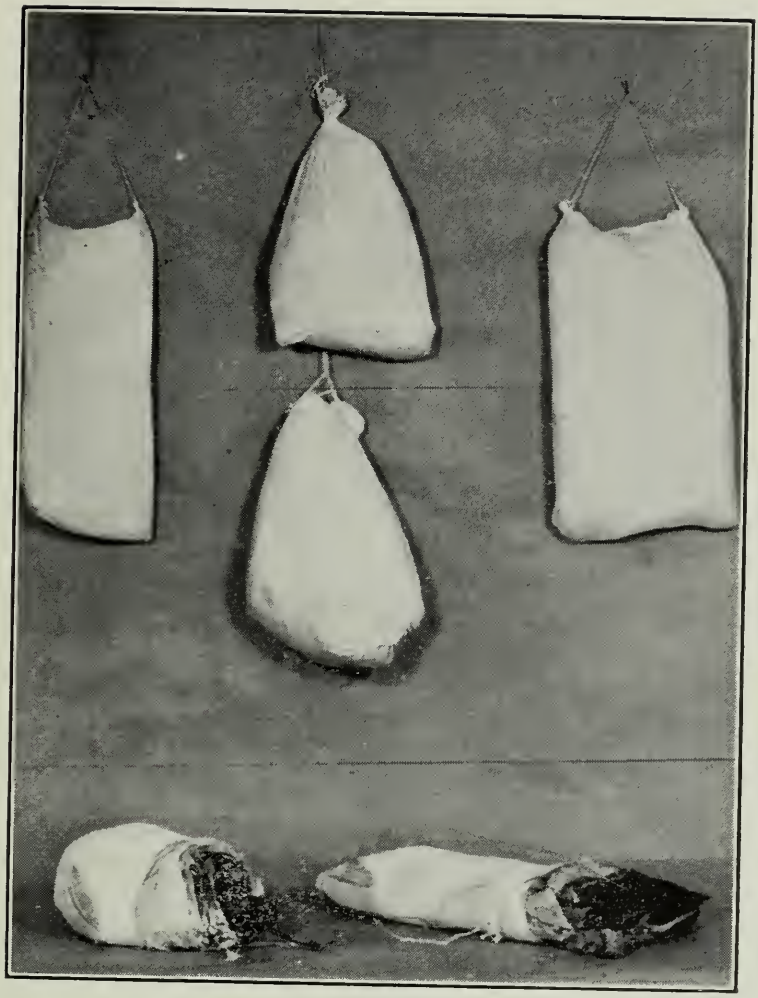


ILLUSTRATION NO. 36

Cured meat ready for the store room.

REFERENCES

"Farm Meats," by M. D. Helser, Iowa State College.
Bulletin 186, United States Department of Agriculture.

BULLETIN 368] [AUGUST, 1932

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

FARM POULTRY

by

Members of the Staff

DEPARTMENT OF POULTRY HUSBANDRY

Poultry Range Scene, Poultry Department, Ontario Agricultural College.

FARM POULTRY

The high standard of the poultry bred in Ontario and in Canada has not come about by accident. It has taken many years of careful breeding to develop so many useful and beautiful breeds and varieties of chickens as are now available. Among this large variety of types and colours are to be found birds suitable for any purpose for which fowl may be desired. We have, therefore, birds in a variety of colours that are satisfactory for the production in quantity, of either white or brown shelled eggs. Some make excellent market fowl, while still others combine a satisfactory egg production with the required fleshing to dress out a good carcass. There is also ample scope for the application of the skill of the exhibition breeder because all the above types, along with other specialized exhibition types, are beautiful as well as useful, and therefore make splendid exhibition material.

The Single Comb White Leghorn is easily the most popular of the producers of white shelled eggs. This variety of Leghorn is a prolific layer of good sized eggs, stands confinement well, and can be successfully handled in large flocks. It has become popular as an egg producer for both large and small egg plants. Among farmers and other who find the production of meat, as well as eggs, profitable, the Plymouth Rock is popular; especially may this be said of the Barred and White varieties of the breed. In this class should be mentioned also the White Wyandotte, the Rhode Island Red, and perhaps the Canadian breed of Chantecler. The Orpington and Sussex breeds also supply varieties suitable for this purpose.

Where the production of table fowl is stressed the Cornish Game, and more especially the first cross of the Cornish with Orpingtons, Jersey Black Giants, Plymouth Rocks or Brahmas, is satisfactory. Some strains of Plymouth Rocks, Wyandottes, and Rhode Island Reds produce birds that dress out well. Other varieties of the above breeds are also useful commercially, but are more popular for exhibition purposes.

Not all birds nor all strains of any one variety are equally good for egg production, meat production, or as dual purpose fowl. Nor is one breed or variety necessarily superior to any other. It is possible, within certain limits, to select out of almost any variety birds excelling in meat or egg production, or birds of an intermediate type. Breeding from only such selected birds will soon result in a strain adapted to the purpose for which the selection is made. The more rigidly a flock is selected for high egg production, the poorer the offspring of that flock will become as meat birds. Where one has a preference for any particular type or colour of bird, almost any suitable breed and variety may be chosen and then developed by selection for any purpose required of it. Trap nesting, pedigreeing, and progeny testing of the stock will facilitate the attainment of the desired goal.

In the production of these numerous breeds and varieties of fowl much credit is due the American Poultry Association, organized by representative poultry breeders of the United States and Canada in 1873. The American Standard of Perfection, issued by this Society, has aided greatly in bringing about uniformity in breeding effort. It has served as an incentive to greater effort on the part of many breeders. In it is described and illustrated the ideal in colour, shape, and other points, of each recognized breed and variety of Chickens, as well as of Geese, Ducks, and Turkeys. The Standard is revised at intervals to keep up with the changing ideals of the leading breeders of the various breeds and varieties. In this way stress is placed on the breed characters, which changing conditions in the trade as well as in the show room indicate should be emphasized.

Practically all present day breeds and varieties of chickens are the outcome of crosses made between birds of various types, colours and comb conditions. These crosses were followed up with rigid selection toward an ideal until such ideal was, to a degree, attained. While careful selection has brought about considerable purity among the breeds and varieties, there are still numerous indications of impurity. These are known as standard disqualifications and since the majority, if not all of them, are hereditary, every breeder is well advised to discard all birds carrying such disqualifications. It is just as important for the production breeder to cull severely in this regard as it is for the exhibition breeder to do so. The purity and quality, as well as the egg production, of much of the poultry of Ontario is dependent on the attention given these points by breeders of production birds. This is true of poultrymen supplying hatcheries with eggs as well as those operating breeder hatcheries.

POULTRY BREEDING

In the breeding of poultry there are two main points to be considered; First, the selection of birds that have the characters desired, and secondly, a further selection from these of birds that can produce offspring as good as or better than themselves.

Many are of the opinion that "Like begets like." In general, this is true, but it is true for general and not necessarily for particular qualities. It is true that a White Leghorn male mated to White Leghorn females will breed chickens that are White Leghorns, or that have white plumage, yellow legs, and white earlobes, but of these offspring there will be no two chicks exactly alike. We find large and small Leghorns; most of them never go broody but some do; some lay large eggs, others small eggs. We also find a great variation in the number of eggs produced by different hens.

Selection is made on the basis that like will produce like, but experience has taught all breeders that to secure uniform superiority, they must carry on the selection through generations of poultry. If we select birds that have laid better than 200 eggs in twelve consecutive months and mate these to a male of similar strain, we do not expect to get daughters that will all lay 200 or more eggs a year, but we do expect, upon the average, a better production than if no selection had been made.

SELECTION

The first step in the breeding of poultry is the selection of the birds to make up the breeding pen. What birds are used in this pen depends upon the object of the breeder; for example, one person may be interested solely in meat production, another only in egg production, another may be careful of breed type and colour, and still another of all of the above and many more.

Selection is made along the lines of the ideal in mind. It is therefore advisable for one to try to form an ideal. The higher the ideal the fewer will be the individuals that will be considered suitable for the breeding pen.

No matter what may be the breeder's ideal, all agree that vigour is the one essential point that must always be present; that is, a bird must be healthy and active. Vigour means the bird's ability to thrive and live under ordinary conditions.

The lower the vigour, the more easily the birds will sicken and die. Perhaps the male that is the boss of the entire flock is the most vigorous, or at least it would be safe to say he has considerable vigour.

It is essential that the breeder should bear in mind that the various characters of the chicken may be inherited separately. Because Plymouth Rocks, for example, have single combs, red earlobes, and yellow legs, it does not mean that all such birds having yellow legs, must have single combs and red earlobes. By means of this inheritance of single characters, the breeder is enabled to correct single defects in the birds bred, and at the same time maintain and improve the good points.

It is, therefore, plain that the first essential is the selection of birds that have the characters wanted, and the next step is to test their power to transmit these characters. Our experience has been that certain birds, male or female, are excellent for breeding one character but fail in others. For instance, hen H19 has never bred a bird without positive bright yellow legs. She appears to be able to transmit this character to all her offspring. Again, we find birds that transmit several desirable characters very well, but may likewise transmit one very undesirable character. As an example of this, male 2227 produced daughters that were very satisfactory in all respects with the exception of size and colour of eggs. In the end the breeder selects, then tests the selected birds for their ability to produce offspring as good or better than themselves.

The most interesting and at the same time the most progressive method of breeding is to know the parentage of each chick, and thus be able to tell which birds are reliable breeders. Our experience is that there is as great difference among birds, in their ability to transmit certain characters, as one may find in any ordinary selecting process among a pure-bred flock. Some birds are good breeders; others appear to be of very little account.

The more selections that are made and the more tests of progeny, the less is the percentage of undesirables found. One may expect some considerable variations within a group, but one may likewise expect a smaller number of inferior stock with each generation.

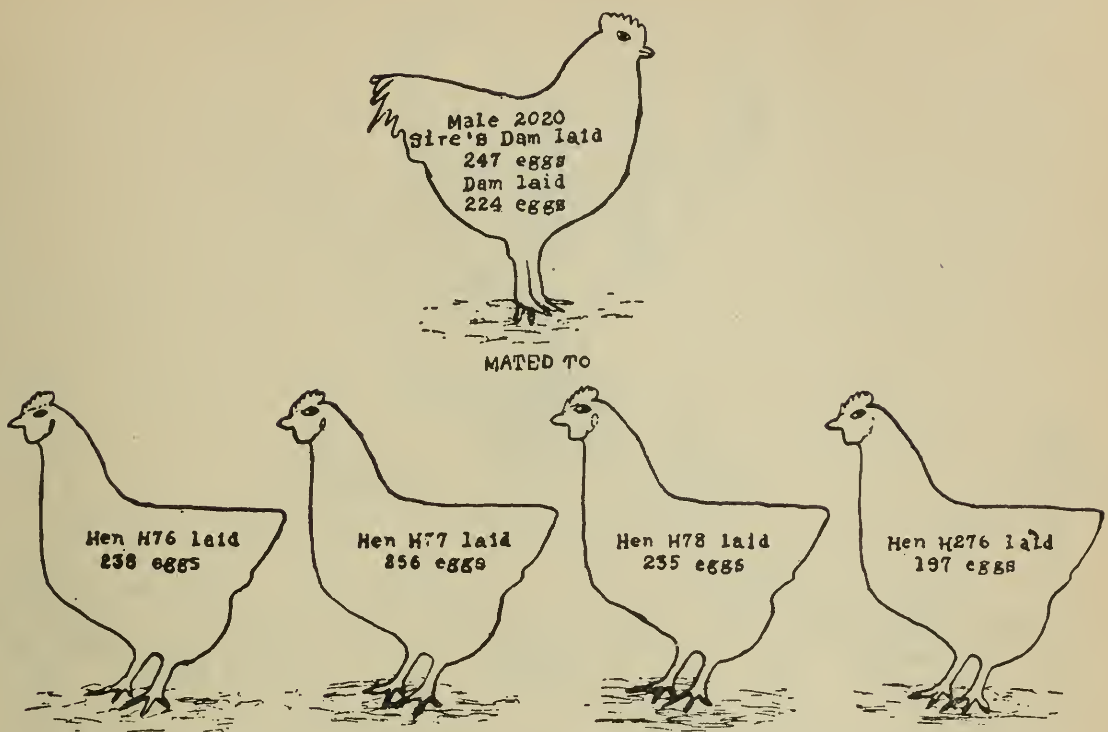
SELECTION AND PROGENY TESTING

The following tables give the results of a test of four Barred Rock males and the hens bred to them, each of which hens had four or more daughters that completed a year's trap-nest record. Where a hen has fewer than four pullets it is more difficult to estimate her value as a breeder. In the following table we have left out all such hens. The results from them do not alter the indicated value of the male as a breeder beyond the figures given. They are of some interest in establishing the value, but where space is limited it has been considered wise to leave such hens out of the figures given.

It must be remembered that in this progeny test only the number of eggs laid are considered. This is some indication as to the hen's ability to get pullets, as is indicated by H237, H19, and H262.

A practical breeder would have to bear in mind such things as breed-type and colour, size and colour of eggs, hatchability, growth of the chicks, and the number of eggs set to secure a mature bird.

RESULTS OF BREEDING MALE 2020 TO HENS H76, H77, H78 AND H276.



Daughters	Eggs laid
L 379	— 171
L 440	— 253
L 2631	— 133
L 3433	— 162
L 3220	— 151

Daughters	Eggs laid
L 45	— 189
L 311	— 162
L 386	— 221
L 2637	— 171

Daughters	Eggs laid
L 106	— 157
L 194	— 245
L 479	— 165
L 2518	— 123
L 2607	— 115

Daughters	Eggs laid
L 319	— 177
L 416	— 166
L 487	— 184
L 2551	— 155
L 2641	— 172
L 2649	— 141
L 3429	— 139

NOTES ON MALE 2020

Male 2020 is the son of a 224 egg hen. The dam of his sire laid 247 eggs.

He was successfully bred to four hens which produced four or more daughters with trap-nest records for a year.

The mating produced three hens that laid two hundred or more eggs in their first year.

H76 produced the highest laying daughter, and this daughter's record exceeded her mother's.

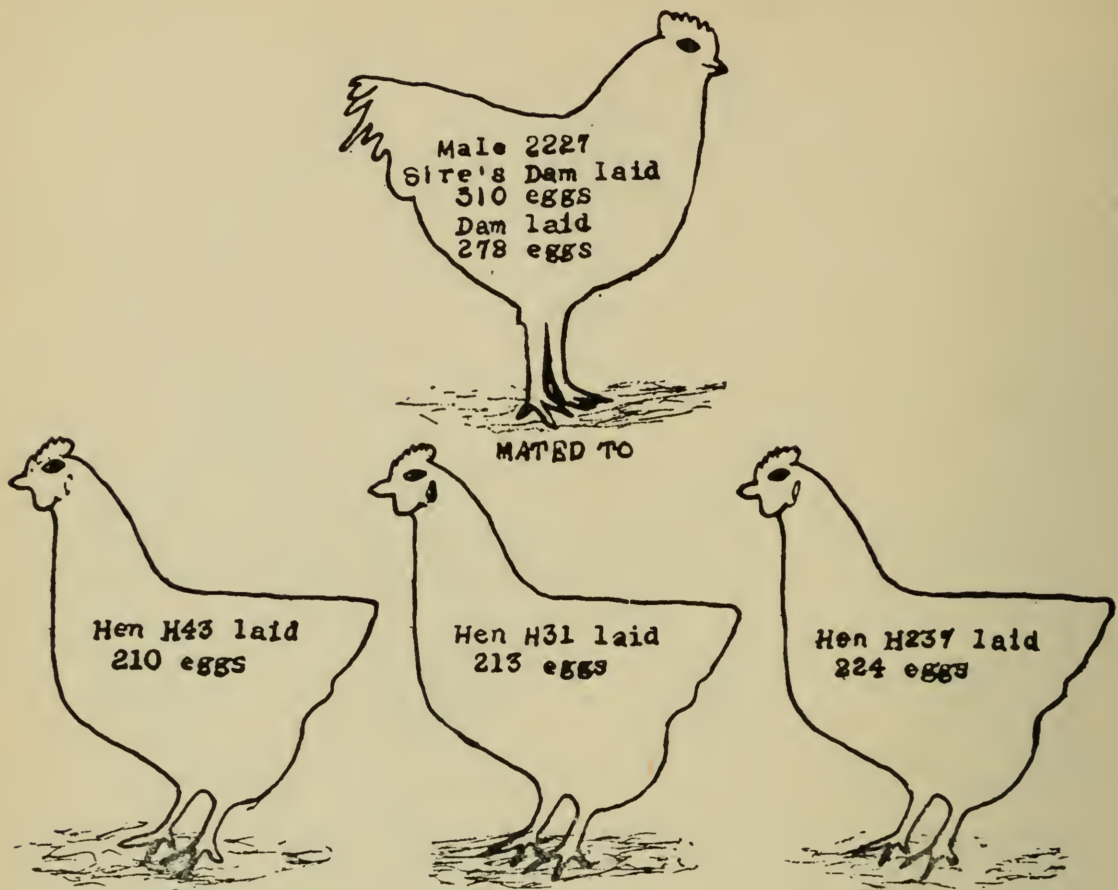
H77 produced one daughter that laid two hundred eggs, but was not as good a layer as was her mother.

H78 produced one daughter with a record higher than the mother's.

H276 produced no daughters equal to herself.

This mating would be considered very ordinary from the results obtained. From such a mating one would not expect future generations to be any better than the parents.

RESULTS OF BREEDING MALE 2227 TO HENS H31, H43 AND H237.



Daughters

	Eggs laid
L 208	260
L 375	228
L 491	194
L 2526	130
L 2557	179
L 2572	191
L 2628	123
L 3436	193

Daughters

	Eggs laid
L 303	219
L 377	271
L 2529	242
L 2575	254

Daughters

	Eggs laid
L 70	202
L 221	204
L 318	227
L 352	244
L 400	227
L 437	224
L 474	249
L 492	223
L 2516	213
L 2582	190
L 2630	243
L 3905	235

NOTES ON MALE 2227

The general results of this mating were exceptionally good. Our experience has been that but few matings produce as many high laying birds as did this one.

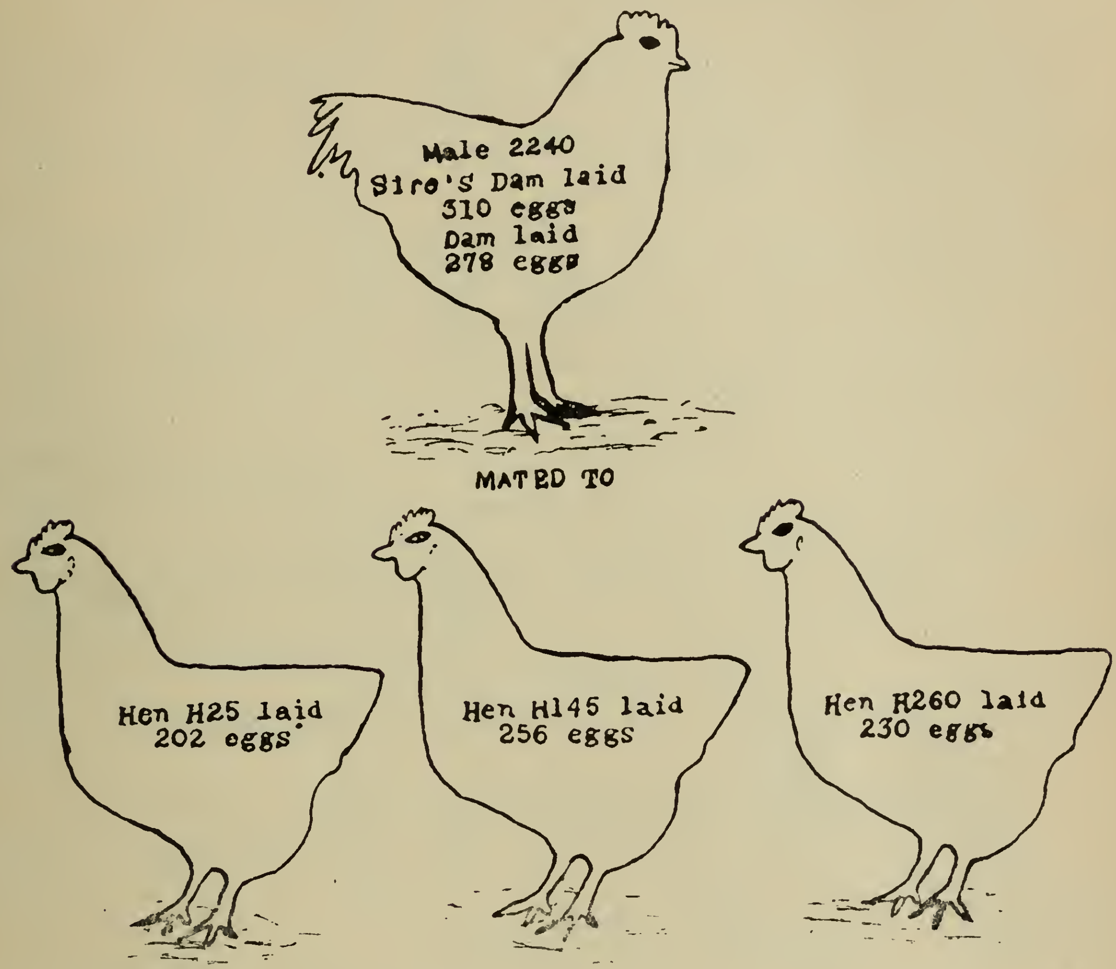
Hen H31 produced daughters all of which were better than herself. She also produced the highest laying individual.

Hen H237 had a large number of daughters, indicating exceptional breeding ability for numbers. It is rare to get a hen with so many daughters that are all good layers. This is a very excellent hen and should be good foundation for a high laying family.

H43 did not breed as many high laying daughters and there is a wide variation among them. It is questionable, if this hen had been bred to an average male, whether her offspring would be very good. Sons of Hens H237 and H31 should be good males from which to breed.

RESULTS OF BREEDING MALE 2240 TO HENS H25, H145, AND H260.

(Male 2240 is a full brother of Male 2227)



Daughters

	Eggs laid
L 15	169
L 404	211
L 451	183
L 483	214

Daughters

	Eggs laid
L 407	224
L 439	145
L 2612	147
L 3208	187
L 3210	134
L 3215	147
L 3237	183

Daughters

	Eggs laid
L 369	263
L 392	202
L 2573	233
L 2599	105
L 2648	180

NOTES ON MALE 2240

The daughters of male 2240 were, on the average, distinctly lower in egg production than those of his brother, 2227.

Hens H260 and H25 indicated that they would breed good stock. One would particularly desire to see the offspring from these hens mated to such a male as 2227.

Hen H145 had no daughters equal to herself and most of the daughters were low producers. This hen would be discarded as a breeder.

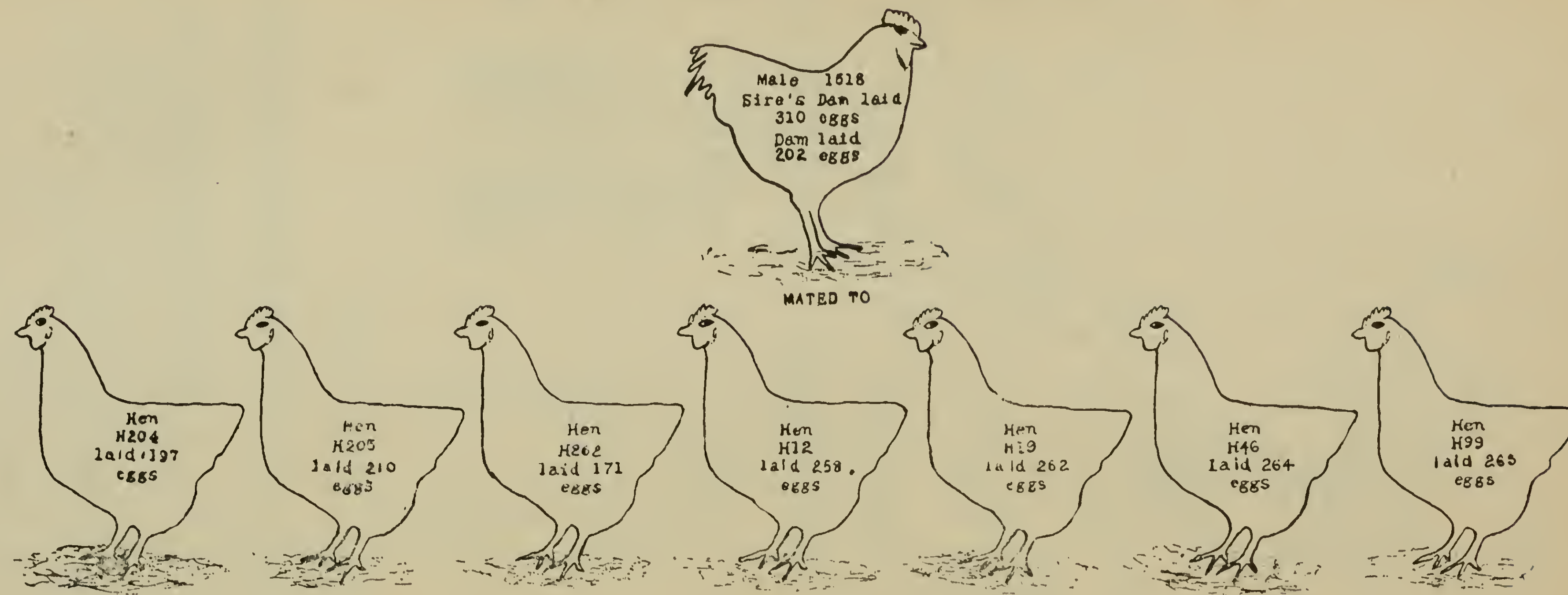
Hen H260 had one very poor daughter. Without further trials it is questionable what bearing this would have on her future breeding.

Hen H25 had two daughters better than herself.

The good pullets from H260 and H25 would be worth using in breeding trials. The cockerels might be good breeders but one would prefer them from a better male.

RESULTS OF BREEDING MALE 1518 to HENS H12, H19, H46, H99, H204, H205, and H262.

(Male 1518 is a half brother of 2237 and 2240)



Daughters	Eggs laid
L 411	143
L 2571	221
L 2594	144
L 3224	179

Daughters	Eggs laid
L 453	137
L 2578	119
L 2613	180
L 3231	166
L 3249	199

Daughters	Eggs laid
K 196	229
K 223	218
K 255	215
K 311	201
K 319	181
K 330	211
K 366	164
K 407	150
K 498	116

Daughters	Eggs laid
L 28	210
L 51	242
L 2542	190
L 2547	234
L 2556	216
L 2626	234
L 3924	212

Daughters	Eggs laid
K 65	277
K 94	278
K 119	137
K 188	198
K 190	203
L 193	210
L 2503	144
L 2531	180
L 2532	187
L 2580	166
L 3202	168
L 3294	160
L 3423	222
L 3901	209

Daughters	Eggs laid
L 2513	105
L 2548	263
L 2576	157
L 2640	95
L 2643	190
L 3442	161
L 3912	196

Daughters	Eggs laid
L 139	224
L 346	164
L 359	222
L 2512	131
L 3203	168

NOTES ON MALE 1518

Male 1518 was successfully bred to more hens that produced four or more daughters than any of the other males. He is a rather interesting male in that he has produced many variations, not only in the range of egg production from his daughter but in the way the daughters from the different hens performed.

The most successful mating was H12. The daughters of this hen were uniformly good.

H46 produced a wide range of daughters and the average results were not very good.

Hen H19 produced some high laying daughters and the average of all was very good.

H99 performed much after the manner of H46, but the average was better.

Hen H204 was in the same class as H46 and H99.

Hens H205 and H262 are full sisters and therefore the results from these two hens become very interesting. It will be noted that it is not always the highest laying hen that is best bred, nor yet the lowest — (Compare H12 and H262).

The Hens H205 and H262 are an excellent example of the value of testing the progeny for the characters under consideration.

Hens H46, H99 and H204 appear to be rather inferior breeders.

TABLE I. GENERAL RESULTS FROM ALL THE HENS

Mother	Egg Production of Mother	Number of Daughters	Average Egg Production of Daughters
H12	258	7	219.7
H25	202	4	194.25
H31	213	4	246.5
H43	210	8	187.25
H46	264	7	162.4
H76	238	5	174.
H77	256	4	185.75
H78	235	5	161.
H99	265	5	181.
H19	262	14	195.
H237	224	12	223.4
H145	256	7	166.7
H204	197	4	171.75
H260	230	5	196.6
H276	197	7	162.
H205	210	5	159.6
H262	171	9	187.2
Total production	3888	112	3174.1
Average production	228.7		186.71

It is not to be expected in the general results from a selected number of high laying hens that all the daughters will be high layers, or that the mother, only, controls the producing ability of the daughters.

Study the following tables as to the variations in breeding ability:

TABLE II. THE INFLUENCE OF THE MALE

		Mother's Egg Production	Number of Daughters	Average Egg Production of Daughters	Total Eggs
Male 1518 Bred to—	H 12	258	7	219.7	1538
	H 46	264	7	162.4	1140
	H 99	265	5	181.	905
	H 19	262	14	195.	2730
	H204	197	4	171.7	687
	H205	210	5	159.6	798
	H262	171	9	187.2	1685
Total	....	1627	51	1276.6	9483
Average	....	232.4	—	182.3	185.9
Male 2020 Bred to—	H 76	238	5	174	870
	H 77	256	4	185.75	743
	H 78	235	5	161	805
	H276	197	7	162	1134
Total	....	926	21	682.75	3552
Average	....	231.5	—	170.6	169.1
Male 2227 Bred to—	H 31	213	4	246.5	986
	H 43	210	8	187.25	1498
	H237	224	12	223.4	2681
Total	....	647	24	657.15	5165
Average	....	215.6	—	219.	215.2
Male 2240 Bred to—	H 25	202	4	194.25	777
	H145	256	7	166.7	1167
	H260	230	5	196.6	983
Total	....	688	16	557.5	2927
Average	....	229.3	—	185.8	182.9

SUMMARY

Of the four males under test, male 2227 was the best breeder of high laying hens and male 2020 was the poorest.

Male 1518 bred some good ones and by careful selection a very good line could be established, especially from the cockerels of H12.

If one desired high laying hens and considered this character only, by taking male 2227 and hens H12, H31, H237, H19, H262, H25, H260 and H77, he would be reasonably sure of getting a number of pullets that should average at least two hundred or more eggs.

Male 2240, being a full brother of 2227, and having proven himself an inferior breeder, would be discarded.

As a matter of fact male 2227 has a fault, in that his daughters do not lay eggs of good size and colour, and the breeder might consider seriously mating 1518, who does produce pullets laying eggs of good size and colour, in preference to male 2227; or a cockerel from Hen H12 bred to the daughters of 2227 would be a mating worth serious consideration.

The remaining hens, if one were short of breeders, could be tested another season by mating these to different males, but one is not likely to get daughters of a very high average from them. It is likely that one will test hens like H46, that have laid two hundred and sixty eggs, with several males, in an effort to find a male with which she will produce daughters her equal or better. Occasionally one is successful.

Our experience has been that by breeding from what appear to be the best sons of the good breeding hens a little progress is made from from year to year, whereas the use of a male, simply because his mother was a high layer, frequently results in a decrease in production.

Pedigree breeding and progeny testing take considerable time and necessitate accurate records. Where one desires to buy males or females from such stock the purchaser should expect to pay a higher price. The labour involved in pedigree breeding, if well done, will double the cost of the ordinary chicken.

Considering that many are interested in what happens when an ordinary hen is bred to a male such as 2240 from a fairly good hen, the following results from such a mating are given.

Hen 114 laid one hundred and twenty eggs in her pullet year and five of her daughters were trapnested with the following results:

K261	laid	156	eggs
K263	"	221	"
K365	"	135	"
K453	"	135	"
K489	"	147	"

The average of the group was 158.8 eggs.

Experience has demonstrated many times that with reasonable care and feeding, an average flock egg production of one hundred and fifty eggs or even better can be secured, by using sons of two hundred egg hens. However, to secure a flock average of one hundred and eighty to two hundred or more eggs, from a flock of three hundred to one thousand birds, requires careful breeding.

Fig. 1. H69 laid 249 eggs in her pullet year.

Fig. 2. K182 laid 220 eggs in her pullet year, 198 in her second year.

Fig. 3. L48-L49 is a son of H69.

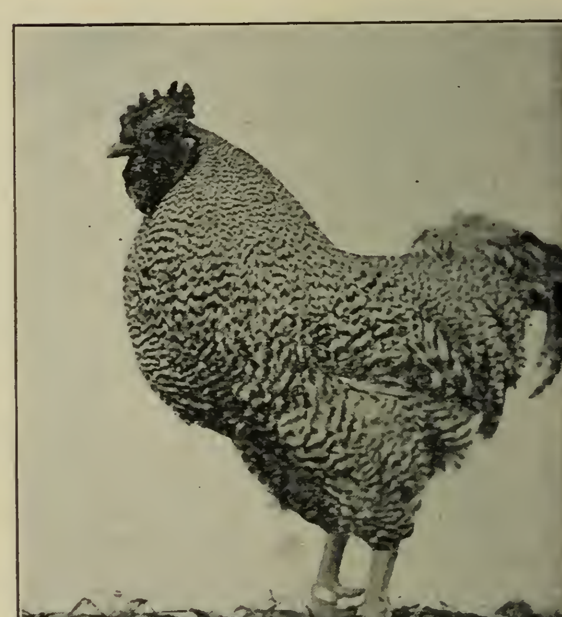


Fig. 4. M1039-M1040 is a son of K182.

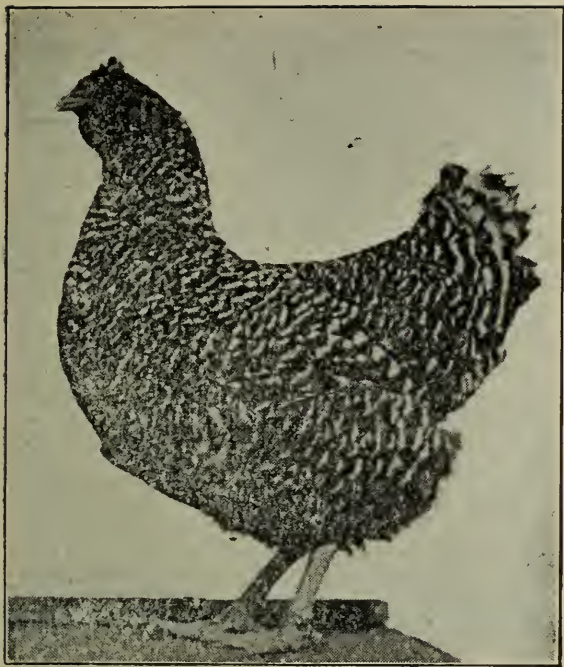


Fig. 5. H7 laid 219 eggs in her pullet year, 194 in her second year, 181 in her third year.

Fig. 6. K67 laid 240 eggs in her pullet year.

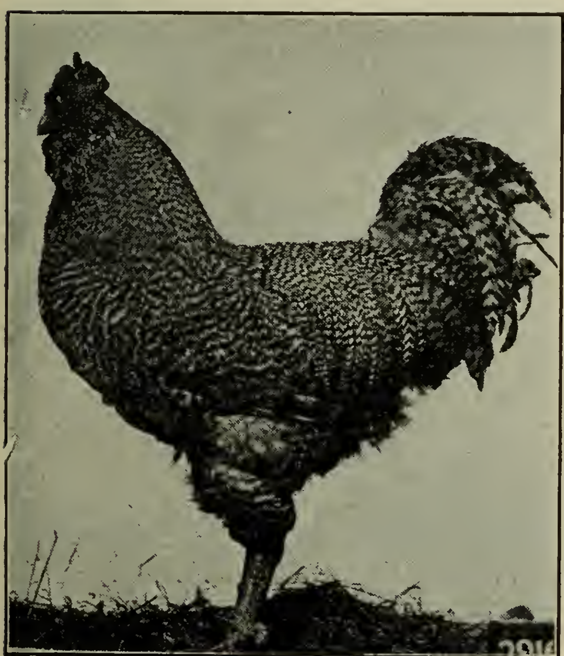


Fig. 7. M2220-M2221 is a son of H7.

Fig. 8. H19 laid 262 eggs in her pullet year.

Fig. 9. L60 laid 301 eggs in her pullet year.

Fig. 10. K186 laid 271 eggs in her pullet year.

Fig. 11. K.1801 laid 253 eggs in her pullet year, 196 in her second year.

Fig. 12. G29 laid 202 eggs in her pullet year, 194 in her second year, 180 in her third year, 143 in her fourth year.

IN-BREEDING AND LINE BREEDING

Having located a successful mating, one can perpetuate it easily so long as the original birds are breeding, but the problem begins after this original mating ceases. Shall one breed mother and son, or brother and sister, or cousins, or what is the best procedure?

Our experience in breeding birds of very close relationship, such as mother-son or brother-sister matings, would not warrant us recommending such a procedure. It is true that we have had some successful results, but it is likewise true that the results of most of such matings have been very bad. If one is anxious to breed closely, our experience would suggest a trial of any relationship, so long as only vigorous birds are used, but it is not wise to depend entirely for the future flock upon such a mating. A good in-bred bird, while difficult to produce, will likely be a **valuable breeder.**

It is very doubtful if one can say what relationship will give the best results, but it would appear to be good advice to the average person not to breed too closely, and to look for new blood from some source where the breeding has been similar.

BREEDING MARKET POULTRY

While the production of eggs is considered by many poultrymen as the most remunerative feature of poultry farming, it is unwise to neglect too much the meat producing ability of the flock. Our extensive records of breeding station flocks indicate clearly that the owner who gives some attention to the meat producing ability of his birds makes more profit, on the average, than does the man who specializes in egg production only. Care should be taken, while selecting the breeders in the farm flock, to select moderately deep breasted birds instead of extremely deep ones. Such birds will, other things being equal, breed not only high laying pullets but also chickens with breasts that appear heavier muscled than do the breasts of the chickens from the extremely deep bodied breeders. It is quite possible to breed a flock of chickens that will produce good broilers and moderately good roasters without losing too much of the desired high production from the pullets. Although the method of feeding and the kind of feed used are influencing factors, the type of breeding stock selected largely controls the amount of muscle that will be found on the broilers and roasters.

POULTRY CULLING

Weeding Out the Boarders

It has been amply demonstrated that good and poor layers can be distinguished one from the other by visual characteristics. The average man or woman interested in poultry can, with a little study and some practice, readily master the more important features of this work sufficiently to remove with ease and considerable accuracy the poor hens from the flock. The fine details of culling require a more extended period of study and practice, but are not absolutely essential in the general application of the work.

Every farmer knows there is a great deal of difference in the type of his cows, and also that there is quite a noticeable correlation between the type and the producing capacity of the individual. There are three distinct types of cattle, namely, beef, dairy, and dual purpose. These types can readily be compared with corresponding types of poultry. There is the round bodied, loose feathered, sluggish type, which fattens readily and lays but few eggs; the flat sided, deep bodied, more closely feathered, clean cut, angular and alert hen, which fattens slowly and performs well as a producer of eggs. There is also the intermediate type which shows certain characteristics that are common to both of the above mentioned types but in which these characteristics are not developed to such a marked degree as they are in either of the above mentioned. The production of this intermediate type is in direct relation to its degree of similarity to the above mentioned meat or egg types. The accompanying illustration, Fig. 13, shows the difference in body type between the skeletons of high and low producing individuals. The outstanding differences are

Low capacity. High capacity.

Fig. 13. Note the great depth in the skeleton of the high class hen.

easily noticed here. The deep, flat side, with ample capacity for strong, well developed organs of digestion, circulation, respiration and production, is easily seen in the high producing hen. Note the long keel running parallel, or tending to slope upward, in the high producing hen as compared with the shallow body, resulting in lack of capacity in the poor layer.

It is necessary that the operator becomes familiar with the several types as indicated by these skeletons in order to recognize them in the birds in the flock. Those birds not conforming to the desirable type should be weeded out. We will first consider type as exhibited by the bird as she stands in the coop or in the yard. In general, the hen must be rectangular in shape when viewed from the side. She must carry a good length of rib, giving her the appearance of being deep from the back to the point of the breast. The back should be long and fairly level, with a corresponding depth behind. In studying type as seen in the run, notice feathering. Loose, fluffy feathering will camouflage real body type, while, as a rule, moderately close feathering is associated with good type. The abdomen should not be overfat and sagging, but should be carried up well and supported by the keel. The illustration shows very well the desirable body type.

How to Hold and Handle Birds in Culling

The amateur poultryman often experiences considerable inconvenience in handling birds, and just as often causes the bird much worry while handling. Fig. 14 shows the proper way to hold a bird. The hen, when held on the arm in this way, with the keel bone resting on the arm, and with one's first finger between the hocks and the thumb and with the second finger used to grasp the upper shank, will rest quietly and give one a chance to examine the various points to be considered.

Fig. 14. Method of holding bird.

Head Types. The head tells an interesting story. It is an index as to what may be expected in the body type and in the performance of the hen. The head should be clean cut, of medium size, not too long or crow-headed, nor too short and bunty. The crow-headed type is an indication of low producing ability, and often of a lack of constitution. The short, beefy head indicates a sluggish type and is often correlated with a predisposed tendency to fatten, and with low egg production.

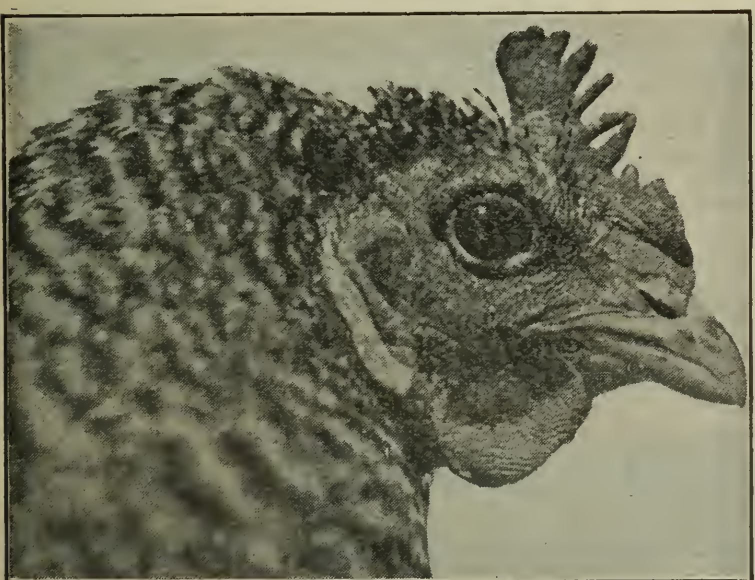


Fig. 15. Side view of good head.

Fig. 16. Front view of good head.

The illustration shows several interesting features in heads. Figs. No. 15 and 16 show heads with abundance of character. Note the well turned beak, the fine texture of skin about the face, and the bright, prominent eyes set well back in large, oval eye sockets. The eyes are set close to the top of the skull with their long axes parallel with the line of the top of the skull and the beak. Note the absence of wrinkles or beefiness over the eyes and about the face. The top of the head is inclined to be flat and fairly wide. This width is carried well forward towards the nostrils. The line made by the top of the beak and skull is straight, thus avoiding an undesirable tendency to dish at the point of the nostrils. The comb is waxy and bright. Both heads show marked indication of vigour, strength, activity and quality.

Compare these heads with those shown in Figs. 17 and 18. Here on the one hand is shown the rather round, narrow skull and long pointed beak of the too refined bird. On the other hand is the head with wrinkles of fat over the eyes and a coarse skin about the face. The full, sluggish eyes are set in close, rather round

Fig. 17. Side view of poor head. (Crow head.)

Fig. 18. Side view of poor head. (Fat head.)

sockets, not so close to the top of the head, nor are the long axes of the sockets so parallel with the top of the head. These heads do not show the strength, character, nor quality exhibited by the heads of the last two birds.

There is danger of going to extremes in head types. However, the hen with the extremely fine or delicate head is apt to lack vigour and may not stand up under prolonged heavy production. The coarse, heavy head usually indicates a sluggish disposition and failure to lay profitably. The quality and character of the head of a hen often gives one a good indication of the economic worth of the bird.

Body Conformation. The head conformation sets one wondering what type of body the hen is likely to have. The type can easily be ascertained by handling. Holding the bird as described above, take the other hand and place the thumb over the back just under the wing, and let the fingers fall along the side of the bird to

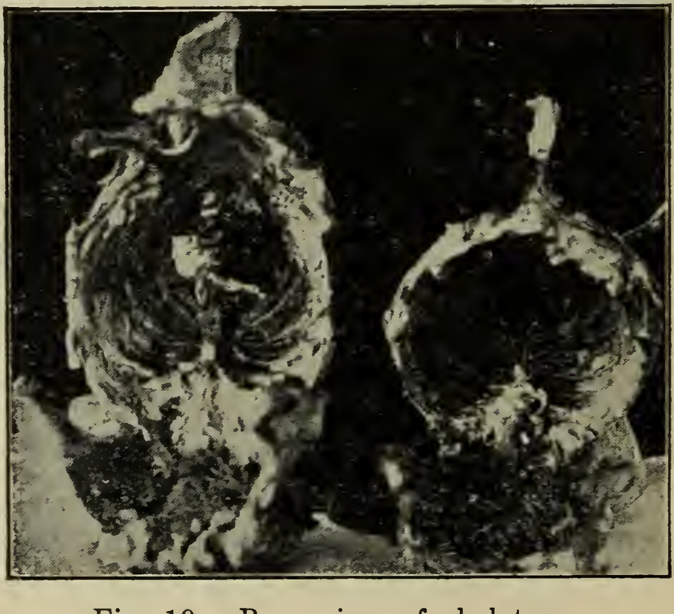


Fig. 19. Rear view of skeletons.

determine the length and spring of rib. This portion of the hen can be compared to the motor of an automobile. Here are all vital organs, such as the heart, lungs, and digestive organs, must function efficiently to assist in producing eggs and in repairing worn out body tissue, so that the bird can stand the wear and tear of heavy production. If the hen is to develop speed as a layer her motor must be large and powerful, and it must have room in which to operate. Thus we find that the hen must possess good spring of rib and a deep, flat side. Fig. 19 shows the difference in the spring of rib in high producing hens as compared with low producers.

Note the long, flat side of the high producer and the round, well-sprung rib on the lower producer. This can be determined by handling as described above.

The back should be of good length and with good width carried well out from the hips to the pubic bones. Note Figs. 20 and 21.

Fig. 20. Broad, flat back, carrying its width to the tail.

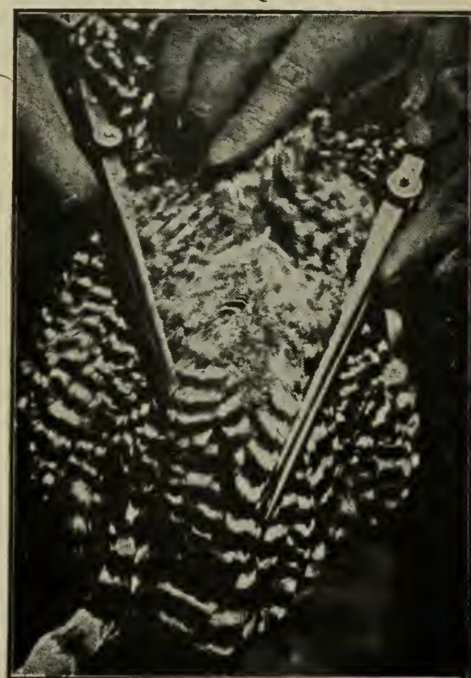


Fig. 21. Rounded back, forming a wedge with the tail. (Poor type.)

The shape of the keel bone is important. It should run back either parallel with the back or slope down. It must be long to support the abdomen or egg sack. In high producers the keel frequently has a decided hook or turn down at the end. This is a good feature and, while not always found, is generally a sign of early and persistent production in the early part of the pullet year. The conformation of keel bone is what goes to make capacity in the egg sack. The undesirable type of keel is one which tends to turn decidedly upward toward the vent, and birds having such keels are often described as being canoe keeled.

In order to determine the capacity of the egg sack the hand can be placed at the rear of the bird, as shown in Fig. 22. The lower finger can readily find the position of the end of the keel, and the first finger the position of the pubic bones. These pubics are two thin bones projecting out one on each side of the vent and just above it. The measure of the distance from these bones to the end of the keel is called the capacity and is spoken of in terms of the number of fingers one is able to insert.

Fig. 22. Good capacity—239 eggs.

Fig. 23. Poor capacity—67 eggs.

Fig. 23 shows a poor producer with a canoe keel and only a two finger capacity. Compare this with the hen shown in Fig. 22 having more than a four finger capacity, and note the relation of this capacity to the production of the birds.

The capacity of a hen is not always the same. If the ovary is dormant and no eggs are being manufactured the capacity will be rather small. However, as soon as ovulation commences the distance between the pubic bones and the keel begins to increase and in full ovulation, or at a hen's highest production, the capacity of the bird will be the greatest.

Any one who has dressed hens will have noticed a large accumulation of fat in the abdomen of some birds. This accumulation can be determined while the hen is living by handling the flesh in the egg sack. The fat, if present, will be hard and firm. This is a sign that ovulation has ceased and that the hen is now using her feed supply to lay up body fat instead of for the production of eggs. If a hen has accumulated a quantity of hard fat in the abdomen it is an almost certain indication that her laying days are about over. It is about time that her stay in the flock is terminated and that she should be sent to market.

Handling Qualities. This term refers chiefly to the quality of the skin in the egg sack. As noted above, there should be no hard fat. The skin should be soft, pliable and elastic to the touch. It should not have a tough, hard, nor leathery feel. This quality of the skin is closely related to the quality of the skin about the face of the bird. The coarse texture can be readily noticed in the face and is found to carry throughout. It is a sure sign of a lack of quality.

Shanks and Toes. Quality in some shanks is indicated in much the same way as in good horses. The legs should be flat, but the bone not too fine. Often in poor type birds the legs are more angular or inclined to be round and hard. The scales on the shanks should be medium in size, fine in texture, and should overlap each other smoothly. Coarse quality birds have coarse scales, not overlapping each other so smoothly. The toe nails carry the index to the amount of scratching the hen is doing. A good layer is always a good worker and her toe nails will be well worn down from scratching. This will vary with the kind of pen the hen is in. A concrete floor will wear the toe nails much faster than will a wood or earth floor. This feature, therefore, must be compared with other birds housed under similar conditions.

The colour changes in the shanks are important and will be described later.

Condition. A hen will not lay if in poor condition. She should be healthy, free from any disease, and should show plenty of vigour and activity. The first pullet to lay in the Fall is the early maturing one. The hen that is a slow grower is slow in feathering out, and is also a slow layer. The condition of moult is important. Shortly after a hen commences to moult she uses a part of her feed to manufacture feathers, and her egg production is lowered, or in many cases ceases entirely. Some hens moult much earlier than others. If a hen commences to moult in July her laying for the summer is about over. It may safely be said that late moulting and heavy egg production are correlated because it gives the hen a longer period of continuous production. Such hens usually moult quickly and are again back in full feather in time for winter production. It is a peculiar fact that those birds commencing their moult early in the Summer usually moult slowly and are often late in returning to laying condition in the Fall. The late but rapid moulters frequently commence laying just as soon or sooner.

Plumage. If a hen is laying heavily the plumage will become dry, hard and brittle. The lustre will disappear and the feathers become broken. The hen certainly loses much of her natural beauty but she cannot retain that bright lustre and also keep up heavy production. Watch for the hen with a full array of feathers all in good form and see if she is not one of the boarders in the flock.

When is a hen laying? The question is often asked, "Can you tell whether or not a hen is laying"? This is very easily done and requires but a few observations. When a hen commences laying the conditions set up in the reproductive organs are very similar to the conditions in any pregnant animal. Preparation is made for laying much as for parturition in a cow.

When the ovary is dormant and no eggs are being produced the distance between the pubic bones is very small. The vent is dry, small, puckered, and in yellow fleshed birds has a band of yellow pigment around the inner border. When laying commences the pubic bones become pliable and spread apart. The distance may increase from one to three fingers' width in a short time. The vent becomes large and moist and after two or three eggs have been laid the ring of yellow pigment has disappeared and the vent is bleached.

Further Colour Changes. There is an interesting study in pigment changes. This refers only to yellow pigmented birds and cannot be determined in white skinned birds such as Orpingtons.

As mentioned above, the first change in pigmentation is in the yellow ring just around the vent. Two or three eggs will remove this colour. The colour then leaves the eye ring, the skin just around the edge of the eye-lid. It usually requires about six eggs, or from ten days to two weeks of production, to remove the yellow colour from this part. At about the same time the colour starts to leave the beak, commencing at the rear of the bill, and gradually fades. There is quite a distinct line of demarcation between the yellow area and the white. As laying proceeds the white area increases, gradually fading the yellow out towards the tip of the beak. When the colour is entirely gone the hen will have laid about thirty eggs, which requires about six weeks' time. The shanks are the next part affected. After the colour has left the beak it commences to leave the front of the shank, the white area here also appearing and the yellow receding down the front of the shanks and from the foot up the back of the shanks, the last trace of yellow being on the back of the hock. It requires about one hundred and fifty eggs, or from five to six months of persistent production to entirely remove the colour from the shanks. There is a difference in the rate at which this colour will disappear. Feeding plenty of green feed tends to produce yellow colour and to prevent its disappearance. Birds closely confined during the Winter show the colour changes more plainly, and with less production, than do birds in Summer on range where they are receiving an abundance of green feed. Small sized birds for the breed, and those lacking somewhat in vitality, lose the yellow pigment more rapidly than do larger and more vigorous birds.

When the hen ceases laying the colour immediately commences to reappear. This change can be readily studied in a hen which has gone broody and is raising chicks. The colour first returns to the vent, then to the eye ring; a yellow area now proceeds down the beak in the same manner as the white area did previously, and this is followed by similar changes in the shanks. Any hen showing extensive pigmentation during the Spring or early Summer suggests either poor production or a prolonged rest period and such a bird should be viewed with suspicion. Short rest periods such as broody periods, often result in a band of yellow showing in the beak, preceded and followed by a band of white. This indicates that during the

A

B

Fig. 24. Wing moult.

A—First primary moulted and in, second primary moulted and partly grown.
B—A pair moulted at same time, one broody period.
C—A duplicate of "A".

time required for the broodiness to be broken up, the bird replaced some yellow pigment, which again was followed by bleaching when laying commenced.

Broodiness has become, for the most part, undesirable as the majority of chickens are now hatched and reared artificially. Since a hen loses from ten to fourteen days each time she is broody, the habit, if present, will soon limit her egg record, especially if she is broody more than twice in a season.

When a hen is broody during the Summer she usually moults one of the primary feathers in each of her wings. This moult commences next to the small axillary feathers at the division of the wing. Fig. 24 shows wings outspread. The flight feathers are divided into two sections, the primary and the secondary. On her first broody period the hen may moult No. 1 and a new feather will grow in. On each succeeding period of broodiness another feather may be moulted and a new one will take its place. In the illustration the hens have had rest periods, as shown by the new feathers. The complete section of primaries contains nine or ten feathers, so by counting these and taking note of any new feathers growing in, the number of rests a hen has taken can be fairly accurately determined. A hen showing a tendency to spend much of her time in brooding can well be removed from the flock, as her production will not be high.

Disposition of the Laying Hen. There is as much difference in the temperament of individual hens as there is difference in the individuality of members of the human race. Almost invariably the heavy layer is quite docile and does not object to handling. She will rest quietly and contentedly in one's hands while being handled. The cull has a disposition quite in keeping with her head type. She is wild and noisy, the quiet behaviour of the good hen being replaced by squawking on the part of the cull. These same differences can be noticed in the actions of the birds in their pens. The heavy layer is always going about busy but contented. She is among the first off the roost in the morning and is late in going to rest at night. She picks few quarrels, has no desire to join a labour union or to demand a six hour day. Her work commences at daybreak, continues usually until sundown, and she spends few daylight hours on the roost with her less ambitious neighbors.

The Time to Cull Hens. There is some difference of opinion as to the proper time to cull flocks. Culls are a liability and should be put on the market early enough to bring as good a price as possible. It is recommended that the culling be done during the latter part of May or early in June. At this time of the year the heavy Spring production is over and the poorer members of the flock will soon be ceasing to lay. The meat price of hens is still good. Later on, during late July and in August the early moulters should be noted, removed and disposed of. It is, however, not necessary nor desirable to allow poor birds to remain in the flock until Spring or Summer.

The most intelligent culling programme is the one which calls for the removal of undesirable birds at any time of the year. The careful poultryman will keep a close watch at all times for outstanding boarders and immediately dispose of such. The birds may be marketed or consumed at home. It must be borne in mind that every unproductive bird may offset the profit of a productive one, with the result that neither returns a profit to the owner.

Marking the Culls. Where one general culling a year is done the hens can easily be graded into three classes. The good performers can be banded and left in the pen and the real culls crated and sold. There are, however, a number of hens which are still laying though of poor type and which will not be desirable birds to hold over. These can be temporarily marked, kept until they have ceased laying, and then sold. A good method of marking these birds is to cut off their tails. This makes them easily identified when it is desirable to dispose of them.

The following chart, developed by the Poultry Department of the Kansas Agricultural College, Manhattan, Kansas, summarizes the points taken into consideration in the instructions for culling chickens.

JUDGING FOR PRESENT PRODUCTION

CHARACTER	LAYING HEN	NON-LAYING HEN
Vent	Large, dilated, oblong, moist.	Small, contracted, round, dry.
Pubic bones	Flexible, and wide apart.	Rigid, close together.
Comb	Large, red, full glossy.	Small, pale, scaly.
Wattles and lobes	Prominent, soft, smooth.	Inconspicuous, rough, and dry.

JUDGING PAST PRODUCTION

CHARACTER	LONG-LAYING PERIOD	SHORT-LAYING PERIOD
Vent	Bluish white.	Flesh colored.
Eyelids	Thin and edges white.	Thick, yellow tinted.
Eye	Prominent, keen, sparkling.	Listless, sunken.
Earlobes	Enamel white.	Yellow tinted.
Beak	Pearly white.	Yellow tinted.
Face	Clean cut, sunken.	Full, well fleshed, yellowish.
Shanks	White, flat, thin, creased.	Yellow, round smooth.
Plumage	Worn, soiled, lifeless, close feathered.	Signs of moulting, loose feathered.

JUDGING RATE OF PRODUCTION

CHARACTER	HIGH RATE	LOW RATE
Keel	Slopes downward.	Slopes upward.
Pubic bones	Tips thin, point straight out.	Tips thick, curved in
Capacity	Four to five fingers.	Two fingers.
Abdomen	Soft, pliable, dilated.	Fatty, hard, contracted.
Rump	Broad, width carried back.	Narrow, cramped.
Lateral processes	Prominent, pointed outward.	Hard to find, pointed inward.
Skin	Soft, thin, loose, silky.	Thick, dry, underlaid with fat.

POULTRY HOUSING

The proper housing of poultry is an essential factor of success. This does not necessarily mean heavy expenditures or elaborate structures. In fact, it is usually found that the cheaper and simpler houses are the more efficient. The type of building is apparently not so important, as one may find a wide divergency of type giving equal efficiency and economy of operation. It is, therefore, not proposed to lay down any hard and fast rule relative to the type of building, but rather to discuss some of the fundamental principles underlying successful housing.

In order that one may get a true perspective of the whole question it is first necessary to give some thought to the question of location, and to the primary essentials in housing. There are two general classes of poultry houses; those used for laying and breeding purposes and those used for rearing. The former are usually on permanent foundations while the latter are mostly portable. The variation is mainly one of size or type. In order to avoid the possibility of confusion in the mind of the reader the laying or permanent house will be discussed first.

Location of Laying or Breeding Houses

Convenience. Locate houses near the source of supplies. Whether the number of birds to be kept is large or small there will be a considerable amount of feed to transport, hence the nearer to the source of supplies, with due consideration to other equally important factors, the greater will be the saving in time and labour.

Exposure. The house should be built facing the south or southeast if possible, as such an exposure will give the maximum amount of sunlight in the pens. There is also greater protection from the prevailing winds, which are usually from the north or northwest. Full advantage should be taken of any shelter (either natural or artificial) from the prevailing winds, as the birds do not take kindly to an exposed location. Bird comfort is closely associated with economic production, and any condition which will make the bird more comfortable should receive full consideration.

Soil. The type of soil and the lay of the land are influencing factors in drainage. The ideal soil is one which is slightly rolling and open in texture, so that the surface water drains off readily after rains or melting snow. Heavy soils at best drain off water drains off readily after rains or melting snow. Heavy soils at best drain poorly and hence are unsatisfactory. A damp soil harbors disease.

Drainage. Drainage about the poultry house and yards is of extreme importance. Poorly drained yards aggravate trouble from dampness in the houses and yards. There is also a manifestly increased amount of trouble from diseases and intestinal parasitic infestation under such conditions.

Shade. Extremes of temperature lessen production and should be modified in so far as practicable. Dense summer shade, however, as from the heavy foliage of trees, shrubs or bushes, is not desirable. Such locations do not benefit from the germicidal action of direct sunlight and hence may serve as sources of infection of disease and parasites.

The Primary Essential in Housing

The main essential in housing is bird comfort. The major factors in providing this condition are, (1) Dryness. (2) Ventilation. (3) Freedom from Draughts. (4) Light. (5) Floor space. One must, of course, bear in mind that *cost* in relation to providing these factors is important.

Dryness. There are three sources of dampness in the poultry house. A large amount of moisture is exhaled from the lungs of the birds. Moisture sometimes enters the house through a badly constructed floor. Considerable water is also spilled by the birds while drinking. It matters not from what source the moisture comes, if allowed to accumulate in the pen it will gradually lower the vitality of the stock, decreasing production and possibly causing disease. The trouble is usually more marked in the Fall and Winter than during other seasons of the year. Where moisture is not entering the house through the floor or from drip about the drinking dish, the trouble will be found associated with lack of ventilation.

Ventilation. It is necessary to ventilate in order to secure dryness, pure air and a proper temperature. Bad ventilation is indicated by frost on the walls or the ceiling and by a foul atmosphere. A greater amount of moisture pound for pound live weight is exhaled from the lungs of birds than from any other class of stock. The ventilating system must remove this moisture from the pen, provide fresh air and do so without producing draughts in the house. Cotton curtains, window shutters and open-front houses are now most generally used, with the cotton curtain either in conjunction with or without the straw loft proving most popular. Curtains must be adjusted from time to time to meet varying weather conditions, and, unless

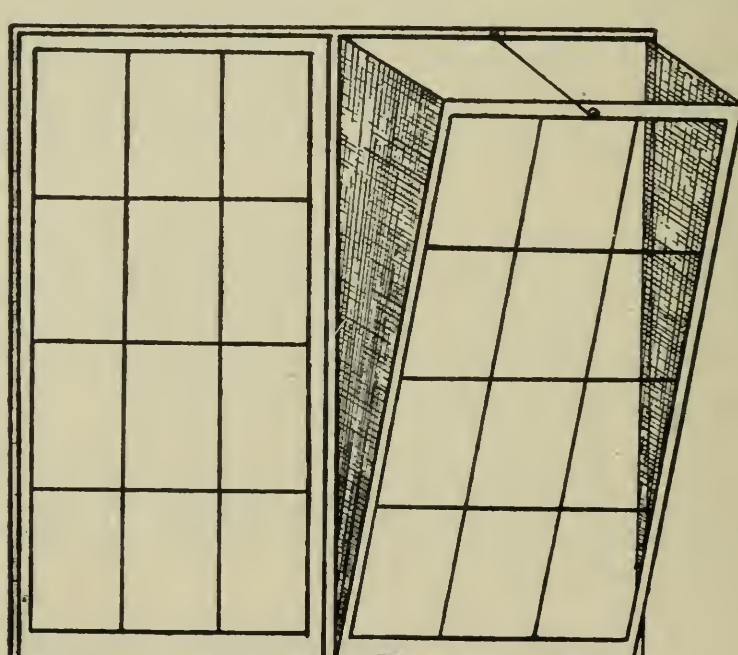


Fig. 25. Window arranged for ventilation purposes

one is prepared to do this, better results will no doubt be secured from the use of the open-front house.

In Figure 25 is shown a cut of a window adjusted for ventilation purposes. The window is six inches from the ceiling and eighteen inches from the floor. It is hinged at the bottom, and the opening at the top is adjusted with a cord. Cotton or boards may be placed along the sides of the open window. This device does not interfere with the light, is not attended with floor draughts, and gives good ventilation. It is suitable for the alteration of some house now in use but which is not at present giving satisfactory ventilation. The alteration can be made at a very small cost, and may be preferred by some to curtains.

Draughts. There is perhaps no condition in the poultry house that is responsible for more trouble and mortality than draughts. This is particularly true if the birds are in a draught while on the roost. Draughts chill the birds, making them uncomfortable, and, therefore, unproductive. They are also a contributing factor in the production of such diseases as colds, roup, rheumatism and kindred ailments in the flock, which may result in heavy mortality. In constructing the house every effort should be made to eliminate draughts. The sides and back of the house should be absolutely tight, and with ventilation from an open front, or curtains, little difficulty will be experienced.

Light. Sunlight is the best germicidal agent in existence. It is, therefore, advisable to make provision for the admission of as much direct sunlight into the pen as possible. This is especially important in the winter, and openings should be so placed in the front of the house that they will admit a maximum of sunlight. One-quarter to one-third of the front of the house should be glass.

The value of direct sunlight in the hen house is now becoming more and more appreciated both from the standpoint of its effect upon the general health of the birds, and also because of its effect upon the hatchability of the eggs. This action of direct sunshine is due to the ultra violet rays, but which are filtered out as the sunshine passes through ordinary window glass. Glass substitutes have been developed, many of which will admit a considerable amount of the ultra violet rays. Their economic value from a durability standpoint has yet to be demonstrated.

Floor Space. Overcrowding is a common fault. The practice reacts adversely upon every phase of production and predisposes to disease. The floor space requirement determines the capacity of a pen or building and it is, therefore, necessary to carefully determine the capacity of the pen and then regulate its population accordingly. Floor space requirement will vary with the size of the pen, the type of building and the breed of birds. In small pens the floor space allowance is greatest being possibly as high as six square feet per bird. Increasing the size of the pen permits a reduction in the per bird floor space requirement with a minimum in even the largest pens of three square feet. The more open the building and the smaller the breed of fowl the greater is the capacity of a given house or pen.

The per bird cost of construction is important. This should be kept as low as possible, consistent with the adequate provision of the essentials. It is often possible to remodel old buildings much more cheaply than to build new ones and still provide efficient accommodation.

Laying or Breeding Houses

Types of Houses. There are two main types of laying houses in general use, i. e., the long or continuous house divided into two or more pens, and the single pen house. Two story and multiple deck houses are also being used by some poultrymen. There are many points in favour of each of these types as well as numerous objections to each. The long house is no doubt more economical to construct than the single pen house and requires less labour to operate. If separate matings are necessary, yards are required, which means added expense and close confinement for the birds. This latter point is important where the birds are used for breeding purposes. The single pen house, while costing more than the continuous type, permits of spreading the birds over a larger area, making it possible to dispense with yards and less trouble is likely to be experienced with disease and loss of vigour in the flock. The greatest objection to this latter method of housing is the extra labour required to care for the stock.

Floors. The chief essentials of a good floor are durability, dryness and ease of cleaning. Cement floors are most satisfactory, and are easily kept clean. The first cost is possibly high, but their durability commends them to general use. Earth floors are more in favour than wood and cost less. The two greatest objections to

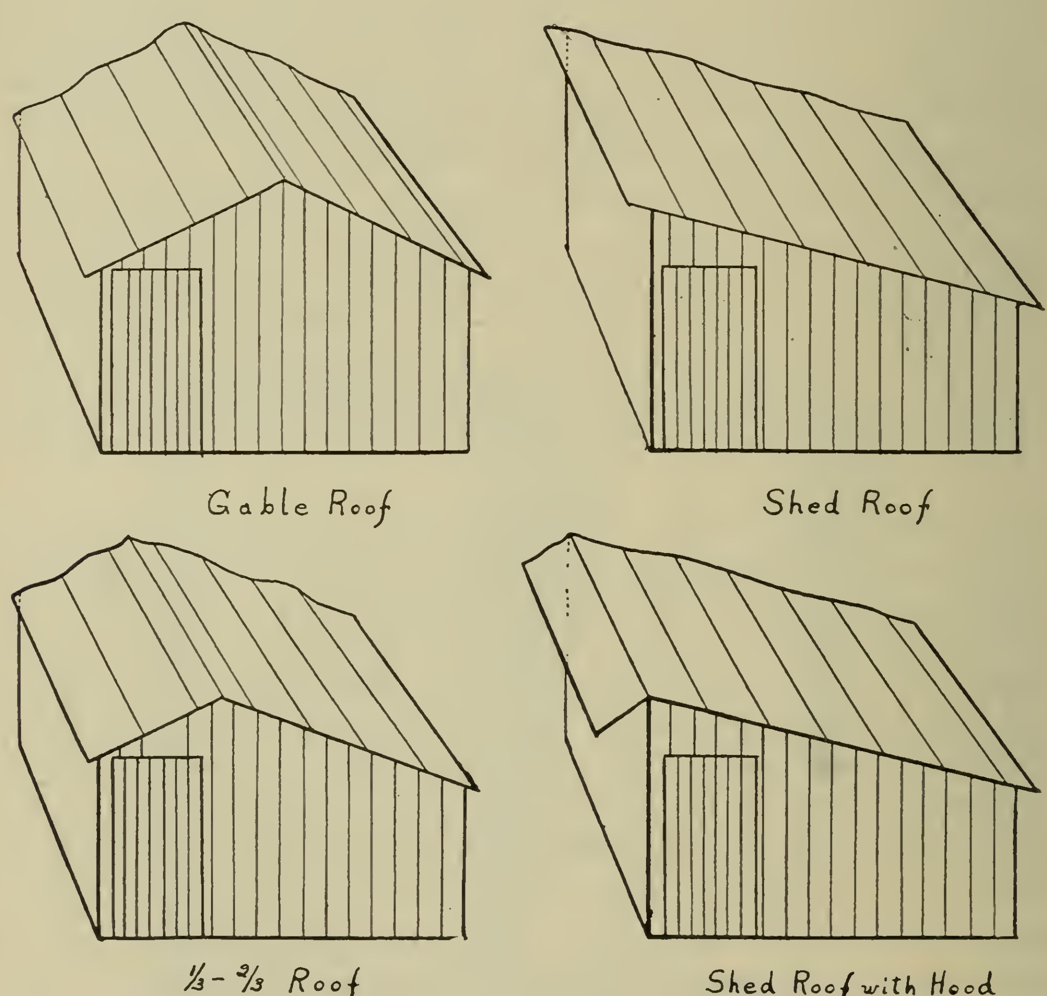


Fig. 26. Roof types.

an earth floor are the excessive amount of dust in the pen and greater trouble with disease control.

Cement floors for best results should be raised so that the surface of the floor is at least eight inches above the highest elevation of the ground. The intervening space is filled with cobble stones or coal cinders well tamped. A three inch cement floor will be found strong enough for the hen house; two and one-quarter inches of filling and three-quarters of an inch of finish.

Types of Roofs. There are three principal types of roof construction commonly used in Ontario. These are shown in Fig. 26. It is true that there are other types used, but the three mentioned are the best suited to Ontario winter conditions. There is some slight difference in the cost of the types shown. The shed or shanty type is no doubt the cheapest to construct. It does not permit of the use of a straw loft which is so important in assisting in the control of moisture in the house during the winter, and in keeping the house cool in the summer. The gable roof is best adapted to the use of a straw loft and, besides, presents a more attractive appearance, blending in better with the general type of buildings on the farm. Perhaps the greatest objection to the shed roof is the extreme heat of the building in the summer, the temperature at times registering as high as 110° F. This may be overcome to some extent by using a hood on the front. This will, of course, increase the cost of the building to practically the same point as that of the gable roof.

The two story house allows the same roof and foundation to give double the housing capacity of a single story building, without additional cost. It also is a more compact structure and the labour requirement is reduced. Two by six inch studs are required for strength and a gable roof covered with a good grade of asphalt or wood shingles is desirable. The second story should be just high enough for comfortable head room, while the window and dropping board arrangements for both upper and lower floors should be similar to those used in the long house. There are a number of farms on which an unused loft or mow can be easily remodelled into a satisfactory fowl pen. In some two story houses it is difficult to secure satisfactory ventilation. It is usually necessary that the birds on the upper floor remain confined throughout the year.

As already stated, the poultry house must be comfortable. Hens cannot be subjected to crowding or draughts, nor to violent changes in temperature and humidity in their pens, without injury to their health. Such injury may show itself either in decreased production or in sickness and even in death. Climatic conditions vary greatly and often the changes are very sudden. The weather may be bright and sunny or there may be prolonged periods of high humidity and rain. It may be calm or there may be strong winds. Conditions within the house change with the weather. No ventilation system yet devised can entirely control such variations though many have been tried. Most systems in general use need considerable adjustment. Much depends on the attendant.

The flow of air through the poultry house depends largely on the velocity of the wind and upon the difference in temperature between the interior of the house and the outside air. If, during cold weather, the house is closed up to conserve the heat given off by the birds, the interior becomes damp and frosty. If, on the other hand, the ventilators are left open the warmer air within the house rises, flows out, and is replaced by cold air. This results in a house that is too cold for comfort. More feed is therefore used to keep the hens warm and less is left for egg production. In order to secure good results it is desirable then to have the flow of air nicely adjusted. During warm weather the reverse condition is present. The house becomes too warm. It is then necessary to facilitate the rapid interchange of air in order to keep the interior cool. Few, if any, ventilation systems have enough capacity to meet this requirement. It is advisable to have the windows and screens so fastened that they may be opened at such times to assist ventilation. Hence again the attendant must use good judgment. No fool-proof house has at yet been devised. A type of building that gives satisfactory results in one location may be entirely unsatisfactory when built somewhere else. This is a fact that many people fail to recognize.

Many attempts have been made to secure a more even temperature in poultry houses throughout the year. Double walls used either with or without sawdust or planer shavings between them, although satisfactory in some ways, make good shelter for rats. A double layer of boards on the walls with tar or building paper between the layers is of some help. Many houses have walls made of a single thickness of siding covered on the outside with shingles or roofing paper. All of these are more or less satisfactory. Probably the best insulating material now available is, however, made of wood or cane fibre pressed into sheets. This material has very high insulating value and is easily applied. It is sometimes necessary to protect such material near the floor and around the roosts by applying coatings of tar or other protective substances to prevent the hens from eating the wall board. Gyproc or similar mineral boards are also used though not of as high insulating value as those made of wood fibre. It is important that the ceiling of the house be insulated as well as the walls. Regulated openings in the ceiling will allow the desired amount of air movement up through the ventilators.

Some poultrymen are heating their poultry houses during cold weather. This may be done in any one of three or four ways. A brooder stove may be enclosed in a metal box, provided with openings near the top to allow the heated air to flow away freely, and having other openings near the bottom for the cold air to come in. Such an arrangement heats the entire house. Such heating is comparatively inexpensive and can be used fairly satisfactorily during extremely cold weather. Other poultrymen use a hot air system with a graduated heating pipe located at the back of the house below the roosts. In order to secure even heating throughout the house, the pipe must be greater in circumference near the heater than at the far end. Hot water heaters with outflow and return pipes located under the roosts and against the back of the house are used in some poultry houses. Still another system of heating calls for hot water pipes laid at 30 inch intervals in the cement floor. The heater is located in a pit at one end of the house and the floors must have a slope of one inch in every ten feet with the high point at the opposite end from the heater. If the pipes are laid level a small electric pump must be installed to give circulation of the water. Such a system heats the house and at the same time keeps the floor dry. A satisfactory, controlled system of ventilation is necessary with any method of heating and the house should be insulated to prevent excessive heat loss. It is *important* to use only enough heat to prevent water from freezing. The supplying of a higher temperature than 45° F. usually results in disastrous moults with accompanying slumps in egg production.

It must be borne in mind that the cost of heating frequently offsets the value of the feed saved and any increased egg production secured. Unless well ventilated, colds and other respiratory diseases are rather common in heated houses and this may increase mortality. It would seem that a heated, insulated house, that is dry and well ventilated, and that will be comfortable, and will maintain a fairly close to optimum temperature throughout the year, is now more or less of a possibility.

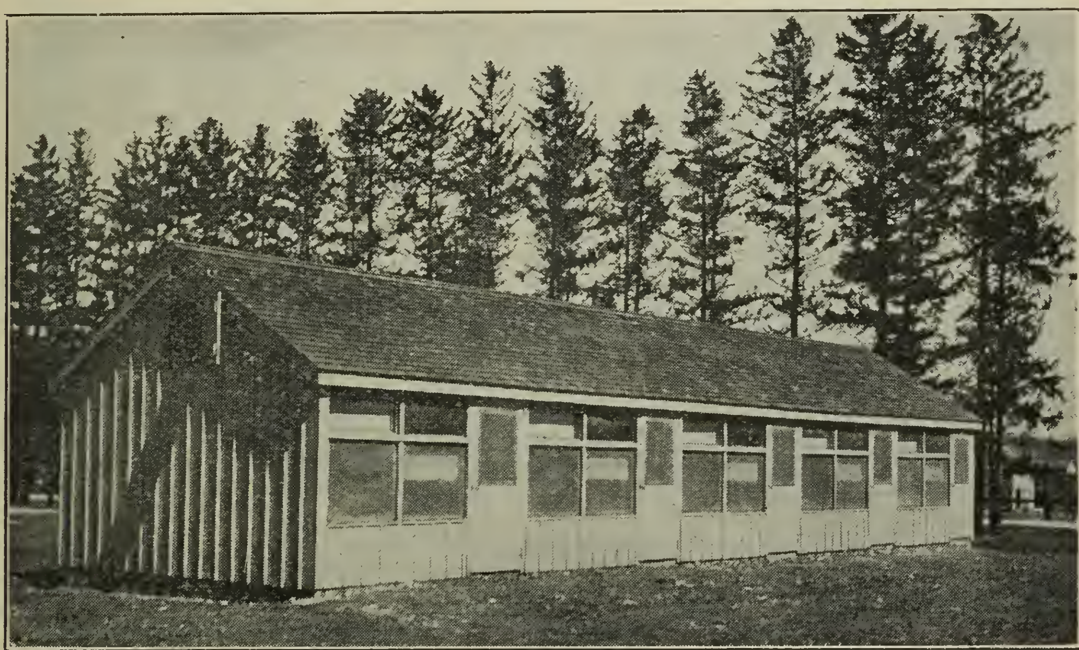


Fig. 27. Poultry Breeding House 12'x60' with glass substitute windows and cotton ceiling loft.

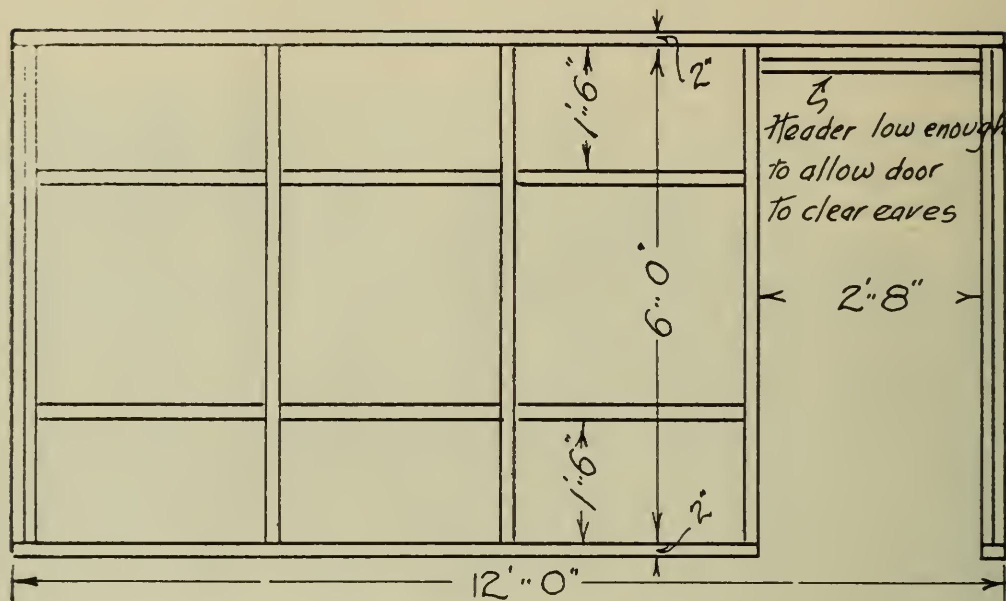
It is, however, questionable whether the average poultryman can secure a sufficiently increased return from birds so housed to warrant the cost involved. While it may or may not pay him to heat the house, it will usually be worth while insulating the walls and ceiling to conserve the birds' body heat in so far as this is compatible with good ventilation.

Plans and Specifications of College Houses

Because of increased interest in poultry housing throughout the country, we are presenting a type of house which lends itself to a variety of measurements, with the object of standardizing house construction. The plans as submitted show two houses, one twelve feet in depth from front to back, and with twelve-foot pens; while the other is twenty feet in depth from front to back, and has twenty foot pens. Either of these houses can be built with any number of pens desired, but maintaining the arrangement and type of construction as shown for the one pen.

The plan of construction of the fronts of these houses is practically identical. The lower section of the front is boarded. Above this is a row of windows extending across the entire front. These are fitted with glass or with glass substitutes. In

FRAMING DETAIL for FRONT.



DETAILED CONSTRUCTION of FRONT.

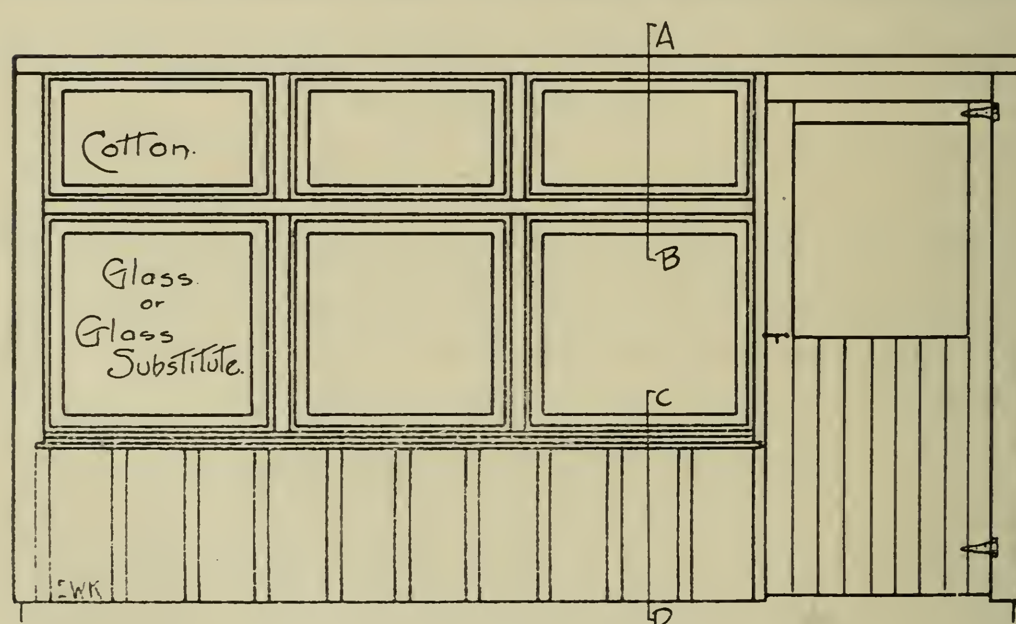


Fig. 28. Plan of house twelve feet in depth which may be fitted with either straw or cotton loft. It may be built one pen or several pens in lengh as desired.

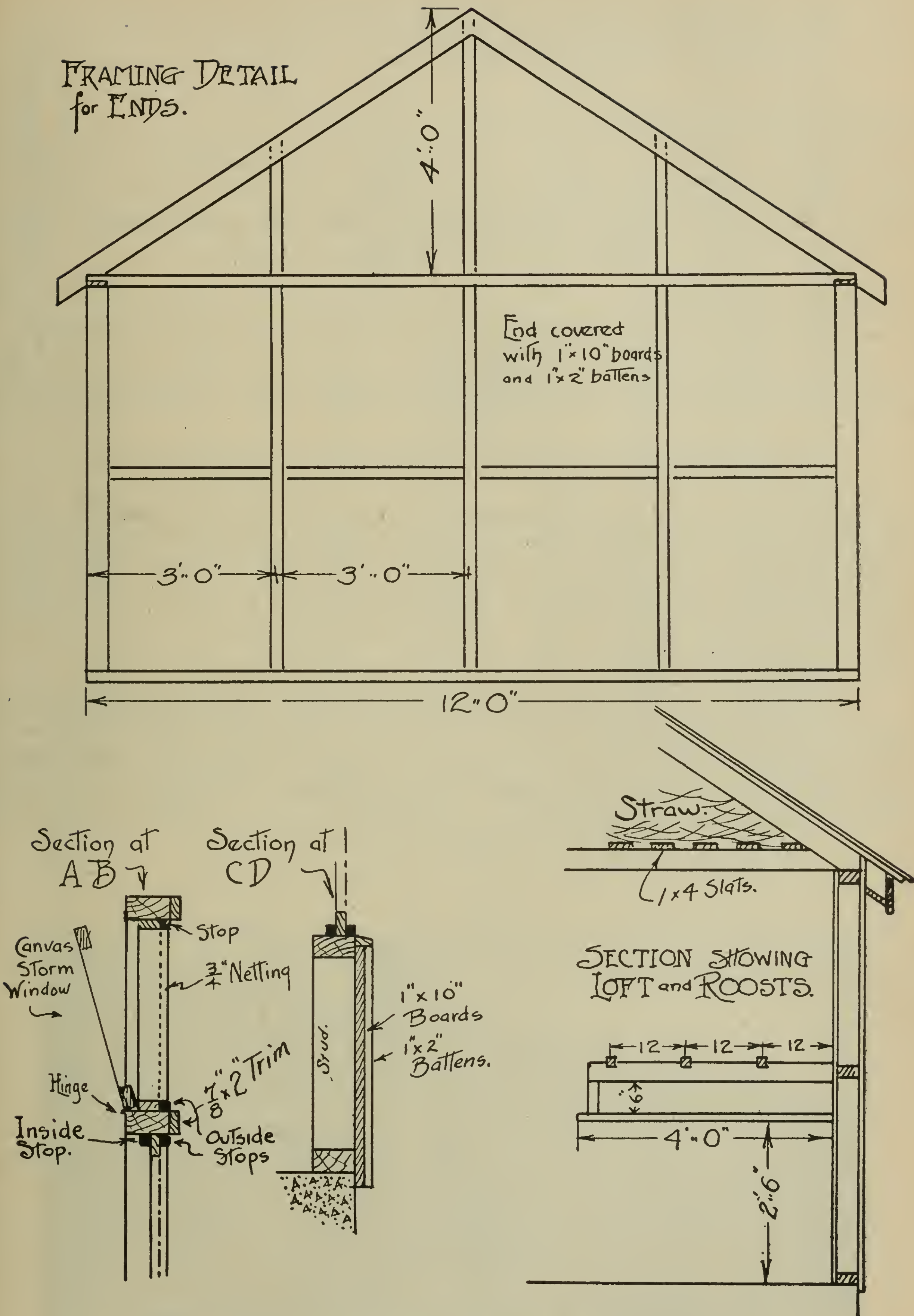


Fig. 29. Framing detail of house shown in Fig. 27.

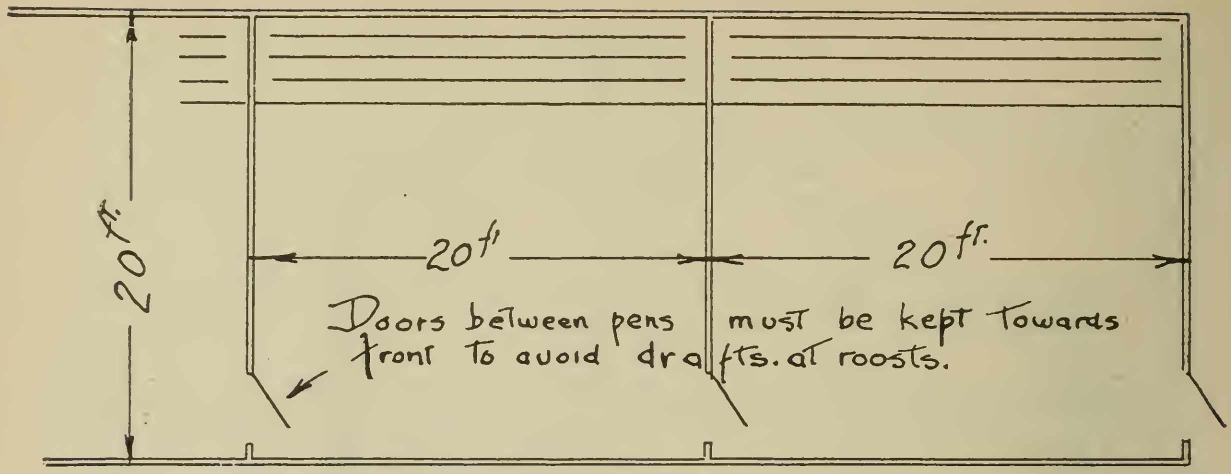


Fig. 30. Showing floor plan arrangement for pens twenty feet square. And the location of partition doors. This idea may be adopted either in Figures 34 or 36.

the case of the latter no sash is is required, as the substitute is attached to a frame as would be done with cotton. Above the glass windows is a row of cotton curtains which are hinged at the bottom, tipping inwards at the top. The plans show doors entering the pens from the front, or a door may be placed at one end of the house, with partition doors in line, which would permit passing from one pen to the next without going out of doors.

Two kinds of ceiling construction are used and these are interchangeable. The straw loft has been extensively used in the past and with good results. It assists in the ventilation of the pen, and thus reduces trouble from dampness. Some people object to the straw as being dirty and a harbouring place for vermin. Such trouble seldom becomes serious, but in order to meet this objection a ceiling of cotton has

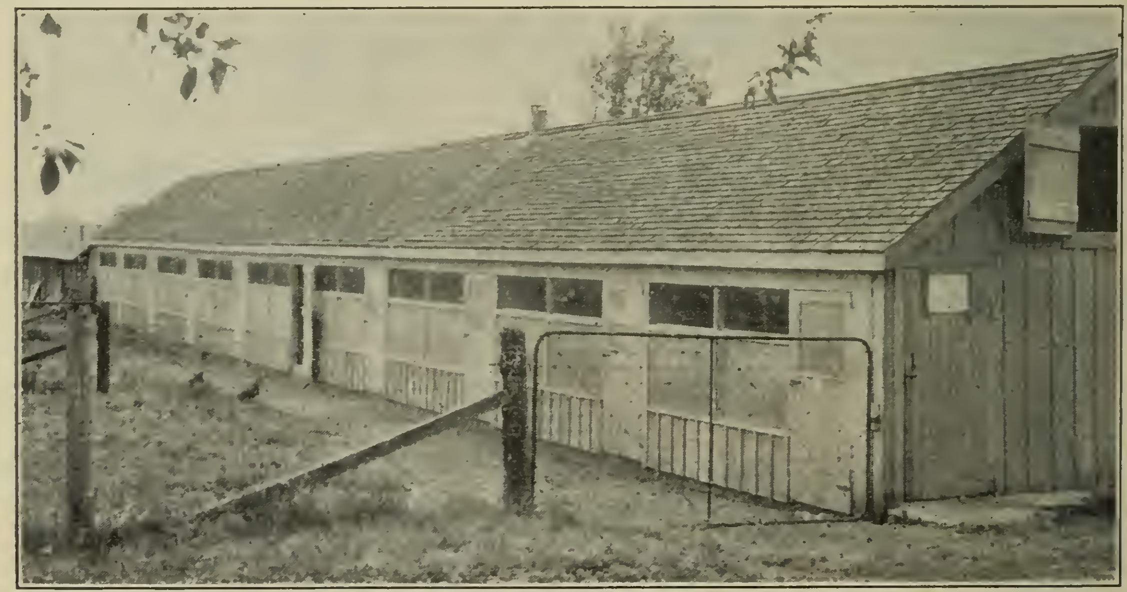


Fig. 31. Laying and breeding house of the long continuous type showing arrangement of cotton curtains above glass windows.

been tried out with very satisfactory results. The cotton is stretched on frames covering the ceiling and while the first cost is slightly higher than that of the straw loft, the cotton ceiling is white which gives a brighter, more pleasant appearance to the pen.

The roof of both houses is of the gable type. This allows for more effective use of the loft idea, which results in a warmer house in winter and a cooler house in summer, than where no loft is used.

The capacity of the pens presented is important. While the floor space of the smaller pen is over one-third that of the larger, the housing capacity of the smaller

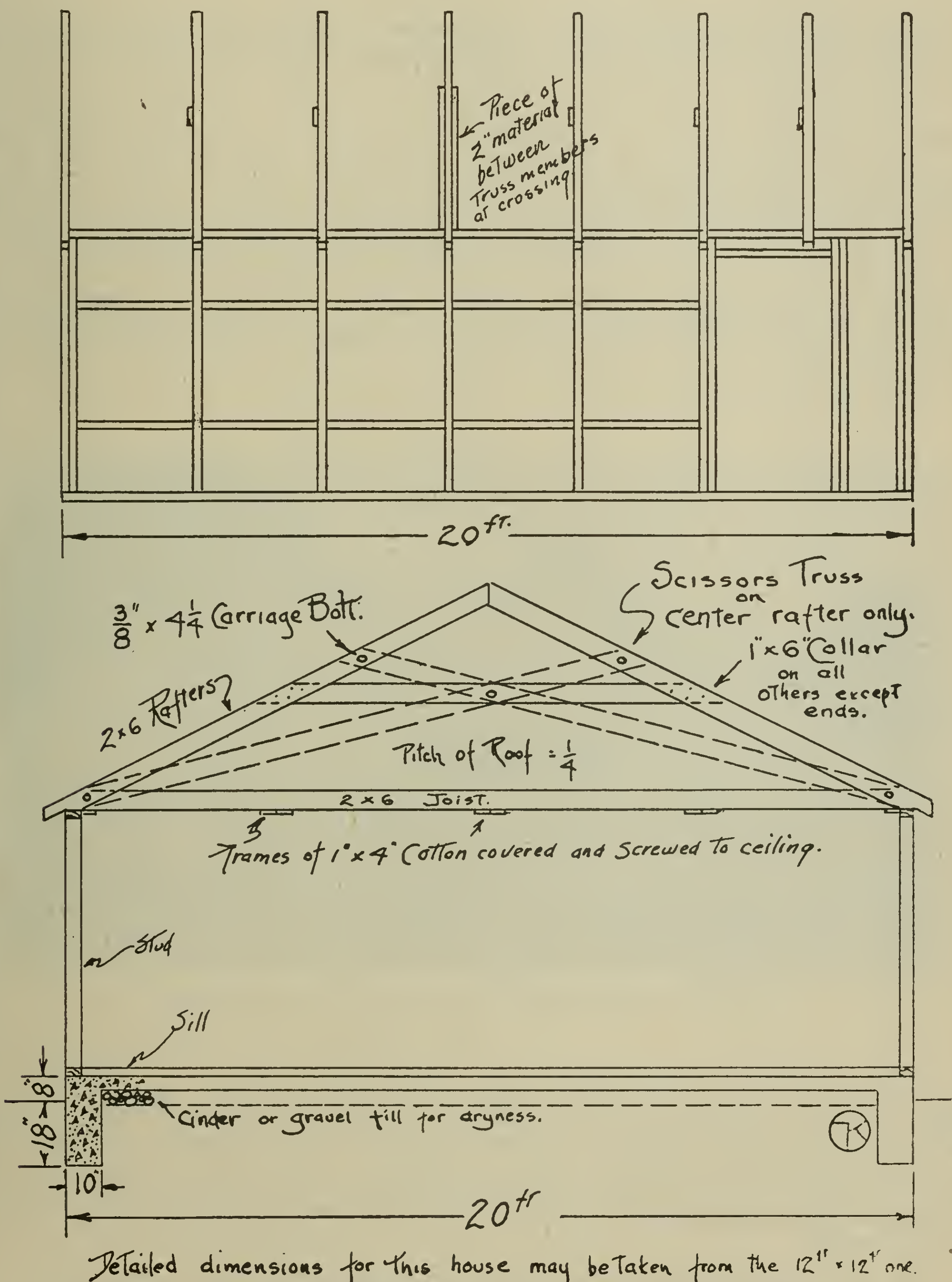


Fig. 32. Plan showing framing construction for a house twenty feet in depth and twenty-foot pen, using the same type of construction for the front as in Figures 28 and 29. House is built with gable roof and for either straw or cotton loft.

pen is actually one-quarter that of the larger. The smaller pen will accommodate twenty-five birds while the 20x20 pen will readily accommodate one hundred.

In the operation of these houses, as is the case in any house fitted with adjustable curtains or screens, it requires the constant attention of the operator to secure satisfactory results under all weather conditions. In dull, heavy, humid weather, the adjustment of the curtains would be somewhat different from that which would be most satisfactory in bright, clear, cold weather, or on rough, stormy, days.

Open Front House

The question naturally arises: Can a house be constructed that is nearly self-operating, and which will keep the birds in health, and at the same time assure a fair egg production.

Our experience has been that birds thrive best in low roofed buildings, especially so during the winter. We have two houses with the fronts entirely removed except a two-foot wire netting which keeps the birds in, and the sparrows, etc., out. Such houses, for this climate, must be built low, especially in front, to keep out the snow and the wind. It is the writers' opinion that Fig. 33 will meet the needs of the average farmer where he wishes to keep from seventy-five to one hundred hens. While such a building may seem too cold, hens housed in it

Fig. 33. Open front house of the 20′ x 20′ type.

usually do well, but they could possibly be made to lay more eggs during the months of January and February, if the house were constructed with cotton screens properly adjusted to meet the weather conditions. Few farmers, however, would be there at the exact time to do the adjusting, hence we use it entirely open, or one-half closed.

The large windows in the west, essential for light, should be hinged at the top so that it can be opened during the summer months, otherwise the house may become too warm.

BILL OF MATERIAL FOR OPEN FRONT 20′ x 20′ HOUSE

	Number of Pieces	Size	Length
Sill	4	4″ x 4″	20′
Plates	2	4″ x 4″	20′
Posts:			
Back	4	4″ x 4″	3′ 10″
Front	4	4″ x 4″	2′ 8″

Cut and erect the above.

Ends:			
Rafters	4	2″ x 6″	12′
Studs	2	2″ x 4″	16′
Studs	2	2″ x 4″	12′
Girts	2	2″ x 4″	12′
Ridge Board	1	2″ x 6″	20′

Cut and erect the above.

Siding .... 400 board feet 1″ x 10″ S. 4 S.
Battens .... 250 lineal feet of 1″ x 2″ S. 4 S.

Put on siding but leave battens until roofing is on.

Rafters .... 18 2″ x 6″ 12′
Roof Sheathing........ 560 board feet of 1″ x 8″ S. 4 S.
Or better 625 board feet of 1″ x 6″ Shiplay
Roll Roofing .... 5 rolls, 3-ply best.
Do not put on until after trim.

Trim:			
Ends	4	1″ x 6″	12′
	4	1″ x 3½″	12′
	4	1″ x 2″	12′
Front	1	1″ x 10″	14′
	1	1″ x 10″	8′
	1	1″ x 6″	12′
	1	1″ x 6″	8′
	2	1″ x 6″	12′
	2	1″ x 6″	10′
Back	1	1″ x 6″	12′
	1	1″ x 6″	8′
	2	1″ x 6″	12′
	2	1″ x 6″	10′

Chicken netting .... ¾″ mesh for front, 3′ x 20′ piece.
Door .... 25 board feet of 3½″ Pine V joint.

It will be noticed that no dropping-boards are used in this building. During the winter the droppings freeze almost as soon as voided, hence they produce no odour or bad results, and if the house is cleaned every month it will answer very well. We would rather have this condition than dropping-boards covered one foot deep with droppings, as is frequently seen.

A number of houses of this style are in operation in various parts of the province, and they are giving fair results. In some of the colder sections, such as in the district north of Barrie, the house appears to be too open for severe winter weather. In such cases we would suggest using movable cotton screens on two sections of the front. The illustration shows three sections, one of which would be open except in extreme conditions of cold or wind.

In some cases open front houses have been built twelve or fifteen feet deep and twenty or more feet across the front. This is not advisable. If there is a direct wind blowing into the house the birds cannot get far enough back to be out of the draught. When a smaller house than one twenty feet square is desired, it may, for

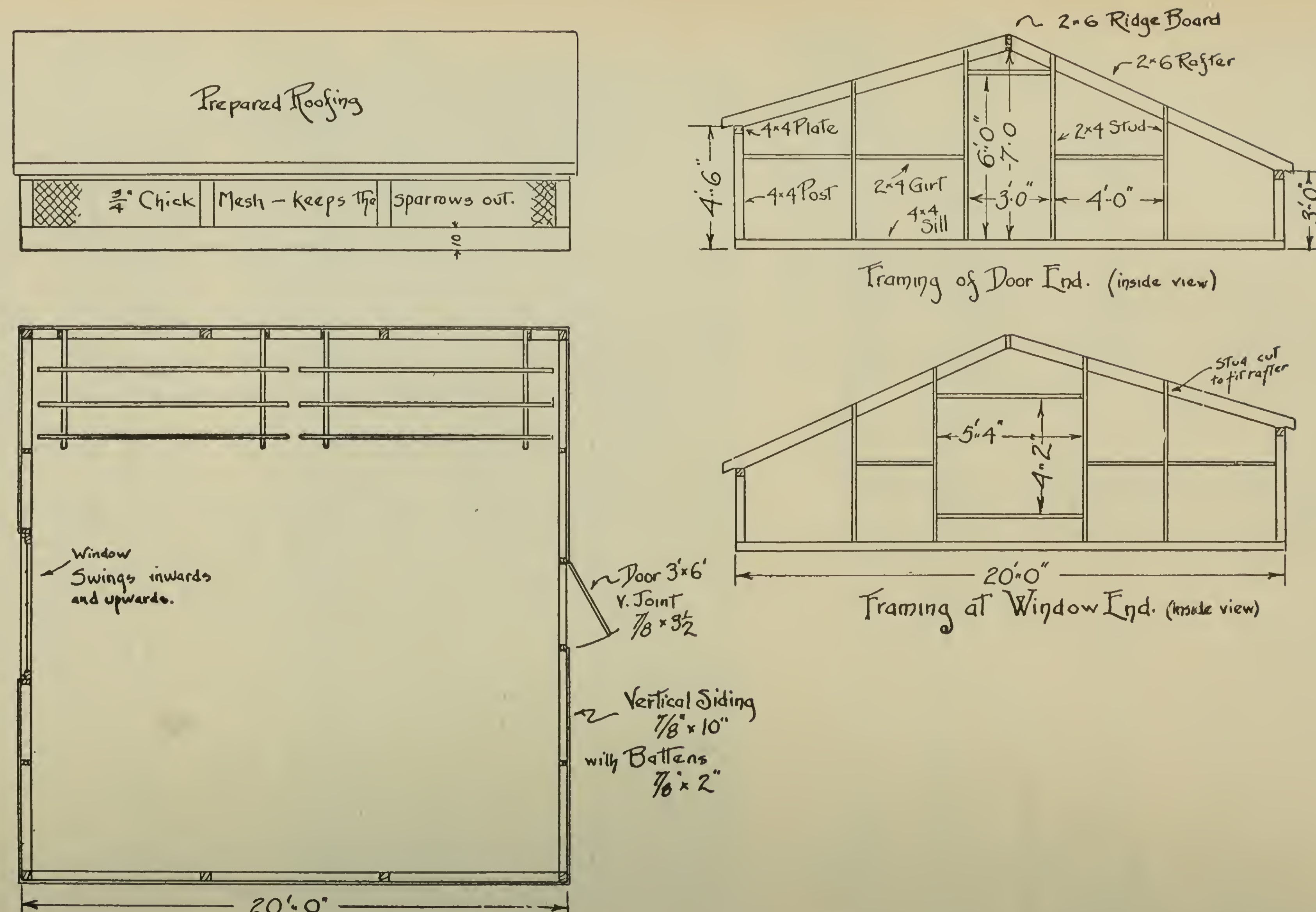


Fig. 34. Plan elevation and framing sections of a 20-foot square open front house, suitable for the accommodation of one hundred hens.

example, be built twenty feet deep and ten feet wide, rather than ten feet deep and twenty feet wide. The width across the front should never exceed the depth in this type of house.

Snow will occasionally blow into the house, but we have had very little trouble in this respect. Having the building deep, low and narrow, tends to prevent this. A rather small opening in front will not allow the wind and snow to blow far back into the house, and the depth allows the birds to keep out of the wind. If there is continuous rainy or damp weather for several days the litter will become damp and should be removed at once. Both walls and floors must be kept dry or the birds are likely to suffer from disease of some kind. There should be no openings except those in the front, otherwise there is likely to be a draught through the house, and this should be avoided.

General Rules for Building

It is necessary to allow from four to six square feet of floor space per bird; the amount actually required depending upon the size of pen and type of construction. The larger and more open the pen, the less floor space is required per bird. Roosting requirements differ with the different breeds. Brahmas, Cochins, and other heavy breeds, require ten inches of perch room per bird; Plymouth Rocks, Wyandottes, Rhode Island Reds, etc., require about nine inches; and Leghorns, etc., about eight inches. All perches should be placed on the level, as in Fig. 29. Perches built ladder style, result in the birds crowding on the top perch, thereby causing trouble.

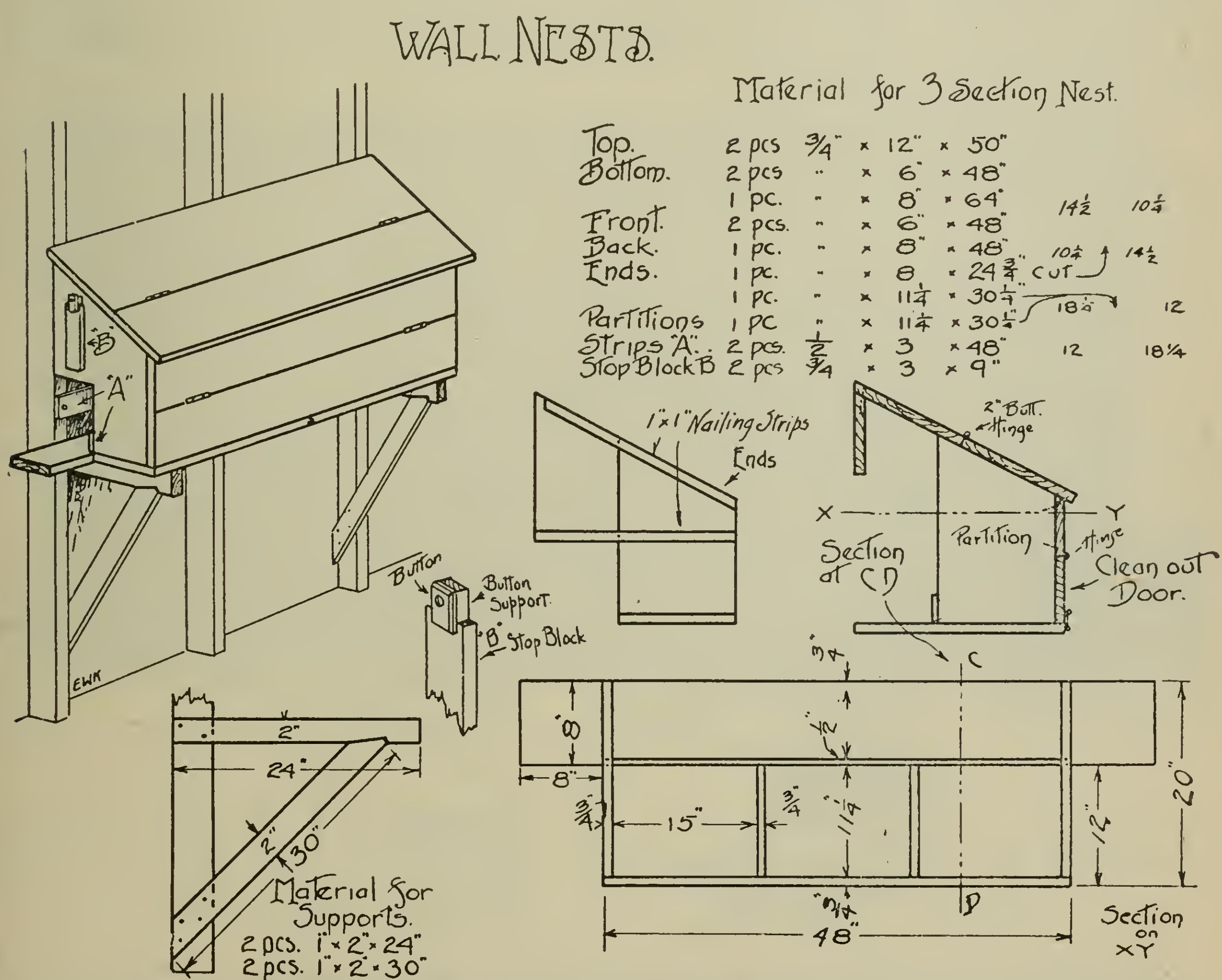


Fig. 35. A convenient type of open nest which may be supported upon brackets upon the wall allowing free use of floor space by the hens.

Roosts should be built low or near the floor. There are several reasons for this. Birds of the heavy breeds cannot fly high up, and any bird is liable to injure the soles of its feet in jumping down from high perches.

When dropping boards are used they should be moderately low down to admit of easy cleaning. Dropping boards should be made of matched lumber and should be twenty inches wide for one roost and three feet wide for two, the first perch being placed ten inches from the wall and the others at fourteen inch centres.

Roosts two inches square or two inches by three inches, are preferred, the upper edges to be slightly rounded.

Nests should be provided at the rate of one nest to every four or five hens in the pen. All types and sizes of nests are used, but with open nests, more trouble may be experienced with hens eating their eggs. This is overcome by providing nests which are partially darkened, as in the case of Fig. 35. The semi-darkened nest may also assist in preventing vent picking and cannibalism. Raising nests off the floor permits the use of the entire floor space for scratching purposes. All nests should be from twelve to fourteen inches square and not over six inches deep.

Trap-nests are necessary where pedigree breeding is to be conducted. Whether it is advisable for a man to trap-nest his stock will depend upon his object, the time available and the expense he is willing to incur in attaining the same. The price of trap-nests varies from eighty cents to one dollar and eighty cents, each. The cost of operating the same is approximately one dollar per bird per year, which will not include the keeping of progeny test records. Where trap-nests are used they must be visited at one and one-half hour to two hour intervals during the day. This is especially important during the hot summer weather, as otherwise birds are liable to die on the nests from suffocation.

Trap-nests are for the most part patented. The nest which we have used for a number of years, and which we believe is as efficient as any on the market, is the one shown in Fig. 36. This nest represents in a general way the type of most trap-nests. It is made up of two compartments, with a trap or door on the front end which closes automatically with the bird's entrance into the nest, thus keeping the bird captive until released by the attendant.

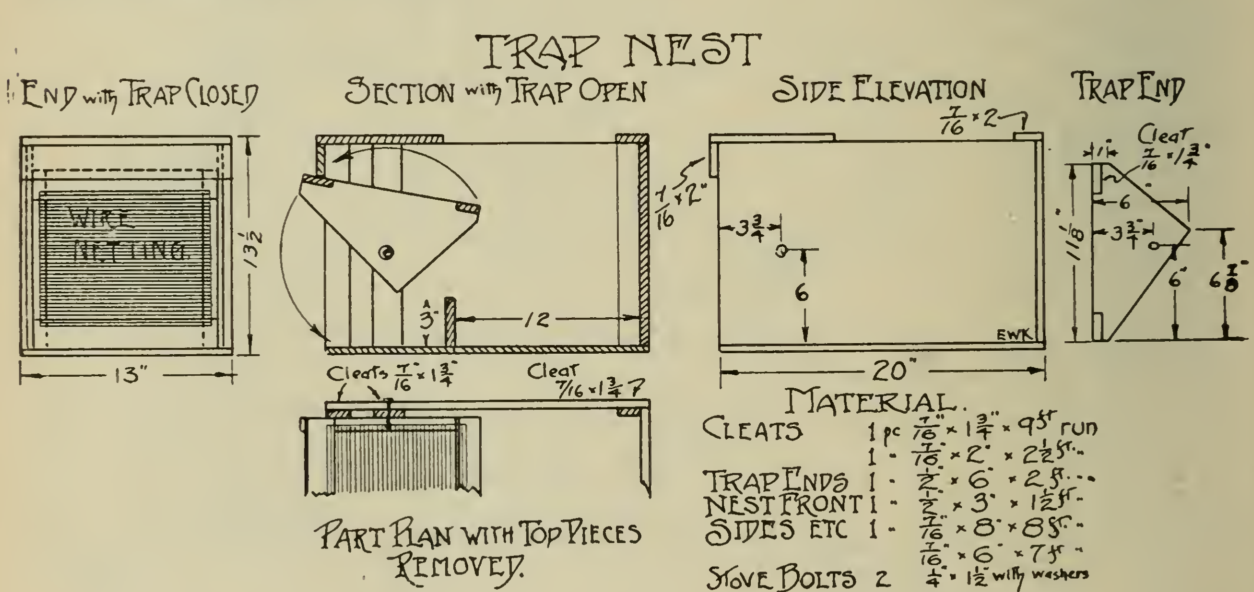


Fig. 36. Plan and specifications for the trap-nest in which the type of construction of trap and its adjustment allows for the entire lower section of the front to be open. This greatly facilitates removing the hens from the nest.

The nest is constructed of seven-sixteenth-inch material, twenty inches long, thirteen inches wide and thirteen and one-half inches high. The front of the nest is left open at the bottom which greatly facilitates the removal of the hen after laying. A three-inch board is placed across the bottom of the nest and divides it into two compartments. The trap has a straight wire front and is so adjusted in the nest that as the bird steps over the three-inch partition, her back comes in contact with the trap, and tips it forward thereby closing the nest.

Drinking utensils of some form or other are necessary, and the more simple in construction they are the better. The writers have found open pans as efficient as any, the size of the pan depending on the size of the flock to be accommodated. They should be made of some material which is smooth and as free from seams as possible, to facilitate cleaning, because frequent cleaning of drinking utensils is necessary to prevent them from becoming slimy and unsanitary. In large flocks we have used steel hog troughs, holding from twenty to thirty quarts, with good results.

In our experience the largest egg yields are obtained from flocks containing twenty to thirty birds. Some succeed with two hundred or more in a flock. Considering, however, the cost of housing, labour, etc., the most economical returns will probably be secured from flocks of about one hundred birds.

Colony Houses

There is a constant demand from people living in towns and cities for plans of houses suitable for housing six to twelve hens. In some instances they wish these houses so constructed that they can be moved easily from place to place.

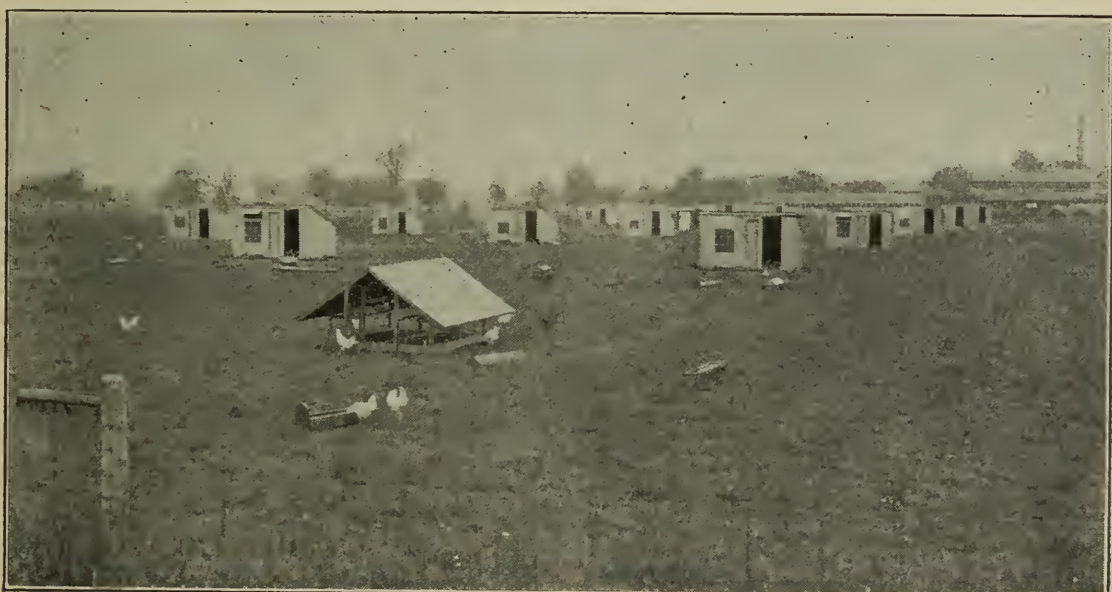
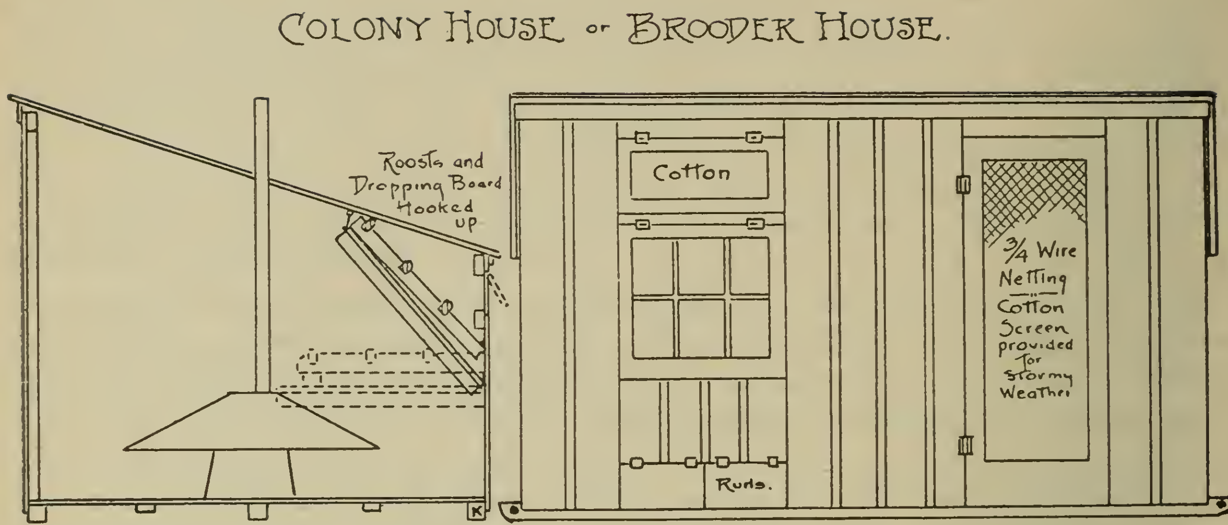


Fig. 37. Range scene with colony houses, range shelter, feed troughs and hoppers.

The man who is using artificial means of brooding and raises over one hundred chicks, is finding the portable colony house a valuable addition to his equipment, as it enables him to place his young chicks on fresh ground every year.

In Fig. 37 are shown medium-sized portable colony houses which are well adapted to the use of the large-sized colony brooder stove. They will accommodate 150 chicks until from eight to ten weeks of age where they have an outside range.



Elevation and cross section of a colony house 8′ x 12′ suitable for coal burning brooder stove.

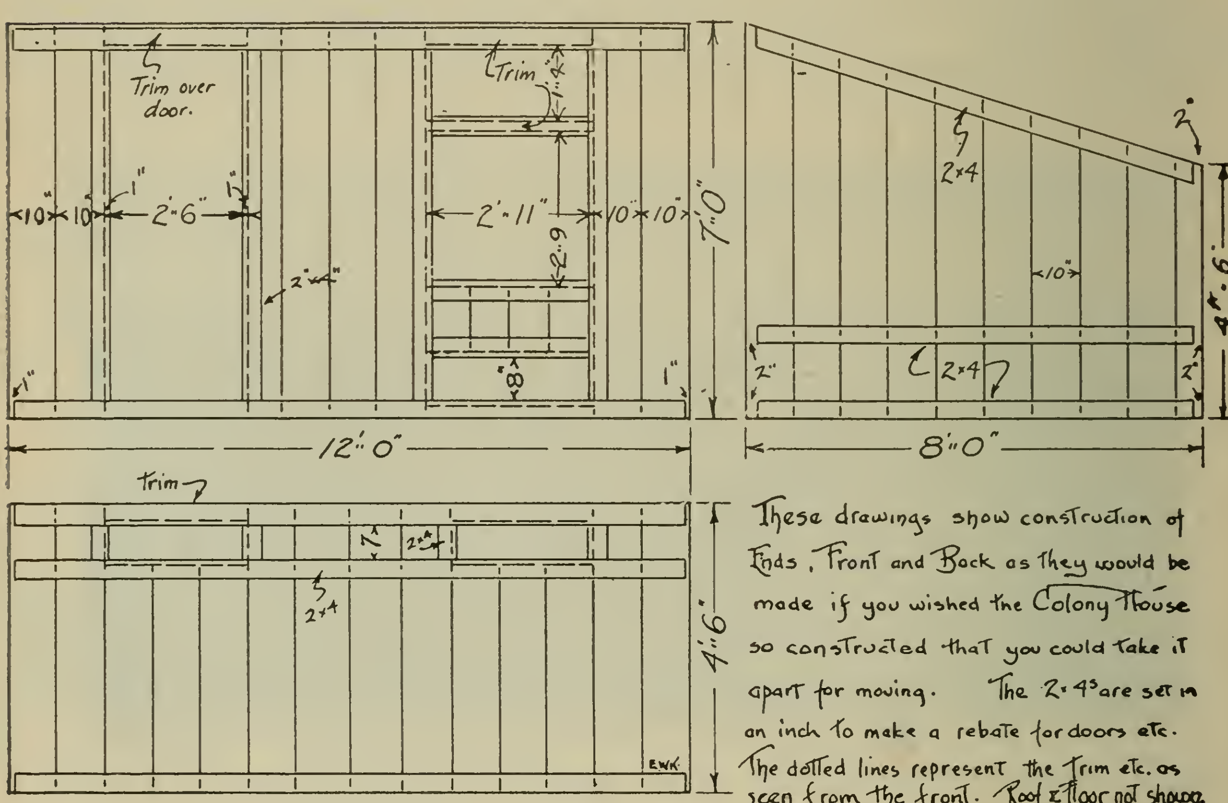


Fig. 38. Plans showing front, end and rear wall construction where desired to have the house of the take down type.

BILL OF MATERIAL FOR 8′ x 12′ COLONY HOUSE

3	pieces 4″ x 4″ x 14′—Hemlock, Cedar or Pine	Runners.
2	” 2″ x 4″ x 12′—Hemlock or Spruce	Runners.
2	” 2″ x 4″ x 14′—Hemlock or Spruce	End Sills—Girts
7	” 2″ x 4″ x 16′—Hemlock or Spruce	Rafters.
3	” 2″ x 4″ x 12′—Hemlock or Spruce	Plates, back girt.
6	” 2″ x 3″ x 14′—Hemlock or Spruce	Corners, door and window sides.
3	” 2″ x 3″ x 12′—Spruce	Roosts.
100	board feet, face ⅞″—Spruce flooring (16′ long)	Floor.
210	board feet 1″ x 10″	Outside Sheeting.
250	lineal feet, ½″ x 2″	Battens.
110	board feet, roof boards—Hemlock.	
1	square shingles.	
3	pieces 1″ x 4″ x 14′	Door and cornice.
2	” 1″ x 3″ x 10′	For cornice ends.
1	sash, 1⅜″ thick, 6 lights, 10″ x 14″ glass.	

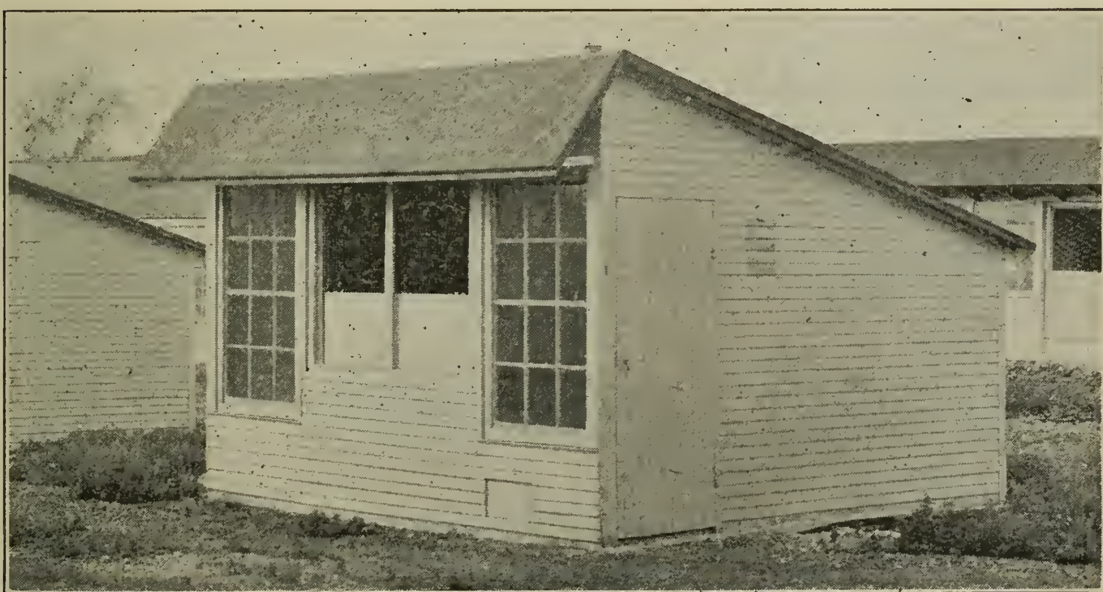


Fig. 39. Colony house 12′ x 12′ suitable for large size breeding pen or small mating of breeders.

In figs. 39 and 40 are shown a large type of colony house which is suitable for operating a colony coal-burning brooder stove, rearing chickens on range, or for a small breeding pen. The house is twelve feet by twelve feet, built on runners, and while portable cannot be moved as easily or satisfactorily as the smaller house. This house has been tested out by the writers both for brooding and for wintering laying hens and has proven quite satisfactory.

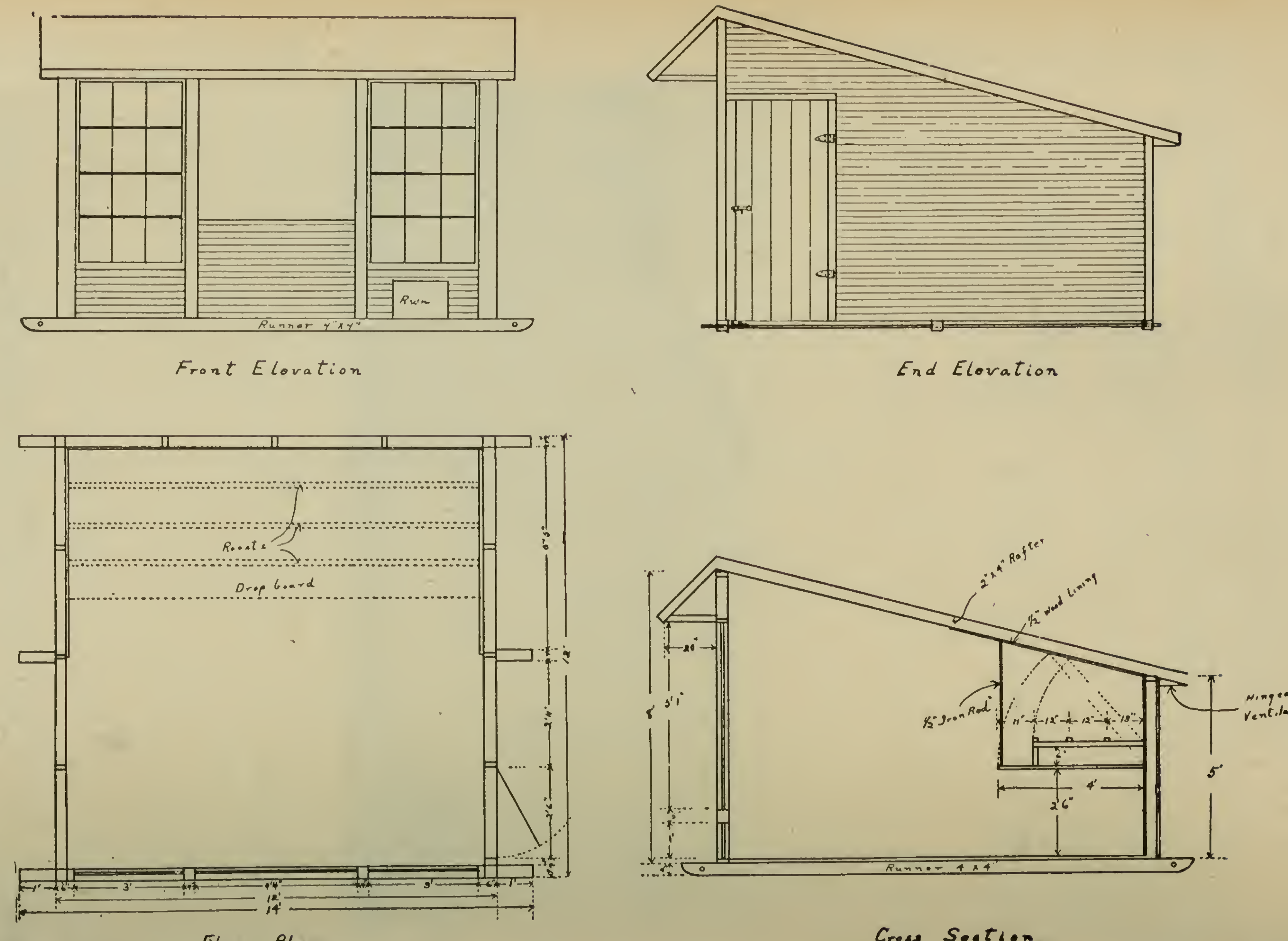


Fig. 40. Plans, elevations and cross-section of 12 ft. x 12 ft. Colony house, suitable for Colony brooder or laying pens.

BILL OF MATERIAL FOR 12′ x 12′ HOUSE

3 pieces, 4″ x 4″ x 14′........................Runners.
11 " 2″ x 4″ x 12′........................Hemlock Joist Plates.
16 " 2″ x 4″ x 14′........................Hemlock Rafters, Studs, etc.
3 " 2″ x 2″ x 12′........................Roosts.
200 feet Matched Hemlock Roof Boards.
230 feet 1″ Spruce Flooring, 12′ long, Floor and Drop Board.
300 feet 1″ Novelty Siding, 12′ long, outside walls.
8 pieces 1″ x 3″ x 14′, for window casings and cornice.
10 pieces 1″ x 2″ x 14′ for screens (cotton for winter)
3 yards 30″ wire for screens (wire for summer)
4 yards 36″ wire for windows.
100 feet ½″ matched Spruce Sheeting Inside, above drop board.
2 Sash, 12 lts. 10″ x 14″, 1⅜″ thick.
2 square Paroid Roofing.
1 door, 2′ 7″ x 5′ 11″ and join.
Dropping board is 3′ 8″ wide x 12′ long.
3 roosts 10″ above drop board, 8′ long; about 12″ apart.

RANGE SHELTERS

The use of the Range Shelter is becoming quite general. While not adaptable for early Spring use, it is just as efficient and much less expensive than a colony house as a shelter under summer conditions. It can be easily constructed by practically anyone. The structure is light and, therefore, can be easily moved about the range. The usual practice is to place a shelter beside a colony house of chickens, and as they grow and the house becomes crowded and when heat is not essential the chickens overflow to the shelter. In late June or early July, chickens not requiring heat may be placed directly into the shelters. Where the surroundings become badly soiled with droppings or mud, the shelter should be moved to a new location.

Fig. 41. Range shelter for range rearing after chicks are feathered and are safe to leave without artificial heat.

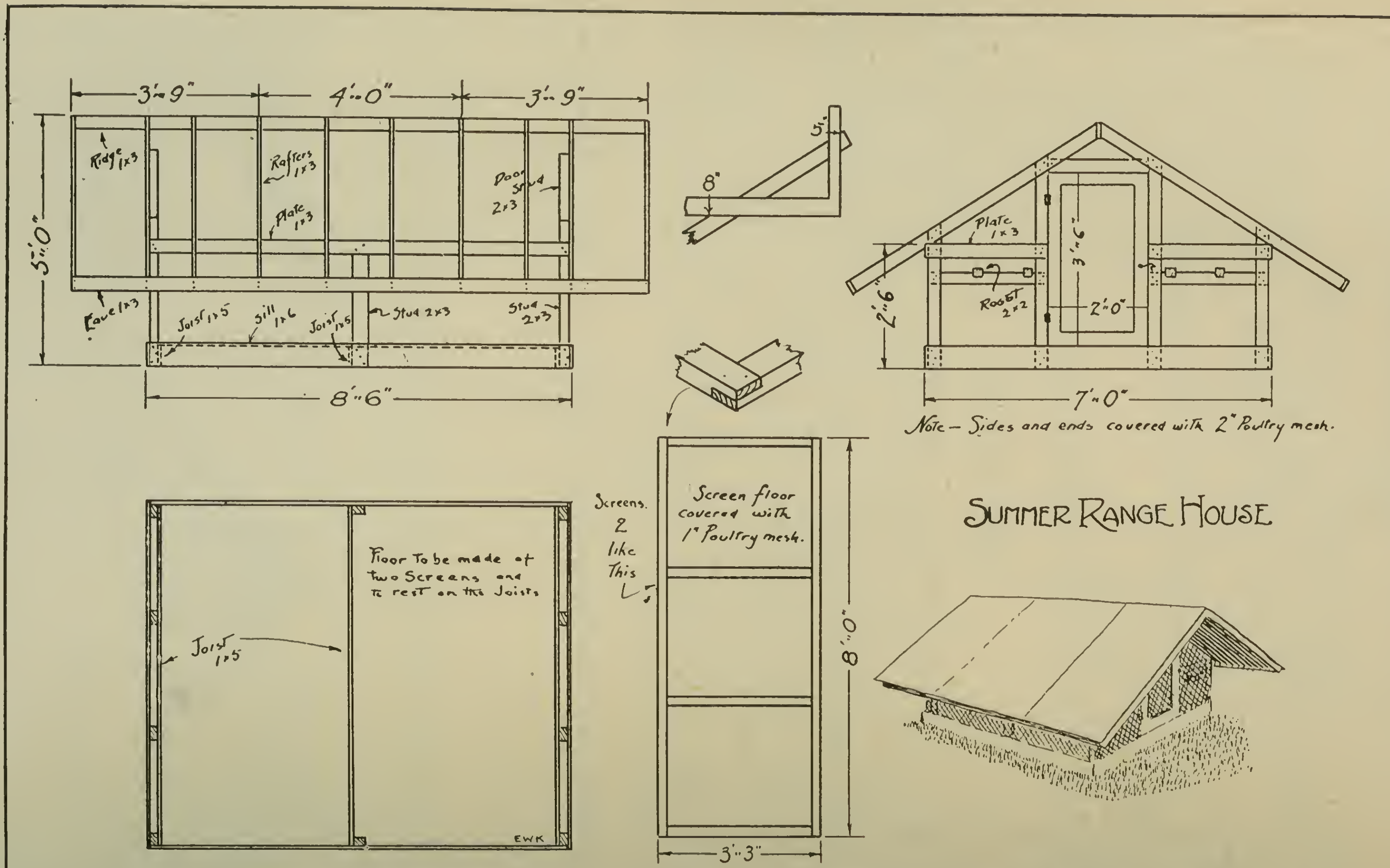


Fig. 42 Plans and construction detail for range shelter shown in Fig. 41.

Bill of material and plan for a range shelter as used at the Poultry Department is submitted herewith. There are other types in use, but this one has proven satisfactory and inexpensive.

BILL OF MATERIAL FOR RANGE SHELTER

Parts	Number of Pieces	Size	Length
Roof	12	3′ x 4′	Masonite Prestwood
Rafters	20	1″ x 3″	6′
Ridges and Eaves	3	1″ x 3″	11′ 5″
Plates — Side	2	1″ x 3″	8′ 4½″
Back	1	1″ x 3″	7′
Front	2	1″ x 3″	2′ 6″
Sills — Side	2	1″ x 6″	8′ 4½″
End	2	1″ x 6″	7′
Studs — Corners	4	2″ x 3″	2′ 8½″
Side	2	2″ x 3″	2′ 6″
Door	4	2″ x 3″	4′ 2″
Roosts	4	2″ x 2″	8′ 5″
Roosts Brackets	4	1″ x 3″	2′ 5″
Door — Stiles	2	1″ x 3″	3′ 5″
Rails	2	1″ x 3″	2′ 0″
Wire	14 yards	24″ wide	
Hinges	1 pair	3″ Butts	
Hook and Eye	1 set		
Joist for Floor Screens	3	⅞″ x 4¾″ x 6′ 10¼″	

FEEDS AND FEEDING

Fowls require a variety of feeds. While it is true that the whole grains, and the milling by-products from the same, form the major portion of the ration, it is absolutely essential that they receive also green feed, animal protein, water, grit, and shell-forming material. All these feeds must be clean and wholesome, and furthermore, a portion of them should be given in some such form that will induce the birds to take healthful exercise. The drinking material should be given at regular and frequent intervals, and may consist of water or milk. The supply must be clean, because dirty water, dirty or slimy drinking dishes, etc., are probably the two most common channels for the spreading of disease. Most attendants are inclined to forget the importance of cleaning the drinking vessels and of keeping them well filled at all times.

Recent investigations with regard to nutrition have helped to clear up some points relative to feeds and feeding.

A complete ration contains all the necessary nutrients for health, growth, reproduction and fattening. This means that such a ration is balanced in its tissue forming elements such as contained in animal proteins and in its heat and energy producing constituents as are found in the cereal grains. It is also balanced in its mineral content as commonly supplied in the form of grit, oyster shell and bone meal and includes the necessary supply of vitamins as commonly found in direct sunlight, tender green feeds, etc.

The experimental results to date suggest that the feeding of a variety of feeds is a safe practice. This applies in the use of cereal grain mixtures, such as corn, wheat, oats and barley, as well as in the use of animal proteins such as milk, beef scrap, fish scrap, etc.

Any trials which we have made using a single cereal, have always indicated that there is a deficiency of some nature in each grain and that this is also true of the animal proteins.

It is essential that the health of the bird be maintained and that there be a surplus of digested feed above that needed for body maintenance, to be used for growth or the production of eggs.

In general, it will be safe to state that grains, such as wheat, oats, barley, and corn, together with their mill by-products, maintain the body temperature, produce fat and egg yolks.

Such feeds as skim-milk, dried milk or any of the many forms of milk, together with animal by-products, such as meat meal, beef scrap, raw liver, etc., go to the production of the muscle of the bird, and to the making of the white of the egg.

Feeds such as bone meal, oyster shell and gravel, are used to produce the bones of the body and the shell of the eggs.

The whole series is required to produce eggs. Many of the materials, other than those cited above, are found in small amounts. As an example, there is considerable Calcium in milk and in clover leaves and wheat bran also contains some bone-forming material.

An understanding of the feeding of poultry is helped materially by remembering that the bird can re-combine many nutrients, but can manufacture but very little, if anything, not found in the ration.

A ration must be considered not only from the standpoint of its chemical composition, but also from its physical action, and it must be palatable.

It is also well to bear in mind that any change in the colour of the feed must be taken into consideration when one attempts to change the ration, due to the price of the materials used. All changes should be gradual.

The physical factors influence the bulk of the ration or the weight per measured bushel, and likewise the mechanical texture of the feed, whether it is granular or sticky. Ground corn tends to be granular, whereas finely ground oat groats and wheat flour are sticky. Bran and clover leaves add bulk to the ration. Some feeds tend to be constipating, while others are of a laxative nature.

Where laying hens or growing chicks are given the free choice of a large number of feeds, prepared in different ways, it is seldom that very finely ground materials are selected. As an example, the birds prefer rolled or crushed oats to finely ground oats, so much so, that they scarcely eat any finely ground oats, where the crushed or rolled material is available. Where feeding space permits the placing before the birds of a large assortment of feeds, they will of free choice take in a great variety of these feeds.

The palatability of any mixture and its physical nature are important points.

FEEDING PRACTICE

The average hen eats about seven pounds of feed each month, or between eighty and ninety pounds per year. Ordinarily, the feed consumption is higher when the birds are laying well. More than half of the feed consumed is used for body maintenance, that is, the daily repair of worn out tissue and the maintenance of the body temperature. It is, therefore, very clear that in order for a hen to lay well, there must be a surplus of digested feed over and above that required for the daily maintenance of the body.

The common practice is to feed about one half of the grain as scratch feed or whole grain and the balance as ground mixtures or mashes.

There is a demand for information as to exactly how much to feed one hundred hens daily. This number of laying hens would eat about twenty-three pounds of feed daily, or say, twelve pounds of scratch grain and eleven pounds of mash. Hens are inclined to eat more mash in the spring and summer months than during the winter months.

It is not good practice to feed an exact amount daily, because the hens' appetites vary according to the weather conditions and the rate of egg production.

Our method is to feed about four pounds of scratch grain per hundred birds, in the litter, in the morning. We generally give a moist mash at noon, giving the birds all they will clean up in fifteen minutes. At night a full feed of grain is given in a trough and any that is not eaten is removed. The dry mash is fed in a hopper and is constantly before the birds. The hopper should be large enough to allow a feed space of one foot for each four or five hens.

This plan insures that the birds have all they desire to eat daily. Hens generally ease off in egg production owing to a loss in body weight, hence the importance of having them consume plenty of feed.

THE ART OF FEEDING

There is something in the art of feeding. A good feeder watches the condition of the droppings as seen on the dropping boards and also sees to it that the hens have plenty to eat but have no feed left in the litter. The appetites of the birds are keen, and moreover the birds like the attendant. There is a friendly relationship between the attendant and the birds. Know your birds and have them know you. Be on friendly terms with one another.

Scratch Grain Mixtures

We use a mixture of two parts wheat and one part yellow cracked corn. Any grain mixture that is palatable will give very good results.

Laying Mash

500 lbs. Ground Barley
200 " Chopped or Ground Yellow Corn
300 " Ground Oats
500 " Shorts
50 " Oil Cake Meal
15 " Bone Meal
15 " Iodized Salt
150 " Alfalfa Meal
100 " Powdered Buttermilk
30 " Cod Liver Meal
60 " Fish Meal
40 " Meat Meal
7 pints Cod Liver Oil

This formula is made with the idea that hens fed the mash will lay well and, at the same time, produce an egg that will hatch reasonably well.

A number of people wish to use home-grown feeds and are asking how changes in the ration can be made to use such feeds.

Barley is used in this ration as a substitute for an equal quantity of corn. Barley is low in vitamin A and is slightly high in fibre. Usually one need not worry about this amount of fibre, but the vitamin A is essential.

Ground wheat could be substituted for the shorts, or some bran and low grade flour may be used.

Mixed grain may be substituted for all the grain mixture in the above mash, provided it does not contain more than 40 lbs. of oats to the 100 lbs. If it has too many oats, one should sift out a considerable quantity of the oat hulls, and the grain mixture will answer.

The oil cake meal is put in the ration mainly to regulate the bowel action.

Ordinary fine table salt will do, but we prefer to use iodized salt.

Clover leaves, or even fine cut clover hay, may be substituted for the alfalfa meal. This may be fed in wire baskets or, if there is a liberal supply, a forkful of clover could be put in daily. Many farms have an abundance of clover leaves.

If there is available an ordinary pailful of skim milk for each 100 hens, all the powdered milk, fish scrap and meat meal may be left out of the ration. Powdered milk is easily mixed into a ration, and milk in some form appears to materially improve the hatching power of eggs. Fish and meat, together with the milk, give a mixed protein source which, with us, produces a more reliable hatching egg.

The cod liver meal carries some oil and at the same time may have some influence on the blood of the bird. If this material is difficult to purchase, leave it out but double the quantity of cod liver oil.

The cod liver oil is essential during the winter months to aid in making available the minerals and is a substitute for sunshine.

The protein feeds (milk, fish and meat meal) are used in the production of egg whites. The yolk is formed chiefly from the grains. The clover and alfalfa meals and the cod liver oil supply some of the essential vitamins.

The minerals for the above ration are fed in hoppers. Some form of available Calcium Carbonate is essential for shell forming material. Oyster shell answers this purpose. Many good poultrymen supply, in addition, a hopper of hard rock grit, and also a hopper or charcoal.

This mash is constantly before the birds.

A Simple Ration

Chickens are very fond or crushed or rolled oats. They do not like ground oats.

We have had very good results by giving a hopper of crushed oats and removing the hull refuse daily, as the hulls have little or no feeding value, and also because the birds do not eat them.

The scratch grain given was whole wheat.

Clover hay or clover leaves were given daily in amounts as controlled by the appetite.

Skim milk or buttermilk was given as drink. One hundred hens require about twenty to twenty-five pounds of milk daily to give the required amount of protein. In winter it may be necessary to warm the milk in order that the hens will drink that amount.

The cod liver oil (about one-third of a teacupful daily per hundred hens). is mixed with the scratch grain fed at night. This is given in a trough, as such grain is oily and collects dirt or filth easily if fed in the litter.

This ration is limited in its use to where milk is available. Crushed oats are difficult to mix with any material, hence are best fed alone.

EGG PRODUCTION

It is generally considered among poultrymen that the production of eggs is the most profitable branch of the business. It must also be conceded that for most people a crop of chickens must be reared annually, and the surplus males and old hens sold, at a profit, if possible.

Many people believe that the secret of getting eggs, particularly in winter, is in the feeds given and in the method of feeding; others believe the whole problem is in the breed, variety or strain; while still others think that the housing is the problem to solve. All these are important, but the main reason for poor results, in the opinion of the writers, is a lack of careful work performed months before the eggs are wanted. While you are collecting the high-priced winter eggs you should be making careful plans to secure the crop of pullets for next season.

The factors influencing production are feeding, housing, age of stock, strain, possibly breed, attendance, cleanliness and the weather. All of these may be more or less controlled, with the exception of the weather and it is perhaps the least important factor.

Some trouble is caused through overcrowding of the birds in the houses and having stock of mixed ages in the same pen. Often yearling and older hens are housed together with early and late pullets as well as surplus cockerels. The pullets should be separated from the older females and any spare cockerels disposed of or housed by themselves. Dirty, damp and draughty houses along with wet and badly soiled litter are other causes.

Where winter eggs are wanted the early hatched pullet is, without doubt, the one to depend upon. Yearling and older hens are veiy rarely good producers during November and December. They are uncertain producers even in January and February and really do not begin to lay well until March. Where the egg production falls below fifteen per cent during the winter months one is not making much profit. The age at which most pullets begin laying is from six to seven months. Some lay at four and one-half to five months, and others not until eight or nine months of age. This means that if a fifty per cent egg yield is wanted in November the pullets should be hatched during March or April. May hatched pullets will lay moderately well, but, a a rule, not over forty per cent daily,

The attendant has responsibilities. There should not be any neglect on his or her part, but careful, constant, regular attendance and a keen interest in the welfare of the birds. A bird that has stopped laying is very hard to start. As pullets mature, they commence laying. It is the attendant's work to keep them going.

The amount of feed a hen will consume, the number of eggs she will lay, and the time at which she lays the eggs, are interesting and important questions. Available data would indicate that one hundred to one hundred and ten eggs per year will pay for the hen's keep, depending on the market prices for feed and eggs, and provided the flock mortality is not in excess of ten per cent.

The body weight must be maintained or increased if production is to be kept up.

The amount of feed consumed varies with the breed and with the number of eggs produced. Our figures show that the general purpose breeds, such as Plymouth Rocks, Rhode Island Reds and Wyandottes, consume from eighty to ninety pounds of grain and mash annually, averaging nearly seven pounds of feed each month. Breeds such as Leghorns or Anconas eat from fourteen to eighteen pounds less or the large birds eat more than small ones, and the heavy layers eat more than the poor layers. The amount of feed required cannot be stated in ounces per bird for each day, as birds' appetites vary similar to human beings. The successful feeder studies his flocks and regulates the amount of feed to be given according to the condition and requirements of his flock. The writers are of the opinion that there are more hens that are too lean than there are hens that are too fat to lay. Most very fat hens are poor layers and are better put on the market than fed sparingly to try to condition them for laying.

In Table No. 1 are given the results of some investigations in feeding. The work has been carried on over a period of six years with Barred Plymouth Rocks and Single Comb White Leghorn pullets hatched at different dates from March 1st to May 31st. The birds were, for the most part, kept under rather closely confined conditions, the yards providing in most cases only sufficient room to allow the birds to get out of the pen and on to the soil.

In computing the above data, feed used in the form of green feed, was not included. The main consideration, in this connection, however, was the oats used for sprouting purposes. It is difficult to determine the exact amount of this particular feed consumed by each bird. In observations and calculations made during the four year period, during which time sprouted oats were fed throughout the entire year, it was found that the consumption was approximately fifteen pounds for Leghorns and seventeen pounds for Rocks. Thus it will be found, that if these amounts are added to the amounts of grain and mash given in the following table, that the total grain consumption per bird per year was for Leghorns 71.59 pounds, and for Rocks 88.45 pounds.

A study of the distribution of the egg production is interesting and important from the standpoint of the annual returns from the birds. Egg prices rise and fall with the seasons and usually the greatest profit is made where producing eggs at a season or seasons of the year when prices are high. Pullets are the chief

TABLE No. 1. FEED CONSUMED

Description	Milk lbs.	Grain lbs.	Mash lbs.	Grit and Shell lbs.	Special Animal Feed lbs.	Eggs Laid
1312 White Leghorn Pullets	102,963	50,535	23,725	3,233.5	1,569.5	197,813
Average per bird..	76.11	38.51	18.08	2.46	1.19	150.7
2375 Barred Bock Pullets	235,698	128,102	42,625	6,372	....	381,503
Average per bird..	99.24	53.51	17.94	2.21	....	160.63

source of egg supply. As stated previously, they require usually from six to seven months in which to mature. It is, therefore, possible to regulate their production in the fall months, at least to some extent by regulating the time they will hatch in the spring. Below is given the average percentage monthly egg production of Barred Rocks and White Leghorns hatched in March, April and May for a period of six years.

TABLE No. 2. AVERAGE PERCENTAGE MONTHLY EGG PRODUCTION FOR 2,375 BARRED ROCK PULLETS HATCHED IN MARCH, APRIL AND MAY.

Month Hatched	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Average Annual Production
March	25.79	44.04	43.94	40.71	38.72	41.39	53.29	57.06	56.98	51.96	46.23	48.46	....	....	166.84
April	....	17.79	36.44	43.25	39.79	45.90	57.06	61.25	56.13	53.12	48.48	46.43	39.22	....	165.75
May	....	....	12.17	30.46	32.36	38.69	48.44	53.94	56.61	50.67	49.09	45.98	43.24	31.17	149.90

TABLE No. 3. AVERAGE PERCENTAGE MONTHLY EGG PRODUCTION FOR 1,312 WHITE LEGHORN PULLETS HATCHED IN MARCH, APRIL AND MAY.

Month Hatched	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Average Annual Production
March	20.80	40.48	35.81	35.43	35.59	40.34	47.93	43.66	54.43	55.62	45.19	40.15	....	....	150.67
April	....	14.68	42.17	38.05	35.86	40.42	46.41	44.63	59.90	56.22	46.14	39.48	30.97	....	150.52
May	....	....	18.66	37.32	44.64	47.12	52.59	51.97	61.66	54.65	46.77	44.52	42.67	26.65	160.96

In the following tables is given the average monthly egg production per bird for three groups of Barred Plymouth Rocks and three groups of Single Comb White Leghorns hatched in March, April and May.

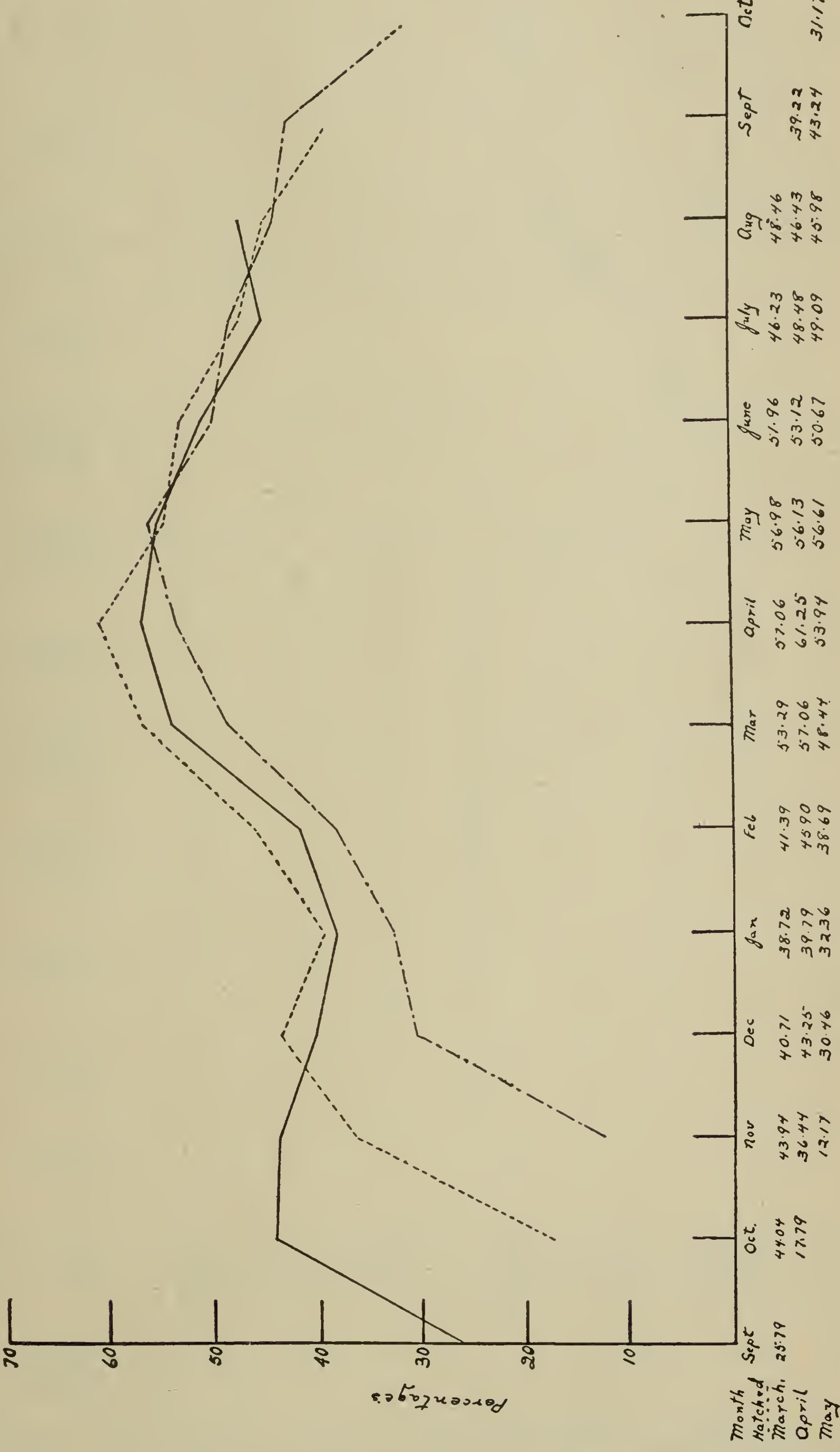
TABLE No. 4. AVERAGE MONTHLY EGG PRODUCTION PER HEN FOR 2,375 BARRED ROCK PULLETS HATCHED IN MARCH, APRIL AND MAY.

Month Hatched	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Average Annual Production
March	7.71	13.64	13.17	12.60	12.00	11.58	16.50	17.11	17.65	15.57	14.31	15.02	....	....	166.84
April	....	5.51	10.93	13.42	12.36	12.86	17.70	18.37	17.40	16.00	15.03	14.40	11.77	....	165.75
May	....	....	3.65	9.44	10.03	10.83	15.07	16.17	17.50	15.20	15.22	14.25	12.97	9.66	149.90

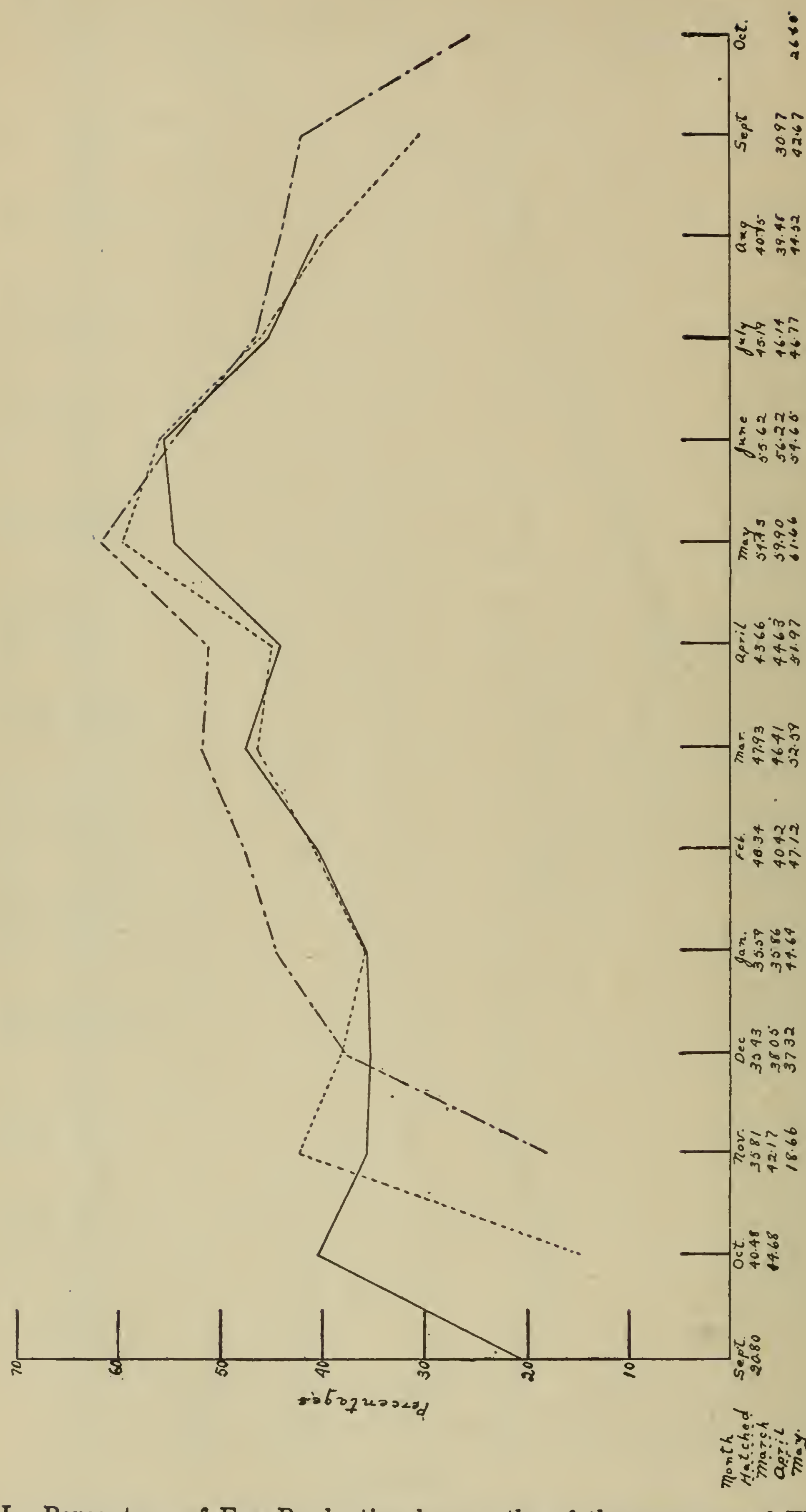
TABLE No. 5. AVERAGE MONTHLY EGG PRODUCTION FOR 1,312 WHITE LEGHORN PULLETS HATCHED IN MARCH, APRIL AND MAY.

Month Hatched	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Average Annual Production
March	6.24	12.55	10.74	10.98	11.03	11.29	14.85	13.10	16.77	16.68	14.00	12.44	....	....	150.67
April	....	4.55	12.65	11.79	11.12	11.31	14.39	13.39	18.57	16.99	14.21	12.27	9.28	....	150.52
May	....	....	6.59	11.57	13.84	13.19	16.30	15.29	18.85	16.00	14.50	13.80	12.80	8.26	160.96

In the foregoing tables it will be noted that the average annual production is practically the same for different dates of hatching. It would, therefore, appear that so far as total production is concerned there is little to be gained by early



Graph V. Percentage Egg Production by months of three groups of Barred Rock Pullets hatched during the months of March, April and May.



Graph VI. Percentage of Egg Production by months of three groups of White Leghorn Pullets hatched during the months of March, April and May.

hatching. If, however, the reader will compare the production figures for the different months, and the different groups, he will find that the early hatched birds produced a moderately large number of eggs in the fall when prices were high, before the later hatched birds got started. This difference is very graphically shown in Graphs V. and VI. There is the further advantage in early hatching, especially with early March hatched chicks, in that the cockerels can often be brought to broiler weight while the price for broilers is still good and the cockerels can be marketed, thus giving the pullets a better chance to develop.

Viewing the matter from the purely economic standpoint of egg production, it is interesting to compare the values of the eggs produced by birds hatched during different periods on the basis of current market prices for eggs at country points. Below is given the average monthly price of eggs per dozen on the grade Extras at country points in Ontario for the four years, January 1st, 1928, to December 1st, 1931.

PAYING PRICE FOR GRADE "EXTRAS" AT COUNTRY POINTS

	1928	1929	1930	1931
January	43	40.5	53.5	29
February	39	43	45	26
March	35	35	30	21.6
April	29.5	27	28	19
May	31	28	29.5	16
June	32	28	35	16.5
July	35	29	28	17
August	39	40	30	22
September	41.5	43	33	23.5
October	47	47	40	36
November	57	56.5	51	43
December	55	57	48	36

On the basis of the above prices and the average production figures as given in tables 4 and 5 it will be found that there is considerable variation in the total value of the eggs laid by the different groups. The production figures would indicate that there would be little difference in the value of the eggs produced by either breed hatched in March and April. The great difference is noticeable when comparing May hatched birds with either of the other groups. The March and April hatched Barred Plymouth Rock pullets laid more eggs during the year and also laid more heavily during the months when eggs were a high price than did those hatched in May. On the contrary, the May hatched White Leghorns laid more eggs for the year, and as many, if not more, during the months of November to February, than did the March and April hatched groups. It is difficult to figure the exact differences from the above tables as the grades of these eggs are not available and much would depend on how the eggs graded. The earlier hatched pullets would be expected to lay larger eggs earlier in the year and consequently their eggs would grade better and so would bring a higher price than would the eggs laid by the later hatched birds.

The above table also shows clearly the decided drop in egg prices in 1931 as compared with the three previous years during which prices were fairly stationary. A study of the table will, however, show that the relative values per month in 1931, as compared with the previous three years, are practically the same. The prices gradually rise from May until they reach a peak in November and December and then fall to the year's low in April and May.

In presenting the foregoing figures it is not the intention that they be interpreted as possibilities of the two breeds, as the strain or selection work might show as great difference between strains of the same breed.

These figures are given in the hope that they may suggest, particularly to the specialized poultryman, the necessity of carefully recording his daily, weekly and monthly records of production costs and profits. The keeping of poultry as a specialized business means, if success is to be obtained, a daily or at least weekly record of the loss and profit. Success or failure depends much upon these accounts. Yearly statements usually show losses, leaks, etc., too late.

In other portions of the bulletin are discussed housing, feeding, sanitation and so forth.

To sum up, the requirements for high egg production are clean, dry, comfortable houses that are free from direct draughts and that are well lighted. The feeding should consist of a variety of grains, green feed, animal feed, grit and shell, which is clean, sweet and wholesome, and is given to the birds regularly and in such quantities that they have all they want to eat before going to roost at night. The supply of drinking material should be clean and abundant. The attendant should be regular in his or her work and interested in the same. The birds should be bred from good laying ancestors and hatched at the proper season, well reared and free from disease.

Fall Care of Breeding Hens

Birds to be considered as next season's breeders may be put out on a good grass range, or where there is a good patch of rape. The colony houses that were used for raising chickens may be moved to this range. The hens then are transferred to the colony house, about fifty hens to a house, each house having a floor space eight feet by twelve feet. This provides roosting space only. No mash feed is given, nor any milk or animal protein. The birds are given a ration of whole grain, water and green feed, and allowed to range as they please. In a few days egg production ceases, the birds start to moult ,the yellow returns to their legs and beaks, and they have a real holiday. There are enough birds in a house to keep it moderately comfortable on rainy or cold days, though it is possible that a few hens may be lost owing to lack of physical fitness.

Our method is to allow these hens to remain on range for at least two months, after which they are placed in the breeding pens.

One usually has some very old, high-class breeding hens that have demonstrated their worth as breeders. Old hens often are late in starting to lay and frequently the first three or four eggs laid after a period of rest are infertile. Because it is desirable to secure as many chicks as possible during March and April from these selected birds, it is our practice to use a little artificial light on them so that they may be laying a high percentage of eggs during February. They are fed the same ration as that fed to the pullets, using milk as a protein source, care being taken that they have plenty of clover and bone meal. The birds are allowed out of doors when the weather permits and receive what direct sunlight is available. They also have two per cent. of cod liver oil or cod liver meal added to their mash mixture.

The Department has used the above plan with satisfactory results for the past four years on upwards of a thousand breeders.

Hatchability of eggs is an inherited factor that is influenced by environment. Some hens' eggs are low in hatchability; others are high in hatchability. The above methods of feeding and management have given good results regardless of the number of eggs the hen may have laid during her pullet year.

EXPERIMENTAL STUDIES OF THE PRODUCTION AND HATCHABILITY OF HENS' EGGS

The Province of Ontario loses many thousands of dollars annually because of poor hatches. Even in our modern types of incubators, with their efficient control for the regulation of temperature, ventilation and moisture, about forty per cent of the eggs set each Spring fail to hatch. Poor hatches may be attributed to many causes. Too often, however, such poor hatches are blamed on the incubator when in reality the fault lies elsewhere. It can be truthfully stated that the majority of incubators in use at the present time will give reasonably good results, provided the eggs set are from a well managed flock and provided that the operator is faithful and accurate in his or her care of the machine.

Good management of the breeding stock is a very important factor in securing good hatches. This involves the selection of the birds used, not only as to their pedigrees and type but also as to their health and vigour. Two other factors, the importance of which in reference to their influence on hatchability are not so generally recognized, are the feed fed to the breeders and the amount of sunlight to which these breeders are given access. It is generally recognized by poultrymen that eggs set during the early part of the hatching season from birds in confinement do not hatch as well as do eggs produced later in the season by birds allowed outdoors and given plenty of sunlight. It was believed by the authors that the source of animal protein has a definite bearing on the value of a ration used for the production of hatching eggs. It was also desired to ascertain more exactly, if possible, the role of sunlight and of its commonly used substitutes in this respect.

In order to gather data on the effect of these factors, viz., the source of animal protein in the ration and sunlight and its substitutes, the experimental trials here reported were conducted. It was hoped that by such trials some measure of the actual effect of these proteins and of sunlight and its substitutes on hatchability would be secured.

The general plan of the experiments was to study the influence of such animal proteins as Milk, Fish Scrap, Meat Scrap and Tankage as they might affect hatchability and egg production. These materials were fed singly and in combination as the sole source of animal protein in the rations, with and without cod liver oil. The experiments consider two main points.

1. The effect of certain animal proteins on the hatchability of hens' eggs.

2. The effect of the amount and quality of sunlight on the hatchability of hens' eggs.

Genetics is also a factor in hatchability and may be of equal importance with animal proteins and the amount and quality of sunlight. This factor is, however, not taken into consideration in the discussion of the results here reported. The birds used in the experimental trial were all of known ancestry and came from the general pedigree pens of the Department. Their ancestors were known for ten years or more, together with their record of performance. This information may help materially in the final study of the problem.

The incubator used was a six thousand egg Petersime machine, which made it possible to set all eggs daily, over the entire period. This was done and so insured that all eggs would be under the same environmental conditions during incubation.

Twenty Barred Rock pullets and one male, as nearly similar in age and breeding as possible, were used in each pen. All pullets used in the experiments conducted by this Department suggest that April hatched Barred Rocks give a lower hatch than birds hatched in February or March. The males were rotated from pen to pen daily. Pullets were used in preference to hens because their eggs were likely to be a little more difficult to hatch, other things being equal.

In case of the death of a bird, it was immediately replaced by a bird of similar breeding so that the pens were constantly up to strength.

It was planned to conduct the trial for five years which would give data on one hundred females for each ration to be studied.

The individual pens were twelve feet wide and twelve feet deep. There were two glass windows three feet by three feet six inches in each pen as well as two movable screens which could be opened on days when the weather permitted. The screens were twenty inches square. One was covered with cheese cloth and the other was covered with cel-o-glass. The trapnests, drinking fountains, pans, feed hoppers, were the same size in each pen. There should be little or no difference between the pens.

The Method of Feeding and Management

In view of the many factors that may affect both production and hatchability, a system of feeding and management was developed to control as many of these as possible. With this in mind, on a measurable basis, the following feed schedule was followed:—

A.M. — A light feed of grain was scattered in the litter.

Noon — A portion of the mash for each pen was fed moistened.
The Cod Liver Oil was fed in this mash daily.

P.M. — A heavy feed of grain was fed in troughs.

N.B.—No artificial lights were used.

The mash for each pen was fed in hoppers and was available for the birds to eat throughout the entire day.

All birds were confined to the pens for the entire eleven months.

RATIONS FOR EXPERIMENTAL PENS

Basal Mash to All Pens
700 lbs. Corn Chop
500 lbs. Wheat Shorts
300 lbs. Oat Chop
10% Alfalfa Meal
2½% Bone Meal
½% Salt

Whole Grain Mixture
50 lbs. Cracked Yellow Corn
50 lbs. Wheat
Daily amount to each pen—
A.M. — ½ lb. in the litter
P.M. — 2 lbs. in the hopper

To the dry mash, kept in front of the birds all the time, was added the following,—

Pen	Amount and Kind of Protein	Other Additions
2	10% B.P. (Buttermilk Powder)	U. V. L. (Irradiation)
4	10% B.P.	Cod Liver Oil
6	5% B.P. + 7½% Fish Scrap	
8	5% B.P. + 7½% Fish Scrap	Cod Liver Oil
10	5% B.P. + 10% Meat Scrap	Cod Liver Oil
12	5% B.P. + 10% Tankage	Cod Liver Oil
18	20% Meat Scrap	Cod Liver Oil
20	10% B.P.	
22	20% Meat Scrap	
24	20% Tankage	
26	15% Fish Scrap	
28	15% Fish Scrap	Cod Liver Oil
30	20% Tankage	Cod Liver Oil
32	37% B.P.	Cod Liver Oil

N.B.—U. V. L. (Ultra Violet Light) a half hour of irradiation daily except Sunday.

C. L. O. (Cod Liver Oil) 20 c. c. daily to each pen in moist mash.

In addition to the dry mash, the birds had free access to oyster shell, grit and water at all times. The weighed quantity of grain, 2½ lbs. per hen per day, was fed on an assumed ratio of 50-50 mash to grain consumption. Any variation in food consumption was thus measured by the amount of dry mash and oyster shell eaten.

The protein supplements with the exception of Buttermilk Powder were added to the basal mash on an equivalent basis. Small quantities of the basal mash were weighed out weekly into separate containers and the different animal proteins added to the various mixtures.

A chemical analysis of each each individual source of protein was determined. An equivalent quantity of Fish Scrap, Meat Scrap and Tankage was fed on the basis of their chemical analysis, with the exception of Buttermilk Powder, of which one half of the quantity by weight was used.

The feeding trials included two pens for which Buttermilk Powder constituted the protein supplement in the mash. For the one pen 10% was added to the mash, while for the other 37%; this being enough to equal the amount of animal protein given to the pens fed Fish Scrap and Beef Scrap.

Composition of the Rations

In Table 1 is shown the percentage composition of representative samples of each of protein supplements used in these experiments. Repeated analysis of different samples of the same protein concentrate, showed that the composition varied within fairly wide limits. For example, the Buttermilk Powder consignments analysed, varied in crude protein content from 29 - 35%. It was, therefore, necessary to make protein determinations on each new batch of feed and to increase or decrease the amount of the protein supplement in the ration, so that the total protein would be kept approximately the same throughout the entire experiment. The percentage composition of the mash fed to each pen is given in Table II. and was calculated from the percentage composition of the ingredients of the mash (see Table 7). To study the affect of adding Cod Liver Oil or Ultra Violet irradiation to the buttermilk powder rations, the total protein of those rations was kept approximately the same at 13.5% (i.e. pens 2, 4 and 20). The total protein content of the rations planned to compare the different protein supplements both with and without Cod Liver Oil (i.e. pens 18, 22, 24, 26, 28, 30 and 32) was approximately 21%. Where comparing the nutritional value of the combinations of these protein supplements (i.e. pens 6, 8, 10 and 12) the total protein of the rations was approximately 18%.

TABLE No. 6. PERCENTAGE COMPOSITION OF PROTEIN SUPPLEMENTS

	Meat Scrap	Tankage	Fish Scrap	Buttermilk Powder	Semi-solid Buttermilk	Basal Mash
Moisture	3.84	5.89	5.90	7.62	71.25	9.82
Crude Protein (N x 6.25)	55.90	56.70	75.77	34.80	9.90	12.34
Ether Extract	14.58	10.91	3.86	5.31	1.65	4.78
Crude Fibre	1.22	1.79	.23	....	....	7.59
Lactose	....	....	....	37.91	10.90	....
Lactic Acid	....	....	....	5.82	4.60	....
Total Ash	10.51	20.28	17.63	8.47	1.90	4.95

70 lbs. ground Yellow Corn
50 lbs. Shorts
30 lbs. Ground Oats

10% Alfalfa
2.5% Bone Meal
1. % Iodized Salt

TABLE No. 7. PERCENTAGE COMPOSITION OF THE MASH

Pen	Ration	Crude Protein (Nx6.25)	Ether Extract	Crude Fibre	Total Ash
2	B.P. + Irradiation	13.5	4.7	6.8	5.3
4	10% B.P. + C.L.O.	13.5	6.7	6.7	5.2
20	10% B.P.	13.6	4.7	6.8	5.3
32	37% B.P. + C.L.O.	20.6	6.9	4.6	6.2
18	20% Meat Scrap + C.L.O.	20.8	8.7	6.1	7.8
28	15% Fish Scrap + C.L.O	21.3	6.4	6.3	6.7
30	20% Tankage + C.L.O	21.1	8.0	6.7	8.1
26	15% Fish Scrap	20.6	4.2	5.7	6.4
22	20% Meat Scrap	21.0	6.7	6.3	7.9
24	20% Tankage	21.2	6.0	6.4	8.0
10	5% B.P. + 10% Meat Scrap + C.L.O.	17.6	7.5	6.4	5.5
8	5% B.P. + 7½% Fish Scrap + C.L.O.	17.9	6.6	6.5	6.0
12	5% B.P. + 10% Tankage + C.L.O.	17.6	7.2	6.5	6.5
6	5% B.P. + 7½% Fish Scrap	18.2	4.7	6.7	6.2

The data referring to the hatchability of egg is based only upon the fertile eggs. All the eggs candled out as infertiles during incubation were broken for examination. A small percentage of the eggs removed as infertile, at the time of candling, contained a dead germ of early development.

For some years observations have been made on the amount of sunlight available and its influence on hatchability.

The following table gives the number of hours of sunlight for the winter and summer hatching seasons.

xx TABLE No. 8

Month	x Hours of Sunshine	
February	100.2	389.8 hours
March	126.2	
April	163.	
May	246.1	823.1 hours
June	263.8	
July	313.2	

x Three years average.
xx Data supplied by the Engineering Department, O.A.C.

From the above table it will be noticed that the month of July has three times as much sunlight as has the month of February. There is also a monthly increase in the amount of sunlight from February until July. April has less than two hundred hours of sunlight, while May exceeds this amount by forty-six hours, hence the division into the two periods.

TABLE No. 9. SHOWING THE INFLUENCE OF THE AMOUNT AND QUALITY OF SUNLIGHT OF THE PERCENTAGE HATCHABILITY.

Ration	Feby.	March	April	May	June	July
Buttermilk Powder	56.3	56.1	59.	71.7	72.8	74.8
Meat Scrap	51.2	47.4	44.6	55.	68.6	63.6
Tankage	10.2	21.7	29.	34.9	48.4	55.

Discussion—

The beneficial influence of the amount and quality of sunlight is clearly shown in Table 9. With over two hundred hours of sunlight the hatch is increased 12.7 per cent., 10.4 per cent and 5.9 per cent. for Buttermilk Powder, Meat Scrap and Tankage. The hatching quality of the eggs gathered in May, June and July has, for all three rations already referred to, been greatly improved over that for the months of February, March and April.

The lack of sunlight during the months of February, March and April may be substituted for by such well known substitutes as Cod Liver Oil and Ultra Violet Light.

The following tables contain a summary of three years' results from several rations differing mainly in the kind of animal protein used. In each table the results are given for a single animal protein supplement both with and without Cod Liver Oil and also with Milk and Cod Liver Oil added to the other animal proteins.

TABLE No. 10. MEAT SCRAP — PER CENT HATCHABILITY

Ration	Feb.	Mar.	April	May	June	July	x Egg Production	Lbs. Feed Required to Produce Doz. Eggs	Average Amount of Feed Consumed per Bird
Meat Scrap	51.2	47.4	44.6	55.	68.6	63.6	138.4	7.05	80.9
Meat Scrap, C. L. O.........	69.2	67.4	59.9	71.9	70.6	72.	164.2	5.95	77.5
Buttermilk Powder, C. L. O.........	76.9	75.2	60.	59.6	66.5	74.5	165.6	5.87	81.

x Eleven Months Only.

Discussion—

A combination of Buttermilk Powder, Meat Scrap and Cod Liver Oil was a more satisfactory ration than either Meat Scrap or Meat Scrap and Cod Liver Oil. When Buttermilk powder and Cod Liver Oil was added to Meat Scrap the egg production was increased thirty-seven eggs per hen, the hatchability of the eggs was much higher for the winter months and over one pound of feed was saved for every dozen of eggs laid. The beneficial influence of Cod Liver Oil when added to Meat Scrap is shown by the increase in the number of eggs produced, the pounds of feed required to produce one dozen eggs and the hatchability of the eggs for all the months but more especially for those of the winter season. It is interesting to note that after two hundred hours of sunlight were available, the Beef Scrap pen produced a much higher hatchability. A combination of animal protein supplements fed with Cod Liver Oil gave more satisfactory results than did a single animal protein supplement with Cod Liver Oil.

TABLE No. 11. FISH SCRAP — PER CENT HATCHABILITY

Ration	Feb.	Mar.	April	May	June	July	x Egg Production	Lbs. Feed Required to Produce Doz. Eggs	Average Amount of Feed Consumed per Bird
Fish Scrap	57.4	59.3	53.	56.6	69.4	71.8	165.4	6.18	85.1
Fish Scrap, C. L. O.........	64.3	60.2	50.3	63.6	66.4	67.5	177.8	5.64	83.6
Fish Scrap, Buttermilk Powder, C. L. O.........	79.2	74.	58.8	63.3	67.9	67.9	166.6	5.91	82.

x Eleven Months Only.

Discussion—

When Cod Liver Oil was added to Fish Scrap the egg production was increased one dozen eggs per hen for eleven months and it required less feed to produce a dozen eggs. Apparently the vitamin content as supplemented by Cod Liver Oil has some influence on the egg production. Cod Liver Oil did not improve the hatch for February, March and April, when added to Fish Scrap, to the same extent that it did when added to Buttermilk Powder or Meat Scrap. With Buttermilk Powder and Cod Liver Oil added to the Fish Scrap the hatch was greatly improved for February and March and was somewhat higher for April. The egg production was eleven eggs less per hen where Buttermilk Powder was added to the Fish Scrap and Cod Liver Oil and it required slightly more feed to produce one dozen eggs.

While the egg production was down eleven eggs on the average for Buttermilk Powder, Fish Scrap and Cod Liver Oil, as compared with Fish Scrap and Cod Liver Oil, the hatchability of the eggs was very much in favour of the combination ration.

TABLE No. 12. TANKAGE — PER CENT HATCHABILITY

Ration	Feb.	Mar.	April	May	June	July	x Egg Production	Lbs. Feed Required to Produce Doz. Eggs	Average Amount of Feed Consumed per Bird
Tankage	10.2	21.7	29.	34.9	48.4	55.	126.6	7.44	78.5
Tankage, C. L. O.........	27.9	41.2	28.7	39.4	57.8	57.6	157.2	6.03	79.3
Tankage, Buttermilk Powder, C. L. O.........	72.	58.6	58.7	42.7	55.6	60.4	151.	6.41	80.7

x Eleven Months Only.

Discussion—

Tankage gave a low egg production, eggs of poor hatchability, and it required over thirty per cent more feed to produce a dozen eggs than where Fish Scrap was used. Cod Liver Oil added to Tankage increased egg production thirty-one eggs per hen with almost one and one-half pounds of feed less required to produce one dozen eggs. The hatching quality of the eggs was improved for all months but was still unsatisfactory. A combination of Buttermilk Powder and Cod Liver Oil with Tankage gave a fair hatch, but did not compare favourably with the results from the other combination rations studied. Not only did Cod Liver Oil improve the hatchability of the eggs when added to Tankage but it also materially increased the egg production.

TABLE No. 13. MILK — PER CENT HATCHABILITY

Ration	Feb.	Mar.	April	May	June	July	x Egg Production	Lbs. Feed Required to Produce Doz. Eggs	Average Amount of Feed Consumed per Bird
10% Buttermilk Powder	56.3	56.1	59.	71.7	72.8	74.8	143.6	7.05	84.4
10% Buttermilk powder, C. L. O.........	73.4	69.9	60.6	54.8	64.1	65.1	153.5	6.48	82.8
xx37% Buttermilk Powder, C. L. O.........	75.8	75.7	65.8	74.1	80.	73.3	153.7	6.07	77.8
H 10% Buttermilk Powder, Irradiation....	74.1	77.2	71.7	74.	79.5	77.1	139.8	7.01	81.7

x Eleven Months Only.

xx Two year results.

H Birds handled every day except Sunday.

Discussion—

With the addition of Cod Liver Oil to Buttermilk Powder the number of eggs produced was increased, the hatchability was improved considerably for the winter months and less feed was required to produce a dozen eggs. Again it may be seen that the amount of Vitamin as supplied by Cod Liver Oil or as activated by irradiation has not only influenced the hatchability of the eggs but also the egg production. By increasing the amount of Buttermilk Powder in the diet of thirty-seven per cent there was no increase in the egg production although a little feed was saved. The hatchability was, however, higher for all the months. Irradiation from a Mercury Quartz Lamp would appear to be more efficient in activating the development of the necessary vitamin D than was Cod Liver Oil. The egg production for this pen was low, but in view of the fact that the birds were handled every day, except Sunday, and were carried in a crate to the top floor of the Poultry building to be irradiated, introduced a point of difference when comparing this pen with the other pens. It would seem that when Buttermilk Powder is fed at the same level as Meat Scrap, Fish Scrap or Tankage, there was possibly a wastage of this material.

TABLE No. 14. A COMBINATION OF PROTEINS
PER CENT HATCHABILITY

Ration	Feb.	Mar.	April	May	June	July	x Egg Production	Lbs. Feed Required to Produce Doz. Eggs	Average Amount of Feed Consumed per Bird
Buttermilk Powder, Fish Scrap....	58.2	49.1	30.9	42.6	64.5	68.1	141.4	6.78	79.9
Buttermilk Powder, Fish Scrap, C. L. O.........	79.2	74.	58.8	63.3	67.9	67.4	166.6	5.91	82.
Buttermilk Powder, Meat Scrap, C. L. O.........	76.9	75.2	60.	59.6	66.5	74.5	165.6	5.87	81.
Buttermilk Powder, Tankage, C. L. O.........	72.	58.6	58.7	42.7	55.6	60.4	151.	6.41	80.7

x Eleven Months Only.

Discussion—

Many are of the opinion that heavy egg production tends to decrease the hatchability of eggs. This does not seem to be the case when the results from the two diets—Buttermilk Powder, Fish Scrap and Cod Liver Oil, and that from Buttermilk Powder, Meat Scrap and Cod Liver Oil are considered. The average production for eleven months was 165 and 166 respectively while the hatchability averaged over seventy per cent for the months of February, March and April. When Tankage was used in place of either Fish Scrap or Meat Scrap, the egg production was down fourteen eggs per bird, more feed was required to produce a dozen eggs and the hatchability of the eggs was decreased considerably. Twenty-five eggs more per hen were produced when Cod Liver Oil was added to Buttermilk Powder and Fish Scrap. Hence almost one pound of feed was saved for every twelve eggs produced and the hatchability of the eggs was greatly increased for the more important hatching months.

A study of the three years' summary shown in Table No. 15 seems to justify the following conclusions.

1. When Fish Scrap, Buttermilk Powder, Meat Scrap and Tankage are compared from the standpoint of their feeding value for the production of eggs, they rank in the order named.

2. The addition of Cod Liver Oil to a single animal protein supplement increased the egg production with all rations tested, but much more so with Meat Scrap and Tankage than with Buttermilk Powder and Fish Scrap.

3. A combination of Fish Scrap and Buttermilk Powder failed to increase either the hatchability of the eggs or of the number of eggs produced.

TABLE No. 15. SUMMARY OF THREE YEARS' RESULTS PER CENT. HATCHABILITY

Ration	Feb.	Mar.	April	May	June	July	x Egg Production	Lbs. Feed Required to Produce Dozen Eggs	Average Amount of Feed Consumed per Bird	Total Eggs Set for Three Years
Buttermilk Powder, Meat Scrap, C. L. O.	76.9	75.2	60.	59.6	66.5	74.5	165.6	5.87	81.	5851
Buttermilk Powder, Fish Scrap, C. L. O.	79.2	74.	58.8	63.3	67.9	67.4	166.6	5.91	82.	5730
Buttermilk Powder, Irradiation	74.1	77.2	71.7	74.	79.5	77.1	139.8	7.01	81.7	4732
10% Buttermilk Powder, C. L. O.	73.4	69.9	60.6	54.8	64.1	65.4	153.5	6.48	82.8	5430
37% Buttermilk Powder, C. L. O.	75.8	75.7	65.8	74.1	80.	73.3	153.7	6.07	77.8	3682
Tankage, C. L. O.	72.	58.6	58.7	42.7	55.6	60.4	151.	6.41	80.7	5256
Buttermilk Powder, Meat Scrap, C. L. O.	69.2	67.4	59.9	71.9	70.6	72.	164.2	5.95	81.3	6103
Fish Scrap, C. L. O.	64.3	60.2	50.3	63.6	66.4	67.5	177.8	5.64	83.6	6575
Fish Scrap	57.4	59.3	53.	56.6	69.4	71.8	165.4	6.18	85.1	5958
Buttermilk Powder	56.3	56.1	59.	71.7	72.8	74.8	143.6	7.05	84.4	4985
Meat Scrap	51.2	47.4	44.6	55.	68.6	63.6	138.4	7.01	80.9	4683
Buttermilk Powder, Fish Scrap	58.2	49.1	30.9	42.6	64.5	68.1	141.4	6.78	79.9	4630
Tankage, C. L. O.	27.9	41.2	28.7	39.4	57.8	57.6	157.2	6.05	79.3	5890
Tankage	10.2	21.7	29.	34.9	48.4	55.	126.6	7.44	78.5	4523

x Two years.

4. Cod Liver Oil when added to a combination of Buttermilk Powder and Fish Scrap, Buttermilk Powder and Meat Scrap, or Buttermilk Powder and Tankage increased both hatchability and egg production.

5. Tankage does not appear to be a desirable source of animal protein, either when fed as the sole source or in combination with other animal proteins.

6. The addition of direct sunlight or sunlight substitutes, such as a high grade of Cod Liver Oil or irradiation by a Quartz Mercury Lamp, to the rations used, plus alfalfa meal, was the most important factor in producing eggs of high hatchability.

7. Vitamin D appears to be a very important factor in hatchability. The birds used in these feeding trials did not get the necessary amount of this factor until there were at least two hundred hours of sunlight per month.

8. Buttermilk Powder with Meat Scrap or with Fish Scrap together with Cod Liver Oil, appears to be the most satisfactory combination of supplements used in these trials, when hatchability, egg production and the pounds of feed required to produce one dozen of eggs are considered.

INCUBATION

The number of eggs needed to produce a chick influences the cost materially. The factors that may influence the hatch are many, including the maturity, age, and breeding of the parent stock and the kind and method of feeding. The method of incubation and the type of incubator, including the operator and the room used for incubation are also important factors.

With many factors influencing the result, the cause or causes of failures are difficult to locate, and furthermore many of these problems are not easy to investigate.

The operator must be painstaking, accurate and methodical in his habits. The management of a large number of setting hens, or the operation of incubators, requires careful attention at regular intervals. Because an incubator is equipped with a regulator does not mean that the machine will take care of all possible variations in temperature, nor will a heater produce the required units of heat without fuel. The operator must realize that he must do his part.

The room in which the incubators are operated must be well ventilated without producing direct draughts over the machines. The air of the incubator room should be as pure as that in a living room. The less variation in temperature within the room the easier the machine will operate. Any well ventilated, *clean* cellar or living room will answer.

Machines as a rule run better when set along a wall or in a corner of the room. They should not be set in direct line between an open door and a window. If so placed, unless screened, the lamp may go out or the machine may heat unevenly.

Machines for hatching, varying in capacity from fifty eggs to forty thousand eggs, are now sold. The larger sized machines are gradually replacing the smaller ones. The reasons are clear, in that the larger machines are more economical with labour and fuel. The general trend is towards central hatching stations where one may have eggs hatched at a given price per egg or where one may buy day-old chicks. Many find incubating eggs a good business, while others prefer to go to a hatchery to get their year's supply of chicks without worrying over setting hens or small lamp incubators.

Many makes of incubators have been used at this Department and most of them will give good results if carefully managed. We have seen no one incubator that excelled all others.

Cleaning and Disinfecting of Incubators

Cleaning:

Thoroughly clean out the machine, scraping from the inside, bottom and sides, any adhering dirt. Scrub out the interior with hot water to which may be added Gillett's Lye, one tablespoonful to a gallon of water, or one of the common coal tar disinfectants in the recommended strength. When the machine and trays have been thoroughly cleaned in this way, they are ready for disinfection.

Methods of Disinfection:

Liquid:—Thoroughly saturate the interior of the machine with any liquid disinfectant. The strength of the solution varies with the brand used, but one should be careful to see that the solution used is well up to strength.

Gas:—In case one does not wish to use a liquid disinfectant, Formaldehyde Gas may be used. Its application is easy and efficient when properly applied. For this use 1 gram Potassium Permanganate crystals to 1.5 cubic centimetres of commercial Formalin to each cubic foot of space in the machine. To apply, prepare the required quantities of the two drugs for your machine. Place the Potassium Permanganate in a wide, flat, enamelled vessel in the bottom of the machine, as the material will boil and spatter when the Formalin is added. When all is ready, add the required quantity of Formalin solution from an open topped container, as this must be done quickly. As soon as the Formalin is added close up the machine. Leave the machine closed for at least fifteen minutes, after which time open the doors and allow the gas to escape.

For most effective results the machine must be warm and the humidity on the wet bulb themometer 85° or better 90°. Eggs may be gassed in the machine at any time *except from the 24th to the 84th hours of incubation,* or in other words, eggs may be gassed during the first 24 hours after setting. Otherwise they must not be exposed to the above concentration of gas until after they have been in the incubator 3½ days.

Frequency of Disinfection:

Machines should be disinfected after each hatch. This, where thoroughly done, prevents any accumulation of infection from one hatch to another. *We do not advise gassing chicks.*

Operating an Incubator

Given a suitable room, the first thing is to clean the machine before and after every hatch. The next operation is to set the machine level. The thermometer must be accurate, and to assure accuracy it should be tested at least once, or better, twice during the year, by having it checked with a clinical thermometer. The temperature given is usually one hundred and three degrees Fahrenheit throughout the hatch. Our experience has been that it is better to take an objective of one hundred and one to one hundred and two degrees, and if the temperature creeps up to one hundred and three degrees, we have no cause to worry. If operated at a temperature of one hundred and three degrees, and the temperature rises to one hundred and four or above, either the hatch is small or the chicks hatched are hard to rear. Low temperatures are not so fatal as are high temperatures.

The amount of moisture required in an incubator depends upon the make and the room. Generally it is best to follow the manufacturer's directions.

Cooling and Turning. Eggs incubated in cabinet type incubators are turned by the use of mechanical turners and are not cooled. A forced draft ventilation supplies plenty of oxygen for best results, and frequent turning of the eggs stimulates the interchange of oxygen for carbon-dioxide given off by the developing embryo. The $C\ 0^2$ is then removed by the ventilation. It is not necessary to hold as high temperature in such a machine as it is in a deck type incubator. If one did, the chicks would hatch before the 21st day. Cabinet type incubators hatch well when operated at 99.5° to 100° F., although the correct temperature depends much on the percentage humidity in the machine.

It is not necessary to cool eggs in a farm or deck type incubator if it has a good ventilation system. Cooling retards development of the embryo by lowering the temperature of the eggs below the optimum for growth. While cooling encourages the interchange of carbon-dioxide within the egg for oxygen in the ouside air, frequent turning of the eggs inside a well ventilated machine will secure just as satisfactory results in this respect without cooling. Where eggs are regularly cooled, it is necessary to operate the incubator at a temperature of from 102° - 103° F. in order to have the chicks hatch on time. A temperature of 101° F. during the first week, 102° F. during the second week and 102½° - 103° F. during the third week of incubation will hatch the chicks on time when no cooling is done. Most modern incubators are well ventilated and sufficient additional airing of the eggs is secured during the time the eggs are removed from the machine for turning. If the temperature should accidentally rise too high, the tray should be removed and set on the top of the machine and the eggs allowed to cool for a short time. The incubator door should be kept closed while turning the eggs in order that the eggs when returned to the inside will return to hatching temperature quickly.

The eggs should be turned at least twice each day, commencing on the third day, although in cabinet machines they are turned from the time they are put into the incubator. Turning prevents the embryo from adhering to the shell membrane and also exercises the embryo. Three or four turnings per day will increase the percentage hatch from 2 to 5% above that secured where only two turnings are given. Machines with mechanical turning devices allow eggs to be turned easily and quickly. When eggs must be turned by hand the value of the time involved in giving more than two turnings per day may offset any improved hatch secured. Turning is discontinued on the eighteenth day. It should be remembered that eggs should be turned fairly gently as rough handling is detrimental to the production of a good hatch.

It is wise to follow the manufacturer's instructions until such time as experience indicates suitable changes for the operator's particular conditions.

Hatching by the Natural Method

Setting the Hen. It is generaly agreed that, in order to secure a goot hatch, the hen must be placed where other hens are not likely to disturb her, for, as a rule, we seldom get good hatches when other hens lay in the nest with the setter. Some farmers do not set a hen until one becomes broody on a nest where no others lay. Such a practice often results in the production of late hatched chicks. The difficulty can be overcome by making a new nest for the broody hen. For this purpose one may use a box about twelve inches square and six inches deep. Place some earth or an overturned sod in the bottom, being careful to have the corners very full so that no eggs can roll out from under the hen and become chilled. Place about two inches of straw or chaff on top of the earth and shape it to the form of the nest, then place in it a few nest eggs or cull eggs for the hen to set on. The hen should be set in some pen where nothing will disturb her. She will usually set better if moved to the nest after dark. Feed and water must be within easy reach, and a dust bath should also be convenient. If on the following day the hen is setting quietly, you will be safe in putting the eggs under her. We get ninety per cent. of the hens to set by the use of this method. The hen should be dusted with Sodium Fouride or some other good insect powder when set, and also a few days before the hatch comes off. This treatment will control body lice and, therefore, keep the hen more comfortable.

Selection of Eggs for Hatching

Select for size, shape and colour. In view of the weight standards for market eggs, it is wise to select eggs for hatching which are two ounces or better in weight. It is well to keep in mind that two-ounce pullet egg is equal to a somewhat heavier egg from the same bird as a hen. Continuous selection, year after year, will give results. Do not select dirty eggs nor handle eggs with soiled hands. The egg shell is porous, hence there is a possibility of contamination.

Eggs deterioate in hatching quality with age. When holding eggs for hatching, keep them in a cool place at about fifty to sixty degrees Fahrenheit. The temperature should be uniform. Be sure that the place is clean and not musty. Eggs for hatching should be kept not longer than ten days, and the sooner the eggs are set after being laid, the better the hatch is likely to be.

CHICK FEEDING PRACTICE

A Baby Chick Starter requires to be as complete a feed as is known. It must contain all the elements for health and for growth. Many chicks are now reared in-doors from hatching time to market age. When chicks have no opportunity of eating things that grow in the fields, such as grass, insects, etc., and are kept out of direct sunlight, it becomes necessary to supply the chicks with a complete ration.

The ration must contain not only a mixture of the cereal grains or their by-products, but a variety of animal proteins and minerals, plus the necessary vitamins

Fortunately there are now offered for sale very good chick rations by many commercial firms.

The following Baby Chick Starter has been the most satisfactory of any ration we have tested to date:

Equal parts by weight of:—

Ground Yellow Corn (grade equal to No. 2 natural),
Ground Wheat,
Ground Barley,
Ground Hulled Oats, or ordinary Oats with most of the hulls sifted out.

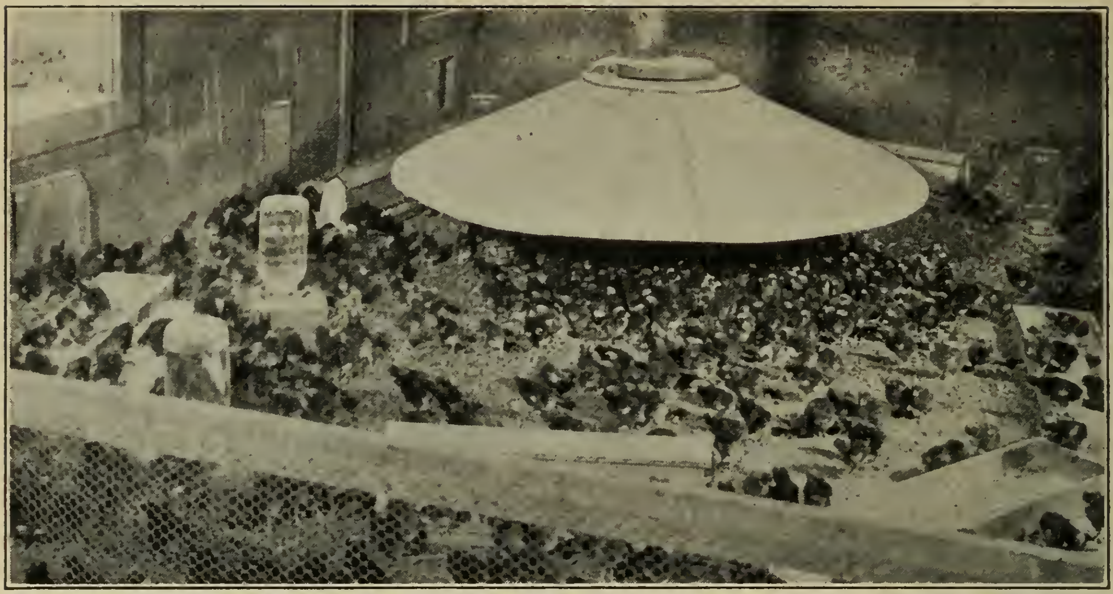


Fig. 43. Coal burning colony brooder stove with baby chicks, hoppers and fountains.

To each 100 pounds of the mixed ground cereals add:

5 pounds Buttermilk Powder,
5 " Fish Meal,
5 " Meat Scrap,
5 " Alfalfa Leaf Meal,
½ " Iodized Salt,
1 pint Cod Liver Oil.

Place a hopper each of Bone Meal, Fine Oyster Shell, small size Grit and Ground Lime Stone in easy access to the chicks.

Where it can be secured, the addition of 5 pouonds of Wheat Germ Meal to each 100 pounds of feed is advised.

The cod liver oil is mixed with some ground corn and then sifted into the entire mixture. This mash should be mixed thoroughly.

Where one has plenty of liquid milk for drink for the chicks, practically all meat scrap, fish meal and buttermilk powder may be left out of the ration.

The chicks may be fed as soon as they are taken from the incubator. Chicks will live very well without feed for three days. The matter of the age of the chicks at the time of the first feed is to a large degree a question of convenience, so long as the chicks are not much over three days old.

The above mixture may be fed from the time the chicks are put in the brooder until they reach broiler age.

The chick starter is fed in hoppers and is constantly before the chicks. We recommend placing a hopper each of grit and bone meal before the chicks, so that they may eat it if they desire this kind of feed.

Hard grain such as whole wheat, small cracked corn and crushed oats may be fed after the chicks are two weeks old. It is likewise good practice to feed some alfalfa or clover leaves, or sprouted grains. The more hard grain given, the lower is the animal protein intake and one may slow up the rate of growth unless additional protein is fed in some form such as milk to drink, or some other form of animal protein.

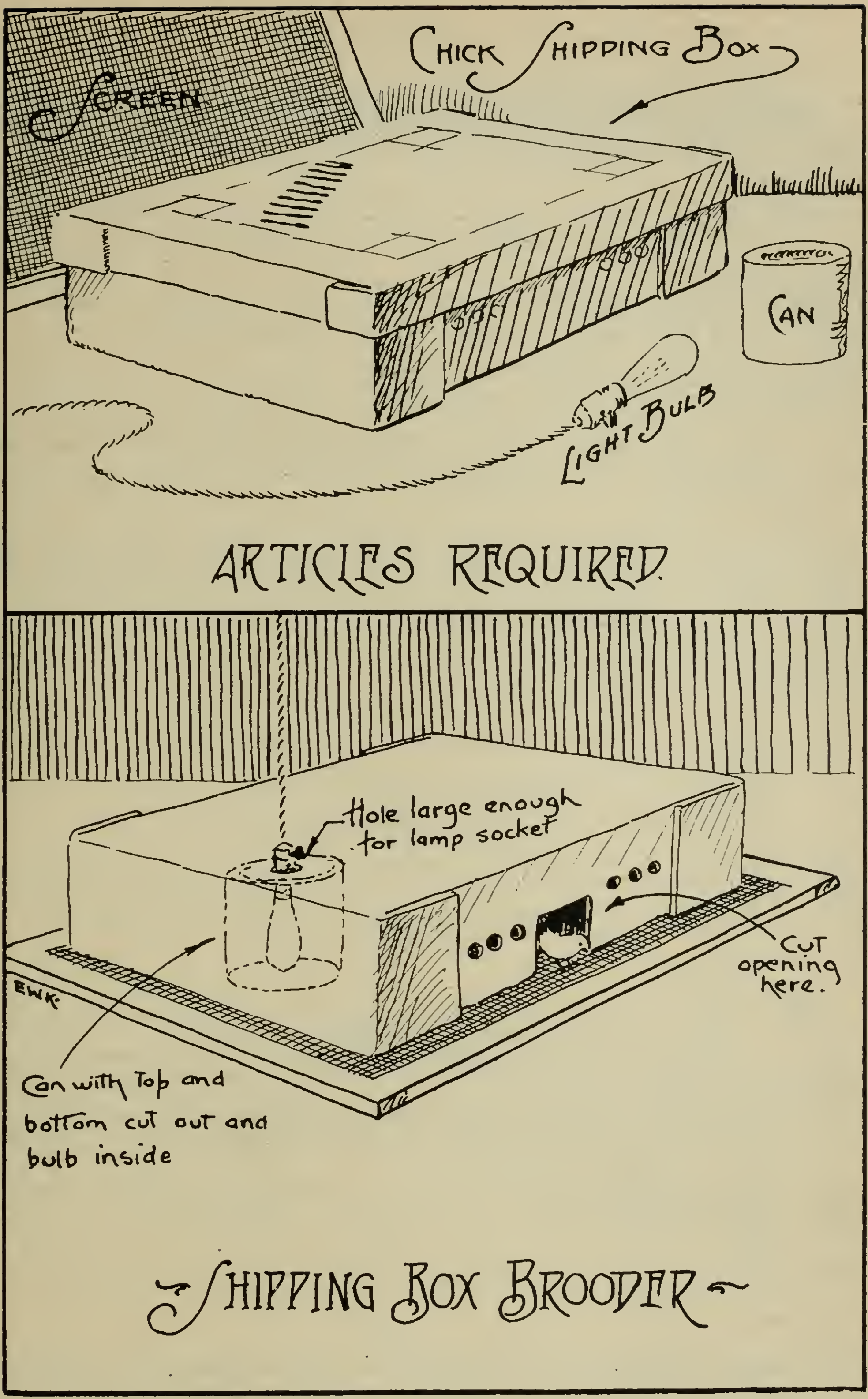


Fig. 44. Shipping box brooder, heated with an electric light bulb, 40 watts.

Many chicks are grown on an all mash ration. It has been our observation that the feeding of a variety of crushed grains in hoppers and in addition the supplying of grit in small hoppers, and also the regular feeding of second cut alfalfa hay, result in a more contented chick but not in a faster growing one.

Internal parasites may be avoided by letting the chicks out of doors on hardware cloth of about one-quarter to one-half inch mesh, raised high enough above the ground to permit of cleaning.

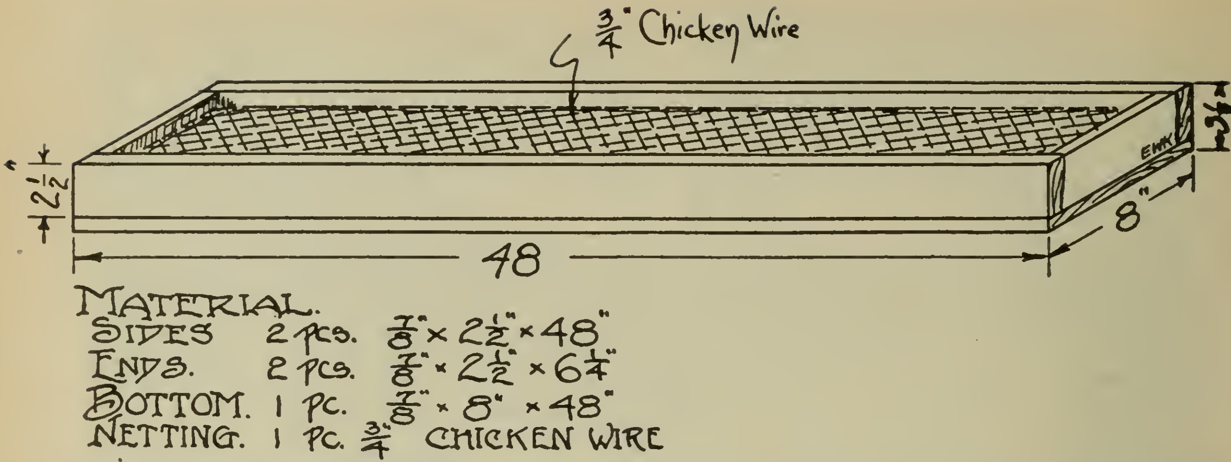


Fig. 45. Plan showing construction of a home-made chick feeder for feeding dry mash to young chicks in the brooder.

When the birds get on good clean grass range, the alfalfa and other green feeds may be left out of the ration. If the grass becomes long, run a mower over it but do not cut the grass too close. It is important to move the feed hoppers and drinking vessels daily. The house should be moved frequently enough to prevent the entire killing of grass near it.

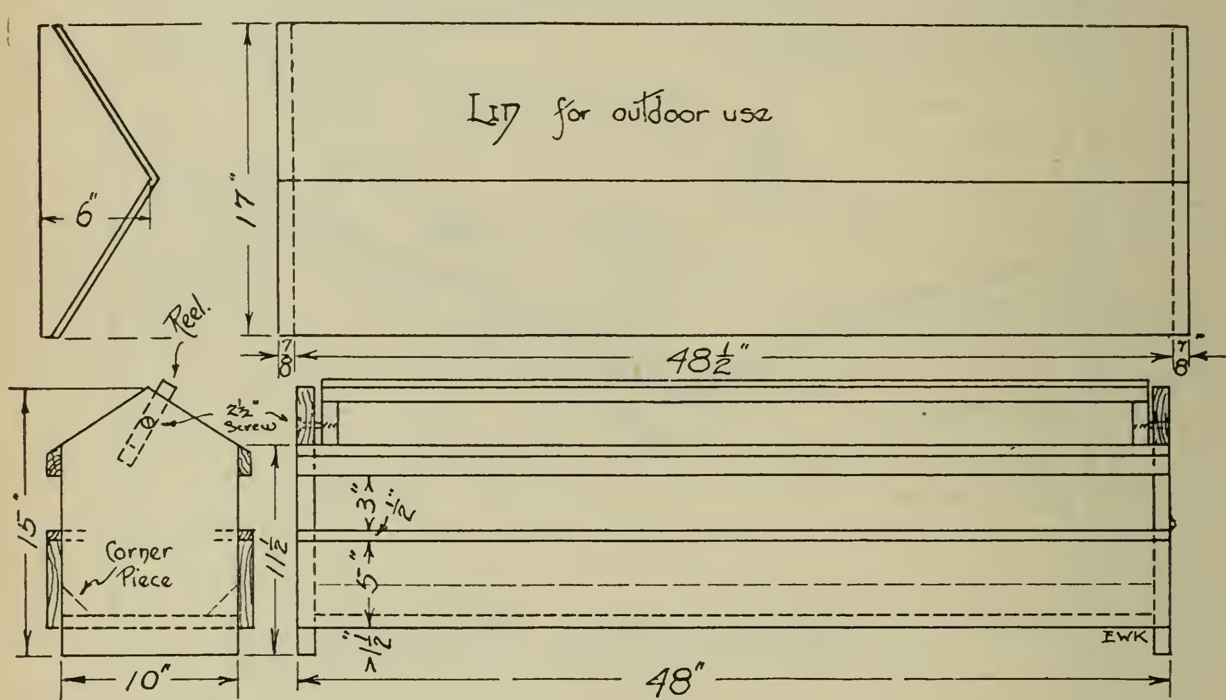


Fig. 46. Showing plans for the construction of a real type of dry mash hopper. This is adapted for feeding of dry mash to growing chicks on range in which case the lid is used. It may also be used for feeding dry mash to laying hens by removing the lid and inserting the reel.

Many good chickens on range have been grown on crushed oats, whole wheat and a good pasture, together with a little skim milk. Care should be taken to daily remove the oat hulls from the hoppers.

Chickens can be grown in confinement, but any grown under such conditions at this department lack normal bloom or condition. One may be forced to grow them off the ground owing to a lack of suitable range, but it is well to remember that a good grass range helps the general appearance and growth of the chickens.

When chickens are on range, supply sufficient hoppers. Do not overcrowd in the house or on the range, and above all, watch for overcrowding during the month of August, at which time birds readily contract summer colds.

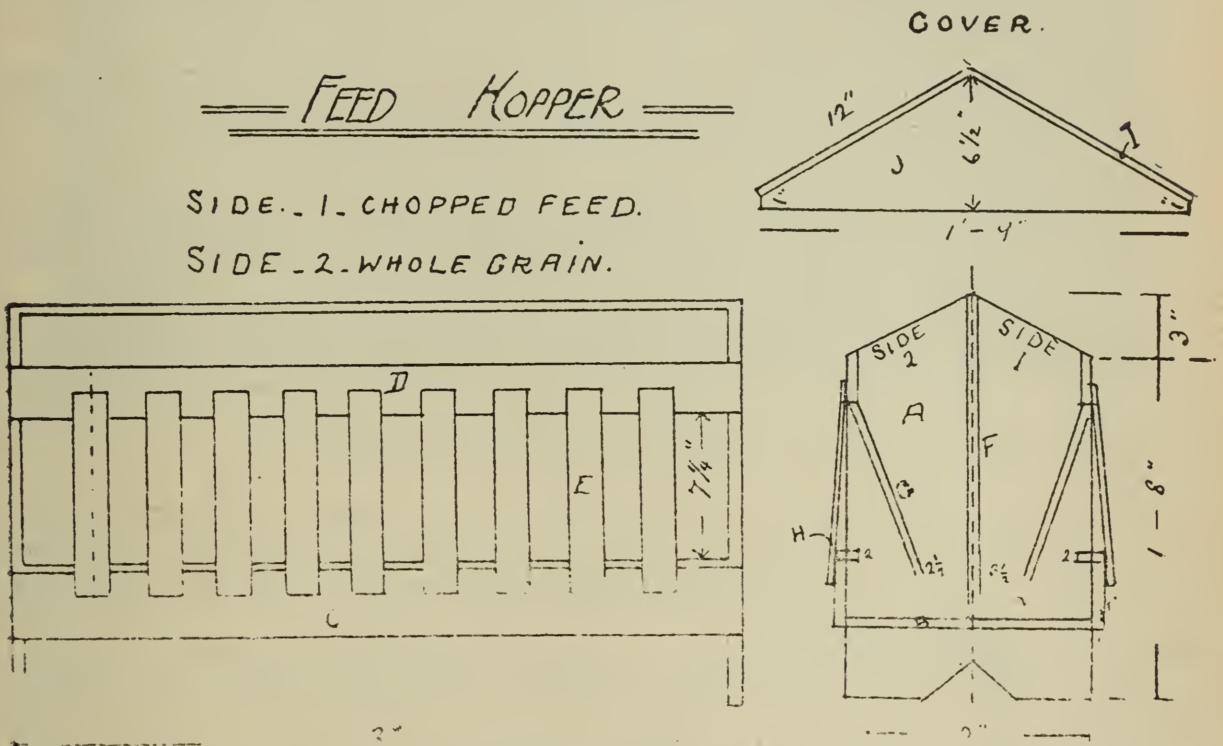


Fig. 47. Double feed hopper for use on range.

Bill of Material.

A. 2 ends ⅞ x 12 in. x 1 ft. 8 in.
B. 1 Bottom ⅞ x 12 in. x 2 ft. 10¼ in.
C. 2 sides ⅞ x 3¾ in. x 3 ft.
D. 2 sides ⅞ x 2½ in. x 3 ft.
E. 18 pieces ⅜ x 1⅝ x 10 in.

Side 1.—Chopped feed.

F. 1 division ½ x 16 in. x 2 ft. 10¼ in.
G. 2 divisions ½ x 9½ in. x 2 ft. 10¼ in.
H. 2 pieces ¼ x 1 in. x 3 ft.
I. 2 pieces ½ x 12 in. x 3 ft. 2 in. } Cover
J. 2 ends ⅞ x 6½ in. x 1 ft. 9 in. } Cover

Side 2.—Whole grain.

When chicks run out in the direct sunlight, no cod liver oil need be fed after the 1st of April. There is plenty of vitamin D in the direct sunlight by the time seeding begins in the Spring.

Unless a person is trying to hurry the chicks along so as to produce broilers in as short a time as possible, it is a good practice to reduce the amount of animal protein in the ration after the chicks are five to six weeks of age. This can be done very easily by gradually increasing the amount of whole or hard grain given, until the feed intake is about equal parts of hard grain and mash.

If the chickens are developing too rapidly, reduce the amount of buttermilk powder, meat scrap, etc., or if giving milk as a drink, decrease the amount. Always keep a supply of grit within easy access.

REARING CHICKS.

Preparing a Brooder for Chicks:

A — Learn how to operate the brooder stove before you put the chicks around it, and remember that high windy days and nights mean more attention to the stove, or it may burn out.

B—Do not place the colony house close to trees, buildings or other obstructions to air currents, otherwise one may have considerable trouble with lack of draught and slow burning coal.

C — Place your brooder as near the centre of the pen as possible, and our experience has been that the stove burns better if the pipes go straight up through the roof.

D — A colony house twelve feet square will accommodate 300 chicks to five or six weeks of age, or, in other words, allow one half square foot of floor space per chick to the age of five or six weeks, and for the following six weeks double the amount of floor space, or reduce the flock to 150 chicks.

E — The temperature of the brooder house is important. Chilling and overheating are very apt to cause bowel trouble. The floor of the pen should be free from draughts. Early in the season it may be necessary to line the house with paper to prevent floor draughts.
The temperature should be 95° at a level of the chick's back at the edge of the hover.

F — Use one drinking vessel for each fifty chicks. A chick hopper two feet long and open to feed from both sides is ample for fifty chicks for the first three weeks—after this age, double the number of hoppers.

G — Run a circle of wire netting of one inch mesh around the hover at least two feet from the edge of the hover. This keeps the chicks near the source of heat and prevents bunching or crowding. Watch the corners of the pen. It is generally good business to put some wire netting across the corners so that the chicks cannot bunch or pile in them.

H — If the sun shines in the pen near the brooder, white wash or cover the windows, for at least the first week. Chicks like to huddle in the sunshine and some broods learn to bunch or crowd in this way.

I — Keep the chicks comfortable and the air pure. The odour of the pen will suggest the amount of ventilation.

J — Put in small roosts as soon as the chicks desire to perch. They will sit on the perches considerably during the day, long before they roost at night; but all the time they are getting the roosting habit, and once on the perch at night, they require much less attention.

K — It is a good plan after the first week in the brooder, to have a small box of grit and fine oyster shell for the chicks to eat.

L — Care must be taken to keep the pen clean and dry. Do not have moist litter near the drinking vessel or anywhere in the pen. Clean the pen at least once each week, or oftener if necessary.

M — Keep the chicks comfortable.

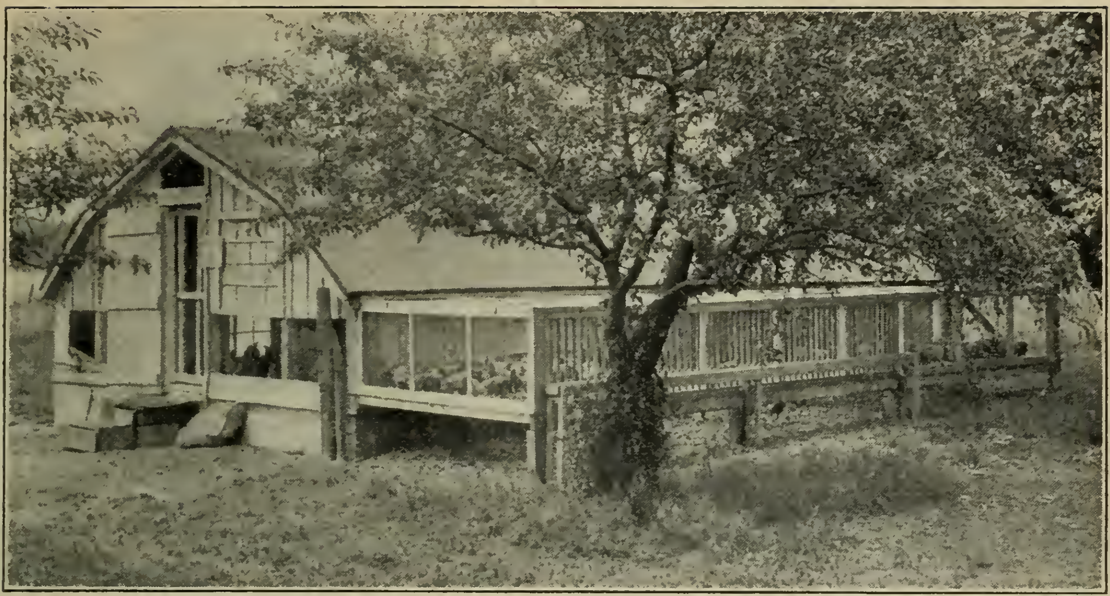


Fig. 48. Wire floored rearing pen of value in the control of Parasites and Coccidiosis.

MARKET POULTRY

The production of dressed poultry of high quality has been a profitable busines to some of the producers during the last few years. The advent of definite legal grades has changed the general marketing conditions in many parts of the Province. There is difficulty in marketing any produce of low grade, and the top grade is not easy to produce.

The regulations governing the grades of poultry are under the Dominion Live Stock Branch, and information as to these grades, regulations, etc., will be gladly furnished to parties writing to The Live Stock Commissioner, in Ottawa.

The market prefers a chicken well fleshed, well fattened, and cleanly plucked. This means that the breast must be well covered with flesh and the back of the chicken should show a considerable layer of fat, as well as a good covering of fat over the pin bones. A well finished chicken will have a layer of fat around the wish bone. The best grades of dressed poultry have white fat. The flesh must be soft.

The production of high grade market poultry is the result of intelligent breeding and feeding. One may expect some difficulty in getting well fleshed birds where the parent stock is not carefully selected for this purpose.

The trade has, for some years, purchased poultry on the market on a classification according to weight and not according to quality.

The mass production of broilers under crowded conditions where little or no attention is paid to properly finishing the chicken has created a serious difficulty in the quality of the broilers. Spring chickens, in order to sell well, must be well fleshed and reasonably fat. Bare backed cockerels and birds with crooked breasts and legs are not wanted on the market.

The general tendency of a young male is not to fatten readily. Where the males are caponized, they fatten more easily. Generally speaking, immature cockerels or birds under five pounds in weight, of such breeds as Plymouth Rocks, Wyandottes, etc., are comparatively easy to get well fleshed and fattened. At heavier weights they may develop spurs and if so will be graded as "stags".

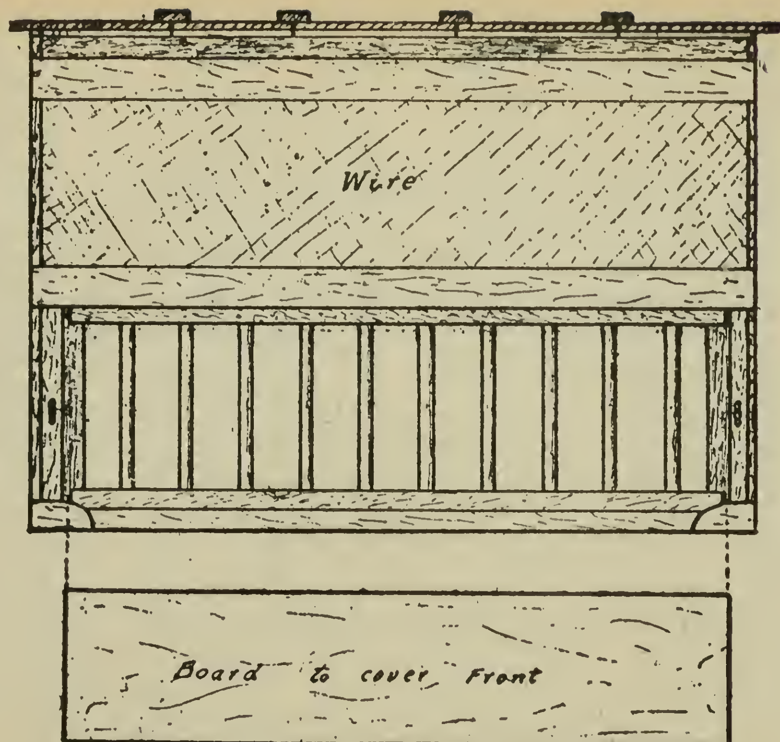


Fig. 49. Front of a convenient coop for hens and chicks.

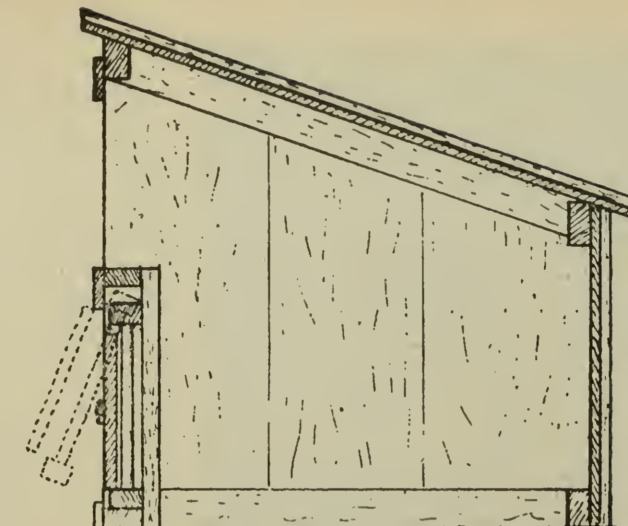


Fig. 50. Cross-section.

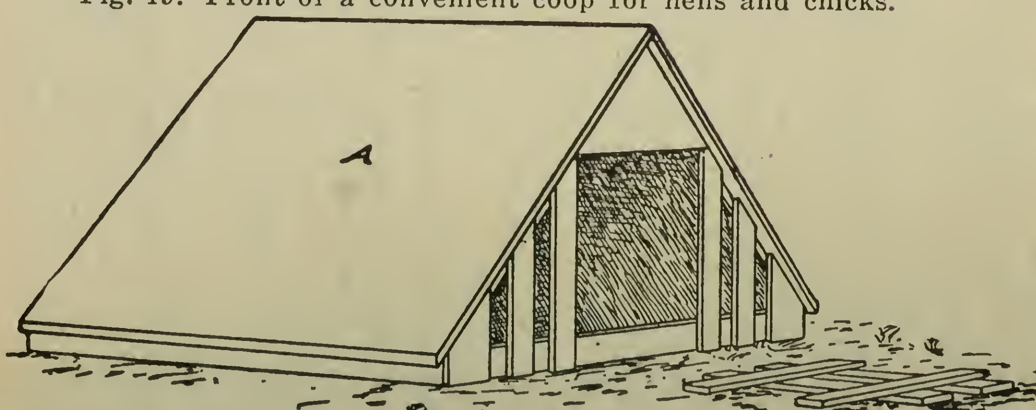


Fig. 51. Coop A—Each side of roof 24 in. by 30 in.; bottom 2 ft. 4 in.

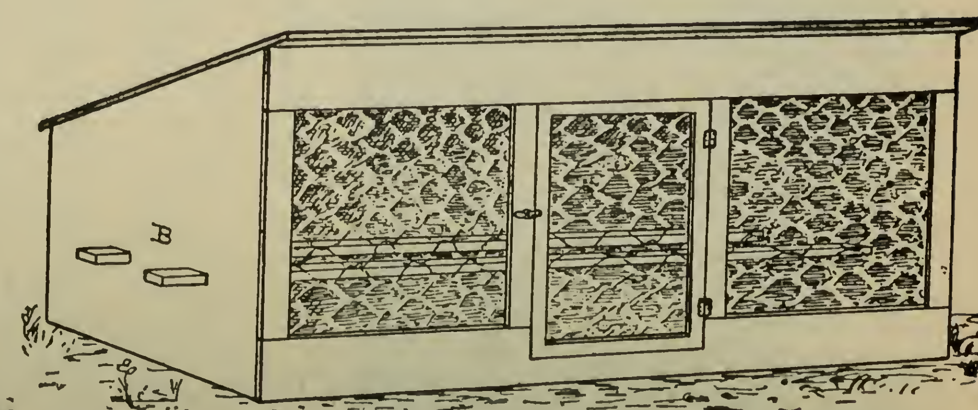


Fig. 52. Coop B—Length 6 ft.; width 2 ft. 6 ins.; height in front, 2 ft. 4 ins.; height at back, 18 ins.

The ordinary cockerel bred from high laying hens is inclined to be deep in the breast bone and not very well fleshed, and, therefore, in the selection of males for breeding purposes some attention should be given to the fleshing of the breasts of the males.

FATTENING CHICKENS

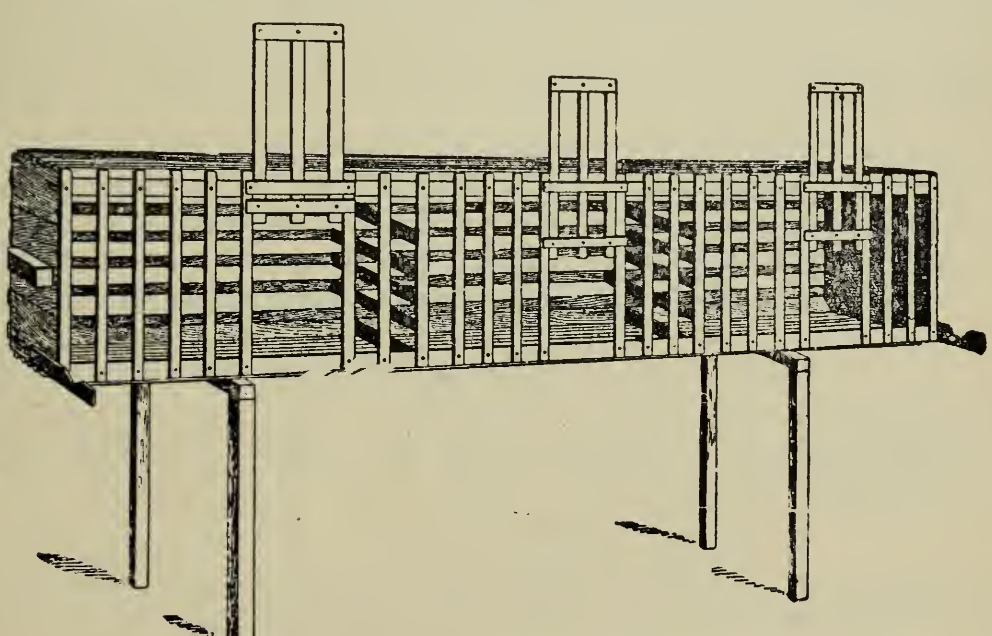
The greater quantity of poultry going on the market today is not properly fatted. The introduction of grading, and the premium price paid for milk-fed A grade should induce the producer to give more attention to the proper finishing of his birds. Chickens taken direct from the range, even where grown under the most ideal conditions, will probably not grade higher than third grade. Such birds if subjected to from two to four weeks of intensive feeding would, in many cases, grade top and, in addition, show very economical gains for the feed consumed.

Birds, to fatten efficiently, must be in good health when placed in the crates. If suffering from colds, roup, worms, or other infections or parasites, they will probably lose rather than gain in weight. Good, thrifty, slightly immature cockerels either pure-bred, crosses or grades, of such breeds as Plymouth Rocks, Wyandottes, Rhode Island Reds, Orpingtons, Sussex, Jersey Giants, Dorkings, Games, etc., make economical gains. It is seldom found profitable to attempt to feed for roasters such breeds as Leghorns, Minorcas, or birds of similar characteristics, although they make fairly good broilers.

The greatest gains are made during the first two weeks of feeding. Where feeding longer it would be necessary to get a premium price in order to pay for the longer feeding and the slower rate of gain. Birds are fed twice daily. Three feeds have been given but the slightly increased gain was often insufficient to pay for the extra labour.

CONSTRUCTION OF FATTENING CRATES

Fattening crates are usually made seven feet six inches long, eighteen to twenty inches high, and eighteen inches wide. The crates are divided into three compartments, each holding from four to five birds, depending upon the size of the chickens.



Fg.i 53. Showing a single crate or coop.

The crate is made of slats, except the ends and partitions between the compartments, which are solid wood. The slats at the top, bottom and back run lengthwise of the coop, while those on the front run up and down. The slats are usually one and one-half inches wide and five-eighth inches thick. Those in the front are placed two inches apart to allow the chickens to put their heads through for feeding. The slats on the bottom are placed about three-quarter inches apart, so as to admit of the dropping passing through to the ground. Care should be taken not to have the first bottom slat at the back fit too closely against the back. An opening between the first slat and the back prevents droppings from collecting and decomposing. The slats on the top and back are usually two inches apart.

There is a small V-shaped trough arranged in front of the coop for feeding and watering the chickens. This trough is from two to three inches deep, and is generally made of three-quarter inch lumber. Very fair coops may be made from old packing boxes by taking off the front and bottom and substituting slats in their place. During warm weather these crates may be placed out of doors. They need to be protected from the rain, which is easily accomplished by placing a few boards oyer them. In cold weather the crates should be placed in a house or shed where they are protected from raw, cold winds. When fattening chickens inside of a building, it is well to darken the building and keep the birds as quiet as possible.

After each lot of birds is killed, the crates are painted with some liquid lice killer. Coal oil and carbolic is very good. Use one gallon of coal-oil to one pint of crude carbolic acid. We have used some of the prepared mixtures with good results. If the birds (bought from different parties) are lousy when put in, they should be well dusted with Sodium Flouride, or other good insect powder. Some people use sulphur, but when this material is used care should be taken not to use too much, as an excess may produce a scaly condition of the birds' skin. Lousy birds do not fatten economically and are unpleasant to pluck.

The birds should be watered at least twice every day in warm weather. Grit should be given them twice a week.

Crate Feeding vs. Loose Pen Fattening of Chickens

The term "fattening of chickens" has been in use for some time, but it does not exactly convey the meaning intended by the feeders of chickens. The object is to improve the fleshing and add just sufficient fat to make the chickens cook well. The chickens are not intended to be abnormally fat, yet at the same time they carry considerable fat well intermixed with lean meat.

We have for a number of years conducted experiments with chickens in crates and in loose pens. We have tried about six different feeders with varying results. Several feeders secured equally as good results with birds in crates as with those in loose pens. Two feeders in particular fed birds to better advantage in crates, while one feeder could get slightly better returns, although not always, with birds in pens.

The majority of buyers seem to think that crate-fed birds are much superior to those fed in loose pens. We prefer feeding birds in crates, because it takes less room, and we believe that we can feed them with less expenditure of labour and get a more even product.

How to Feed

We have received a number of enquiries as to how to feed birds that are being fattened, and the exact amount of feed fed each day. In answer to these enquiries, a sample feeding schedule is here given.

Birds brought in from the range hould be starved for about twenty-four hours, during which time water may be given. They must be fed lightly at first, giving only what will be eaten up in about 10 minutes. As the amount fed is increased the time for feeding is also increased until at the end of the feeding period they are allowed from twenty to thirty minutes in which to feed. Any feed left in the troughs after the specified time is removed.

Table 16, showing amounts fed morning and evening to two lots of four birds each. The first lot shows steady increase in amount fed, while the second shows irregular increase.

	LOT No. 1				LOT No. 2			
	Morning		Evening		Morning		Evening	
Dates	Meal	Milk	Meal	Milk	Meal	Milk	Meal	Milk
Oct. 10..	..........oz.	.... oz.	4.25 oz.	6.25 oz.	..........oz.	.... oz.	5.0 oz.	7.5 oz.
" 11..	5.0 "	7.5 "	5.5 "	8.25 "	5.0 "	7.5 "	6.0 "	9.0 "
" 12..	6.0 "	9.0 "	6.5 "	9.75 "	6.5 "	9.25 "	6.0 "	9.0 "
" 13..	7.0 "	10.5 "	7.0 "	10.5 "	6.0 "	9.0 "	5.5 "	8.25 "
" 14..	7.0 "	10.5 "	7.0 "	10.5 "	6.0 "	9.0 "	6.5 "	9.25 "
" 15..	7.5 "	11.25 "	7.5 "	11.25 "	6.0 "	9.0 "	5.5 "	8.25 "
" 16..	7.75 "	11.75 "	7.75 "	11.75 "	6.0 "	6.0 "	6.0 "	9.0 "
" 17..	8.0 "	12.00 "	8.25 "	12.00 "	6.5 "	9.25 "	7.0 "	10.5 "
" 18..	8.5 "	12.25 "	8.75 "	13.00 "	8.0 "	12.00 "	8.0 "	12.0 "
" 19..	9.0 "	13.50 "	9.25 "	14.00 "	8.0 "	12.00 "	9.0 "	13.5 "
" 20..	9.5 "	14.25 "	9.75 "	15.75 "	10.0 "	15.0 "	10.0 "	15.0 "
" 21..	10.0 "	15.00 "	10.25 "	15.25 "	10.0 "	15.0 "	9.0 "	13.5 "
" 22..	10.5 "	15.50 "	10.75 "	16.00 "	9.0 "	13.5 "	9.0 "	13.5 "
" 23..	11.0 "	16.50 "	11.25 "	16.75 "	10.0 "	15.0 "	8.0 "	12.00 "
" 24..	11.25 "	16.75 "	12.00 "	18.00 "	10.0 "	15.0 "	10.0 "	15.0 "

It is difficult to give a ration suitable for fattening chickens that meets the requirements of every individual. Many of us have to use whatever feeds are available, and for that reason we are giving several rations that have generally proved satisfactory. The grains in a ration should be ground as finely as possible and mixed with milk to the consistency of a pancake batter, so it will pour. Usually better results are secured when the feed is mixed twelve hours prior to feeding. It is advisable to feed some grit at least once each week.

It is of the utmost importance that the birds be kept with keen appetites, as a little over feeding at the beginning usually results in indifferent gains. The birds should be kept in a cool, comfortable and rather secluded place, so as not to be disturbed by other birds or by the visiting public.

Fattening Rations

One satisfactory ration is composed of equal parts, by weight, of ground oats (with the hulls sifted out, or ground oat groats, or oat middlings), white hominy and ground wheat. This is mixed with thick sour milk, or where milk powder is used, add twenty per cent. to the grain mixture.

The hominy and oats improve the palatability of the ration and help in the production of fat. Meat meal may be used in place of the milk but does not produce as good colour of fat nor as satisfactory gains.

Another very good ration is composed of two parts finely ground oats, two parts finely ground buckwheat and one part of finely ground corn, moistened with sour milk.

Any feeds that are palatable and well mixed, so that the meal will stay in suspension with the milk, will give in most cases reasonably good results. It is not advisable to use only one kind of cereal.

KILLING AND DRESSING POULTRY

All birds should be fasted for twenty-four hours before killing, and during the period of fast be given some water to drink. If this is not done, any feed remaining in the crop and intestines at the time the bird is killed, decomposes. As a result of this decomposition, strong smelling gases are liberated which taint the flesh of the bird, not only destroying its flavour but very seriously lowering its keeping qualities.

All birds should be killed by bleeding, preferably through the mouth. This is a very simple operation and a little practice will ordinarily make one fairly proficient at this work. Two general methods of handling the bird are used. The

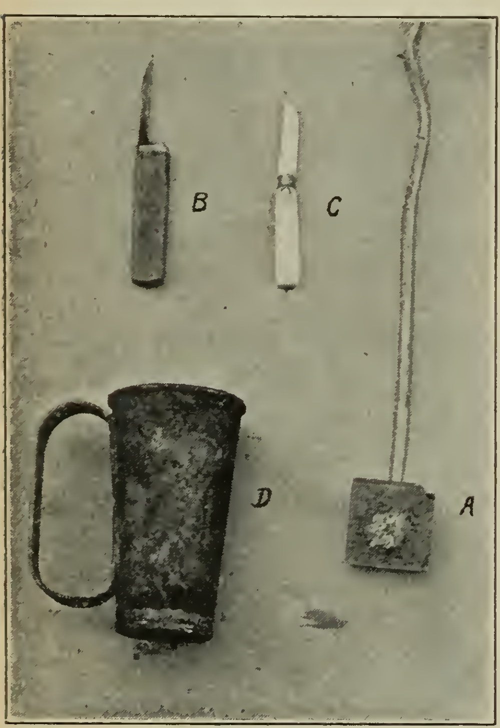


Fig. 54. Killing and Plucking Equipment. Killing knife, pinning knife, weighted blood-cup, and rope with block for hanging bird up.

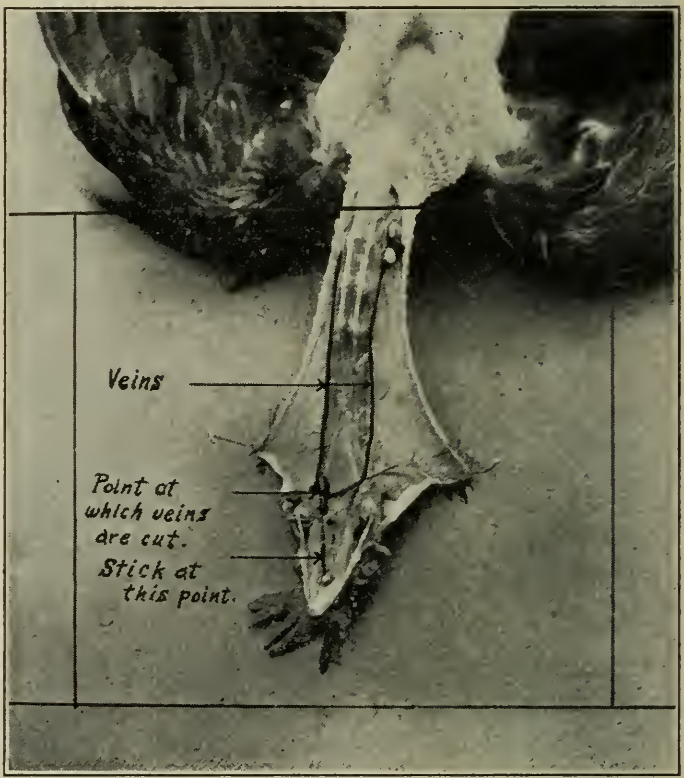


Fig. 55. Anatomical view of neck showing the location of veins, also the cleft in the roof of the mouth where bleeding and braining operations are performed.

one is to place the bird on a padded bench or table, and the other is to hang the bird up by the feet with a rope or cord. For the average person the latter method is preferred, as with it there is less danger of bruising or barking the skin than where the bird is lying upon some object. The one end of the rope or cord may be fastened to a small rod or pole and to the other end is attached a small block about two inches by two inches as shown in Fig. 54.

Fig. 56. Bleeding operation.

When hanging the bird up, the end of the rope which is attached to the block is placed around the feet and the block dropped in between the bird's feet and the rope. This holds the bird without tying, and should be so adjusted that the bird's feet are about on a level with the picker's shoulders.

For bleeding, a sharp knife with a blade about three inches in length is most satisfactory. A regulation killing knife is shown in Fig. 54. To bleed, catch the bird's head with the thumb and forefinger just at the juncture of the neck and head, or at the ear-lobes as shown in Fig. 56, then with the third finger open the chicken's mouth. Next insert the knife and pass it down the throat practically the full length of the blade, then with the edge of the blade turned downward, cut rather heavily with a drawing stroke of the knife. The object is to sever the jugular veins at the point where they unite at the upper part of the throat, as shown in Fig. 55.

The bird should bleed freely if the cut is made at the proper point. Next, turn the blade of the knife over and insert the point of the blade in the slit or groove in the roof of the mouth, as shown in Fig. 55 and then quickly push backward so as to pierce the brain. If the back of the knife is kept in a line with, and touching the point of the bill, the blade will pierce the brain. One can tell when this is done because the chicken will squawk. If the bird does not squawk the brain is not pierced, which means tight feathers and hard picking. As soon as the sticking operations are completed attach a blood can to the lower bill. This catches the blood, thus preventing it being thrown about, and the can being weighted tends to hold the bird still. For a blood can, any small can to which a small hook can be attached will answer the purpose. In Fig. 54 is shown a style of blood can which is used extensively in the packing houses. In this can the hook is solidly attached on the inside near the handle. The can is weighted with three-quarters of an inch of lead in the bottom. Cement or a small stone will answer the purpose equally well.

The chicken should be plucked immediately, first removing the long wing feathers and tail feathers, then those feathers on each side of the breast, those on the legs, and lastly those on the back. Do not try to pull the feathers either forward or backward, but somewhat sideways or at an angle. The rough or coarse feathers should be removed in the shortest time possible, as the more quickly the feathers are removed after sticking the easier they will pull and the less danger there is of tearing the skin. In removing the wing feathers for instance, grasp both wings in the left hand and the feathers of both in the right, removing them all at one stroke of the right hand. Next, raise the right hand to the tail, grasping all the feathers in the tail, and with a slight twist remove with a second stroke of the right hand, and so on over the different sections of the body. To remove the pin feathers, use a dull, round-bladed knife, similar to an ordinary paring knife. (See Fig. 54). Be careful not to rub or bark the skin. This may be done very easily by rough handling, or by placing the chicken in contact with coarse clothing, hence do not put the chicken on your lap to pluck it. If you should, unfortunately, tear the skin, hold the skin at the torn part tightly to the body between the thumb and first finger, and then remove the rough feathers near the torn part. Anyone, with a little practice, can entirely remove the rough feathers from a bird in from three to five minutes. Expert pickers will do it in from three-quarters of a minute to one minute.

The bird should be plucked clean, the blood washed from the head and out out the mouth, and the feet washed clean.

The cooling rack allows free circulation of air around the birds, resulting in more rapid cooling, which in large packing plants is very important. In such places we find the cooling rack in common use.

Many good chickens are spoiled by being packed before they are thoroughly cooled. Care should be taken that all the animal heat is out of the body before they are packed. We find it advisable to cool the birds at least twelve hours before packing them.

Fig. 57. Cooling rack.

In packing for shipping, they should be packed in boxes holding one dozen birds to the box. The size of the boxes varies with the grade or size of chickens placed in them, but should be such that when the chickens are packed they are absolutely tight, so that there is no possibility of them shaking about, and becoming bruised. The boxes are best made of basswood or similar wood, free from odour, as otherwise the flesh of the birds will absorb the odour, tainting the flesh. The box is lined with parchment paper and, if the chickens are to be shipped a long distance, each bird is also wrapped in parchment. This prevents the chickens bruising each other and, at the same time, to a considerable extent, checks decomposition. Do not use ordinary wrapping paper as it absorbs dampness and will cause the chicks to become clammy, which makes them unsaleable.

The dimensions of some of the boxes are: For broilers, weighing about twenty-four pounds per dozen, sixteen inches by fifteen inches by three and one-half inches inside measurements. This is where they are packed in single layer with the breast up and the legs extended.

For chickens weighing thirty-six to forty-two pounds per dozen, a box twenty-three inches by fifteen and one-half inches by four inches inside measurements would do. For one dozen roasters, weighing four to four and one-half pounds each, a box thirty-two inches by nineteen inches by four inches inside measurements; and for heavy roasters, weighing five to five and one-half pounds each, and packed single layer, a box thirty-three inches by twenty inches by four and one-quarter inches inside measurement. The material used varies in thickness from one-quarter inch for sides, bottom and top, one one-half inch for ends in the smallest size boxes, to one-half inch for sides, top and bottom, and with seven-eighths inch ends in the largest boxes.

(The writers wish to acknowledge the use of *Poultry Packers' Guide* in preparation of box dimensions above stated, for which credit is hereby given).

Fig. 58

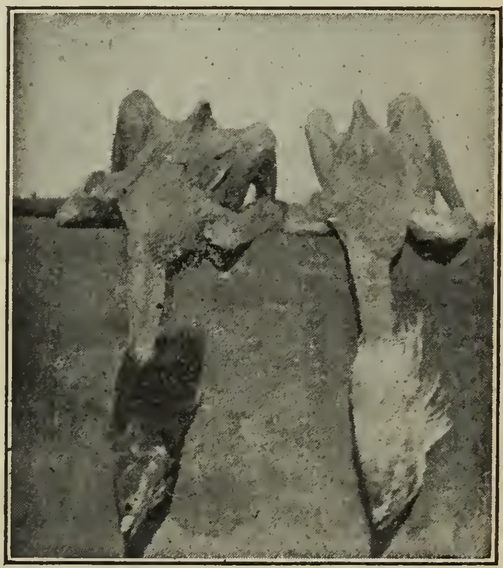


Fig. 59

Showing Good (58) and Poorly-fleshed (59) Birds.

Poultry and Eggs for Market

The only method fair to both the producer and the consumer is the sale and purchase of eggs and poultry on a graded basis. The producer of a first-class product should get the best price, and the consumer should know what he or she is buying.

Poultry and eggs are good food. For some unknown reason the average Canadian does not consume very much poultry meat. The average person, we think, should eat at least one egg each day.

In the producing sections situated away from the centres of consumption, the securing of a price commensurate with the actual value of the product is a problem. There are two factors that will assist in solving this problem. One is for the buyer, whether dealer or grocer, to buy the produce on the quality payment basis; and the other is selling through co-operative organizations. Which is the better method depends entirely on local circumstances. A co-operative society situated away from large local markets, when well managed, should be the better method; on the other hand, payment on the basis of quality is simple and just. These problems can be best solved by the producer and dealer getting together. Co-operative buying and selling is the ideal method, but everybody must work together and stay with the association. It is seldom that a co-operative society or joint stock company does not have occasional poor years and unsatisfactory conditions. Success depends on united efforts.

There appears to be a general idea that the shell of an egg protects the contents against all kinds of germs and also the weather, and that while the outside of the shell may be filthy the interior is not in the least affected by this filth on the outside.

There is nothing more disgusting than to break a bad egg at the breakfast table. No more eggs are wanted for days, perhaps for weeks, and consequently egg consumption decreases, or eggs are looked upon as a doubtful source of food. Many bad eggs are the result of ignorance on the part of the producers and consumers, and many dealers are careless in their methods.

The shell of an egg is porous. The egg is designed to hatch a chick. The embryo under favourable conditions grows inside the shell and finally pips the shell and emerges. The pores in the shell supply the embryo with air as it develops, also allow the bad air to escape. Science has proved this, but we have ample illustration in practical work. Eggs that become badly smeared with the contents of eggs broken in the nest during incubation usually rot, owing to the breathing pores becoming sealed over by the broken egg content. Greased eggs will not hatch for the same reason.

Knowing that the shell is porous, we can readily understand how minute animal or plant life may enter the eggs. Let us take a common example of mouldy or musty eggs. Frequently the paper fillers of egg boxes will become damp, due to the boxes being left in a shower or rain or something of the kind. The fillers may be only slightly damp, and we think they will do. If no eggs are put in the boxes and the boxes with fillers are set aside for a week or so, they smell musty when opened and upon examination we may see slight developments of mould here and there. In cases where eggs are put in such fillers they soon become musty, and when they are left in for some time they become mouldy, not only on the outside of the shell, but on the inside as well. The writers have taken clean eggs on the day they were laid and put them in dry paper boxes which were slightly mouldy, and set them aside in a dry cellar for a period of a few weeks. At the end of this time many of the eggs had well-developed mould on the inside of the shell.

Many eggs are spoiled by being partially incubated. Most people believe that an egg must be set under a hen, or put in an incubator, before it will commence to hatch. Eggs will commence to hatch at less than ninety degrees of heat. Many eggs are submitted to this or higher temperatures for several hours, if not days, before reaching the consuming public. When the germ inside the egg commences to develop, the edible qualities of the egg are lowered, or the egg goes off flavour. Eggs may be kept at an incubating temperature for a day, thus resulting in some embryonic development. On the next day the temperature may be so low that the embryo is killed, and from that point decomposition begins, possibly slowly, but nevertheless the egg is being rendered unfit for food.

There are numerous ways in which eggs may start hatching during the summer, such as forgetting to gather the eggs daily, and leaving some under broody hens over night, leaving them exposed to the sun or in warm rooms, stores, cars, etc., or even by having them in the kitchen cupboards.

No one can guarantee the quality of eggs during warm weather unless the males are removed from the flock. It is essential to produce only non-fertilized eggs during warm weather. We may take every precaution at the farm, but we have no control over where or how the cook may keep the eggs, after they have been passed from the dealer's hands. Allowing males to run with the hens all summer costs the Ontario producers a large sum of money.

Filthy eggs, or even washed eggs, may decompose or be rendered unfit for food due to these conditions. The washing of eggs is not objectionable if the eggs are used immediately, but they deteriorate very rapidly after washing.

Flavour of Eggs

Many people fail to recognize that eggs will absorb odours. They will not absorb odours as readily as milk. At the same time, care should be taken to keep the egg storage room free of strong odours. The placing of eggs alongside of onions, turnips, or similar strong smelling foods will result in the eggs absorbing more or less of these flavours.

The feed that a hen consumes may very materially affect the flavour of the eggs. This fact can be easily demonstrated by feeding considerable scorched grain, or by feeding large quantities of pulped onions in the mash. One demonstration will convince anyone that eggs may have a scorched or onion flavour, no matter how cooked.

Hens that are forced to forage for most of their living during the summer, may produce eggs in which the yolks are dark in colour and strong in flavour. Under such conditions, the eggs may also contain thin watery whites, with poor keeping qualities and are little better, if as good, as fair pickled or cold storage eggs. Such eggs also help to give rise to the opinion held by some consumers, that winter eggs are superior in quality to those produced in the summer. However, summer eggs produced by hens fed on a properly balanced ration and freely exposed to direct sunlight, produce eggs of good quality and may be considered of superior nutritional value.

POULTRY HYGIENE AND SANITATION

There is very great doubt in the minds of the writers as to the advisability of "doctoring" sick chickens. The unit of production (the individual bird) is so small that if a man's time is worth anything it will not pay him to do so unless he considers the bird especially valuable. The "cured" bird may always remain a menace to the flock, and upon the slightest adverse conditions may show a return of the disease. Disease of any kind usually weakens the constitution of the individual, and hence lowers its breeding value. In such simple diseases as indigestion, colds, etc., where the greater part of the flock is affected, and the flock can be treated as a unit, treatment is, no doubt, advisable. Where the birds are kept for the production of eggs and meat only, the hatchet will be found the safest and most effective method of treatment for individuals.

Prevention is better than cure, and every effort on the part of the poultry keeper should be exerted to maintain such environmental and sanitary conditions as will prevent disease gaining a foothold in the flock.

The stock which is used for breeding purposes should be selected first for constitutional vigour, as this is the foundation upon which the breeder must build future success. Discard all birds that have at any time been sick, and cull very closely birds which, as chicks, were raised in closely confined quarters.

The housing of the birds is very important in the prevention of disease. Abundance of fresh air and sunlight in the house, without draughts or dampness, will do much in maintaining a healthy flock. Houses must be kept sanitary by the frequent removal of droppings, and the litter as the latter becomes soiled. At least once during the year, preferably about the month of August, the house should be thoroughly cleaned and disinfected. All movable fittings, such as nests, hoppers and roosts, should be removed from the pen to facilitate cleaning. Thoroughly scrape the dropping boards, if used; remove all litter from the floor, and then brush the ceiling and the walls with a broom. Scrub the pen thoroughly with soap and water or a lye solution *until it is clean.* The house is now ready to be disinfected. The writers find it advisable to apply a coat of whitewash to all pens once a year to brighten and help to cleanse them. They have also found it most economical to combine the writewashing and disinfecting processes by adding the disinfectant to the whitewash. The whitewash is made according to one of the formulae given below. To this is added ten per cent. of crude carbolic acid or some of the tarry compounds used for disinfecting purposes, and the whole applied with a hand spray pump. A pump capable of developing a fair amount of pressure is desirable, as it forces the solution into all cracks and crevices about the building. Nests, roosts, and other movable fittings are best treated by dipping them in disinfectant, or they may be sprayed but dipping is preferred.

The land upon which birds are running must receive close attention in order to keep it clean and sanitary. The constant ranging of birds over a piece of land tends to foul it, making it "chicken-sick". The heavier the soil the more serious is the trouble. Aim to cultivate the run or yard at least once during the year and grow a crop of grain or rape on it. This tends to cleanse the soil of droppings and at the same time produces succulent green feed for the birds.

Follow a three or four year rotation for chicken range and move the range equipment three or four times each season. Avoid ranging young stock on land used for old birds, as such land may be badly contaminated with worms and coccidiosis.

The feed must be closely attended to and no feed given the birds that is musty or mouldy, or in which putrefaction has started. Only the purest and most wholesome feeds should be used, or they will not only have an ill effect on the health of the birds, but seriously affect the product from the flock.

Exercise is very essential to health, and this applies to chickens just as much as to other classes of stock. It is particularly important in the winter months, especially if one wishes to secure good hatches of strong, vigorous chicks.

In case of sickness, isolate all birds from the flock and either treat or destroy them. All dead birds should be disposed of by burying them deeply (two or three feet) or by burning them. The latter is the safer method of disposal.

Birds which are badly infested with vermin, such as lice or mites, will not thrive. If the vermin are not kept under control they will in time become so bad as to seriously lower the vitality of the birds, thus rendering them more susceptible to disease.

WHITEWASHES FOR FARM USE

E. W. Kendall, B.S.A., Department of Farm Mechanics.

Whitewash has a wide application to farm use and deserves a much greater popularity than it, at present, enjoys. Its ingredients are inexpensive and readily obtained. It is not difficult to make and it is easy to apply. In addition to these advantages, it protects the surfaces to which it is applied, brightens up dark interiors and improves sanitation. A fact not generally known is that whitewash may be coloured, provided that light tints and shades are used and that the pigments are not affected by lime. Among such are yellow ochre, raw and burnt umber and raw and burnt sienna.

Preparation of the Surface—The surface to be whitewashed should be just as clean as one that is to be painted and it is a first esential to good results that all dirt, grease and scaley material be removed before there is any attempt to apply the wash. This implies a liberal use of scrapers and stiff brushes. When the cleaning is finished and the surface dusted, it is well to dampen it slightly before applying the wash.

Application of Whitewash—Whitewash may be applied with a brush or with a sprayer. In applying with a brush use one at least four inches wide and work rapidly, making no attempt to "brush out" as in painting. Let the coat be fairly thin and transparent. It will be opaque when dry. Small hand sprayers, such as sold by seed firms, may be used. These will cost around $10. and should be of brass if you expect them to last for a number of years. In using sprayers it is quite necessary that the wash be strained through at least two thicknesses of cheese cloth. Spraying under certain conditions has many advantages over brushing, as it forces the material into cracks and crevises that would not be reached by the brush. In using the sprayer always hold the nozzle so that the wash is applied at right angles to the surface; this gives even application. The sprayer should be thoroughly cleaned after use and especially the nozzles, as a small particle of dirt clogging one side of the nozzle will cause it to send out a lop-sided stream, and the work will be patchy.

Estimating Quantities—In estimating the quantity of material required, many problems and conditions are encountered, but the following general figures may be used as a basis. One gallon of whitewash will cover approximately 225 square feet of wood, 180 square feet of brick and 270 square feet of plaster. Using a 4-inch brush a man will cover 200 square feet of ceiling, 200 square feet of rough wall or 350 square feet of smooth wall in one hour.

EXAMPLE—Basement 36′ wide x 60′ long x 9′ high.

Distance around walls is 192 feet.
Area of wall is 192′ x 9′ = 1,728 square feet.
Area of ceiling 60′ x 36′ = 2,160 square feet.
Total area .... 3,888 square feet.
225 square feet require 1 gallon.
3,888 square feet require 3,888 divided by 225 = 18 gallons approximately.
200 square feet are covered in 1 hour.
3,888 square feet are covered in 20 hours.

Notes on the Preparation of Whitewash

(*a*) Prepare the lime and water paste a few days before you wish to use it.

(*b*) Where casein, glue or formaldehyde are to be used, the solutions must be brought together only when they are *quite cold*. This is very important.

(*c*) The solutions mentioned in (*b*) should be added *quite slowly* and at the same time they should be stirred vigorously and constantly.

(*d*) In no case should you mix more of the wash in one day than you can use in that day when any of the solutions mentioned in (*b*) are used.

(*e*) Skim milk may be used as a substitute for casein, but it is not quite so effective.

(*f*) In the place of one sack (fifty pounds) of hydrated lime, you may use the paste made by slaking one-half bushel (thirty-eight pounds) of fresh quick-lime with about six gallons of water. This slaking is sometimes done by placing the quick-lime in a barrel and adding the water boiling hot. If cold water is used the water may be added a little at a time, stirring each time; when heat ceases to be given off the lime is slaked.

Before using, strain this paste through a fine screen.

(*g*) Molasses is said to render the lime more soluble and it gives it greater penetrating power. Use in proportion of one pint of molasses to five gallons of the wash.

(*h*) Alum tends to prevent rubbing and is used in proportion of one ounce to one gallon of the wash. It would not be needed in the formulae C., D., or E., given below.

(*i*) If a gloss is desired, dissolve one pound of bar soap in a gallon of boiling water and when it is cold add it to five gallons of the thick wash.

Some Common Formulae

A. 1. Dissolve fifteen pounds of common salt in seven and one-half gallons of water.
   2. Slowly add one sack of hydrated lime, *stirring vigorously.*
   3. Thin this to a milk-like consistency with water.

B. 1. Make a paste of one sack of hydrated lime and seven gallons of water.
   2. Dissolve one pound of common salt and one-half pound of zinc-sulphate in one gallon of boiling water. Allow this to cool.
   3. Pour this last solution into the lime paste solution a little at a time, stirring vigorously.
   4. Stir in two gallons of skim milk.

C. 1. Soak five pounds of casein in two gallons of hot water for two hours.
   2. Dissolve three pounds of trisodium phosphate in one gallon of water.
   3. Mix these two and allow the casein to dissolve and cool.
   4. Make a cream of one sack of hydrated lime and seven gallons of water.
   5. *Slowly add* 3 to 4, stirring vigorously.
   6. Just before using, dissolve three pints of formaldehyde in three gallons of water and add it *very slowly* to 5, stirring vigorously. Do not mix more than can be used in one day.

D. 1. Soak five pounds of casein in two gallons of hot water for two hours.
   2. Add three pints of household ammonia to one gallon of water.
   3. *When cold,* mix 1 and 2.
   4. Make a cream of one sack of hydrated lime and seven gallons of water.
   5. *Slowly* add 3 to 4, stirring vigorously.
   6. Just before using, dissolve five pints of formaldehyde in three gallons of water and add it *very slowly* to 5, stirring vigorously.
   7. Thin to a milk-like consistency.

E. 1. Dissolve three pounds of glue in two gallons of hot water and allow to *cool.*
   2. Make a cream of one sack of hydrated lime and seven gallons of water.
   3. Mix 1 and 2, stirring vigorously.
   4. Thin to a milk-like consistency.

F. 1. Make a cream of one sack of hydrated lime and eight gallons of water.
   2. Slowly add one quart of crude carbolic acid, stirring vigorously. The quantity of acid may be doubled, if desired.
   3. Thin to a milk-like consistency.

G. 1. Make a cream of one sack of hydrated lime and seven gallons of water.
   2. Dissolve six pounds of salt in three gallons of boiling water.
   3. Mix 1 and 2 when cold.
   4. Stir three pounds of Portland cement into 3.

Uses for the Different Formulae

Formulae	A. and B.	Unimportant outdoor work, sheds, fences and trees.
"	C. and G.	Higher grade work on dairies, buildings and trees.
Formula	D.	Basements that tend to be damp.
"	E.	Dry basements.
"	F.	As a disinfectant wash but liable to rub.

B369

BULLETIN 369] [OCTOBER, 1932

Ontario Department of Agriculture

Vegetable Gardening

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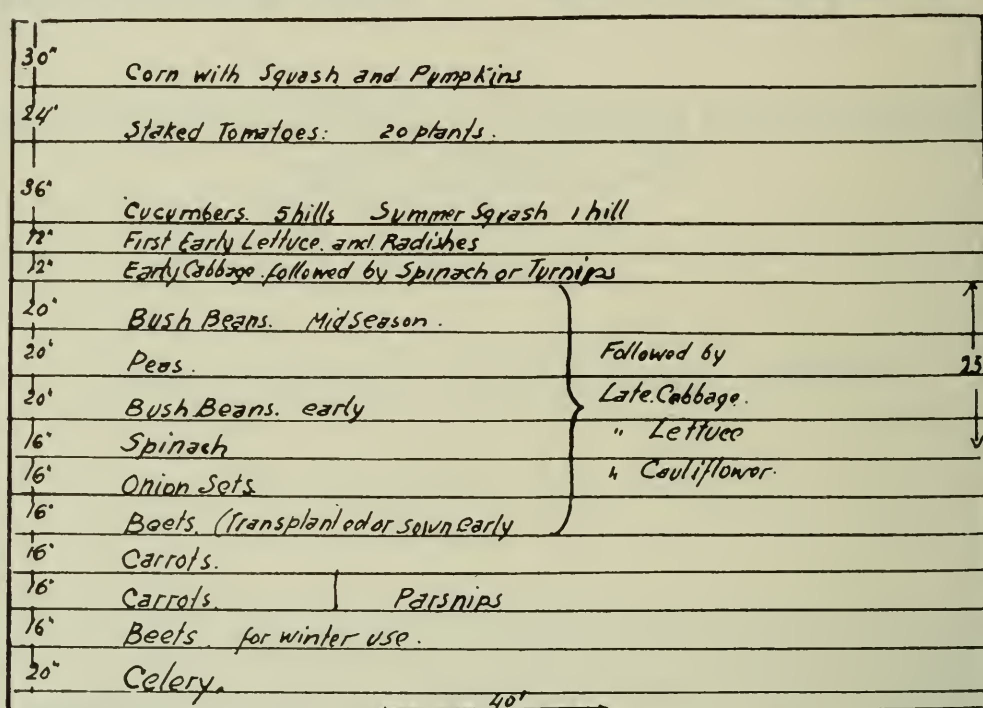
Celery Growing — Thedford, Ontario — on muck soil, 400 crates per acre.

PLANNING THE HOME VEGETABLE GARDEN

A definite plan of a garden prepared a considerable time previous to planting affords advantages. A fresh supply of all vegetables, when desired in quantities meeting the demands of each member of the family, is provided. With a plan as a basis of consideration the correct amounts of seeds and fertilizers may be ordered in advance to avoid any absence or duplication of these commodities at planting. Economy of space in the garden and time at planting are effected by carefully allotting previous to planting the exact space and planting distances for each vegetable. Provision for a continuous vegetable supply is made by provision for space at the correct time for each successional planting of any particular kind or variety.

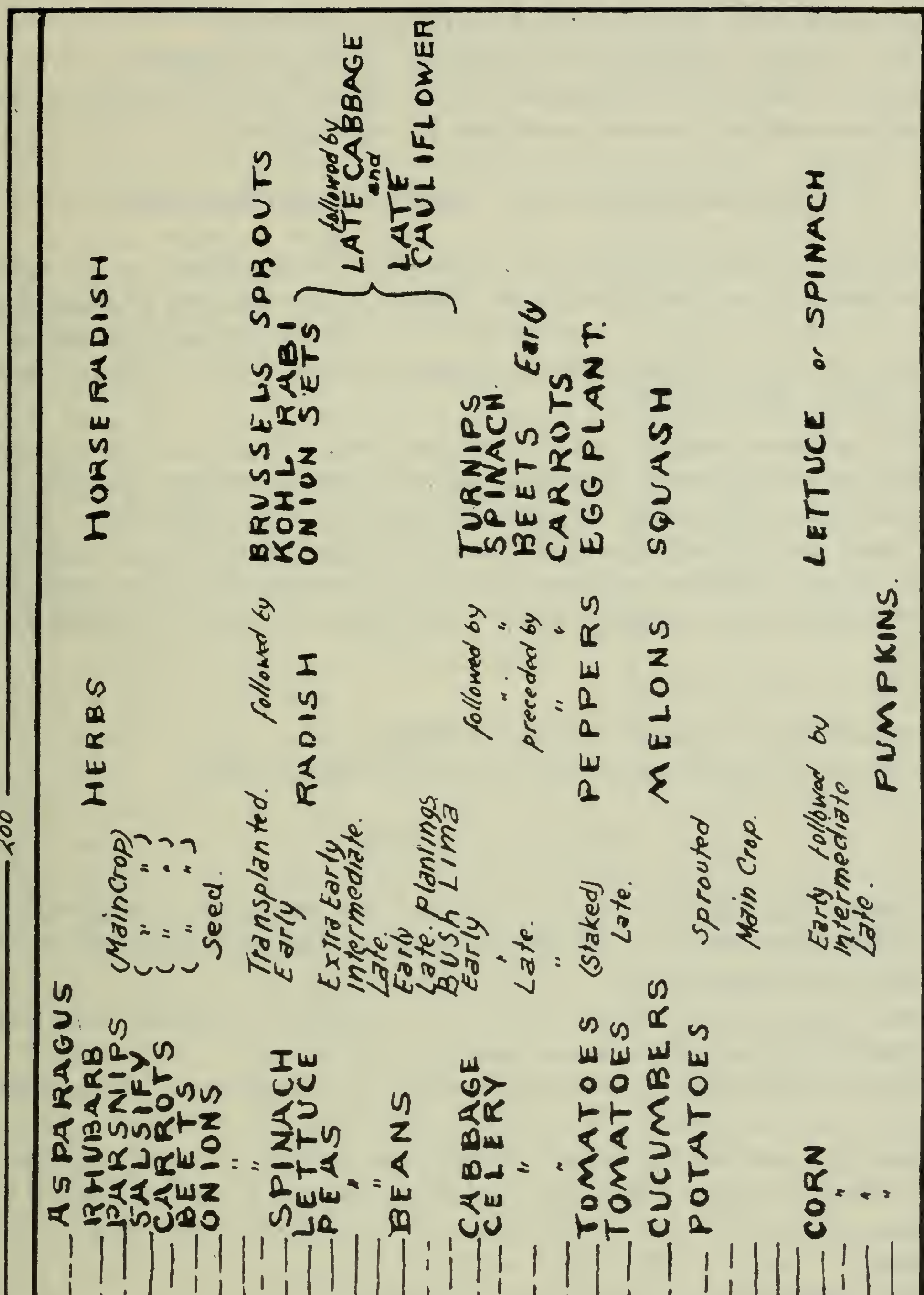


Plan for a small home garden 40 ft. by 25 ft.

A study of these two garden plans demonstrates that close planting and intensive cultivating implements such as the wheel-hoe are used in the small home backyard garden; whereas the more extensive space afforded by the farm home garden, permits wide distances between rows and turning distances at ends of rows for horse or tractor drawn implements. Quick maturing crops should follow one another in successive rows to afford planting of later crops after harvesting the early crop. Perennial crops should be at one side of the garden to permit plowing and other continuous cultivation.

SUCCESSION CROPPING

Succession cropping is the growing of two or more crops on the same land in one growing season. These plantings are not confined to one vegetable crop. One kind of vegetable may immediately follow a different kind of vegetable on the same soil. Sometimes three different crops are grown in succession. This cropping demands well fertilized land and efficient cultural practices. The length of the growing season and the nature of the crops grown control the number of crops capable of being produced.



Plan for a farm home garden 200 ft by 112 ft The rows are spaced to permit of horse cultivation.

Succession cropping examples consist of:

Lettuce followed by late celery, especially on muck soil.

Radish or lettuce followed by late cabbage, parsnip or spinach.

A numerous number of combinations of this method can be arranged to coincide with market demands and the soil conditions for each grower.

INTER-CROPPING OR COMPANION-CROPPING

This system is conducted when two or more crops are grown on the same soil at the same time. Crops which mature at different dates are sown or planted at the same time. The first maturing crop, usually a small-growing quick-maturing crop is harvested, and then the later larger slower-growing crop is allowed sufficient space and time to reach maturity.

Economy of space and of cultivation; increased revenue; and more complete use of plant-food are effected. However, intensive inter-cropping demands a large amount of labour; and usually prevents the use of large implements. With this cropping system the habit of growth; the space, required by each crop; and the time required to reach marketing condition are to be considered. Large quantities of manure and fertilizers are requisite to have the plants well fed for efficient growing conditions.

Examples of this system are:

Two rows lettuce or spinach between cabbage.

Early lettuce or radish and beets about twelve inches apart.

CROP ROTATION

Crop rotation applicable to crop production is the systematic arrangement of the growing of different crops in a regular sequence on the same land over a period of two, three or more years.

The more important advantages provided by rotation of vegetable crops are:

The control of plant diseases and insects is aided.

The drain on the supply of raw materials in the soil tends to be equalized.

The plant food supplied to the soil is used with greater efficiency.

In planning a rotation one should consider the following recommendations.

Allow as much time as practicable for the production of soil improving crops.

Following crops which furnish organic matter with those which favour its rapid decomposition.

Alternate deep-rooted with shallow-rooted crops.

Vary the crops in rotation in respect to the kinds and amounts of plant foods required, character of root growth and time of year at which they occupy the soil.

THE SOIL

With few exceptions vegetable crops always prefer soil types that range from light clay loams to light, sandy loams and well decomposed mucks. Within the whole range of variety of vegetable crops certain crops are especially adapted to a particular type of soil, while other crops will grow successfully on any one of the soil types mentioned. However, as the soil is the prime requisite in successful vegetable crop production, it behooves the grower to understand the physical and chemical characteristics of not only the surface soil but the subsoil as it influences the retention of plant food nutrients and water holding capacity of the soil.

Lack of space forbids an exhaustive discourse on the physical and chemical characteristics of each soil type. Therefore, only a brief discussion will be given of the more important chemical and physical characteristics. Anyone wishing to make a further study will find any good text book on soils very helpful.

Light Clay Loams—Physical characteristics consist of approximately 20 — 30 percent clay, 30 — 50 percent silt and 20 — 50 percent sand. This soil type has a high water holding capacity, is retentive of plant food added but rather difficult to work when wet owing to sticky nature, and a tendency to bake and crack in dry weather. It is generally rich in potash and phosphoric acid and under good management the organic matter content will be quite good, and, consequently, it will be rich in nitrogen.

Heavy Sandy Loams—Physical characteristics consist of approximately 20 — 30 per cent clay, 10 — 20 percent silt and 50 — 70 percent sand. This type of soil is easy to work even when quite wet and will not become very sticky. When dry it will not bake or crack. It is fairly retentive of moisture and plant food and is suitable to a very wide range of vegetable crops. It is naturally fairly well provided with potash and phosphoric acid, though not quite so much as the light clay loams. The nitrogen content will vary directly with the organic matter content. In general, owing to the open nature of this soil it will be slightly more difficult to maintain as high a standard of natural fertility as in the light clay loams but what is present will be in a more active form.

Light Sandy Loams—Physical characteristics consist of approximately 5 — 10 percent clay, 5 — 15 percent silt and 75 — 90 percent sand of various sized particles. This type of soil is very open in nature, is not very retentive of plant food constituents and has a low water holding capacity. Consequently, whatever plant food is added either in the form of manures or fertilizers will soon disappear if not consumed by the growing plant. Providing it is properly nourished this type of soil is very suitable for vegetable growing, especially for very early crops. It can be worked very early in the spring and growth commences quite early as it is well drained and warms up quickly.

This soil type is usually very low in nitrogen, phosphoric acid and potassium and responds quite readily to applications of complete fertilizers and organic manures.

Mucks—These are well decomposed peat soils and are formed by the accumulation of large amounts of organic matter in shallow lakes or ponds over a long period of time. The composition of muck soils varies, depending on how much mineral matter may be present by erosion from higher ground. Consequently, the soil may contain from 35 to as much as 95 percent organic matter, the remainder consisting of mineral constituents, such as sand, clay and silt. Muck soils become of extreme value for market garden crops when drained and are especially adapted to the growing of such crops as onions, celery and lettuce.

Muck soils are extremely rich in nitrogen but often light applications of quickly available nitrogen are profitable as the organic nitrogen is too slowly available for quick growing crops. As the percentage of mineral constituents is very small they are very low in phosphoric acid and potassium, hence fertilizers containing high percentages of these constituents should be used.

Importance of the Subsoil—Very often the top soil appears to be ideally suited for the production of vegetables but often results prove to be very disappointing and in a large number of instances examination of the subsoil will reveal quite unexpected conditions, such as a layer of heavy clay, hard pan or quick sand, giving rise to poor drainage, a cold wet subsoil or one which dries out very quickly. The darkness of the surface soil indicates the amount of organic matter it contains and is a direct measure of suitability of the soil for retaining moisture and bacterial activity. If the colour of the subsoil is reddish yellow it indicates good drainage conditions and air circulation in the soil which is absolutely essential for bacterial activity and root development. If, however, the colour is gray-blue, slate colour or mottled, or a hard pan formed, indications are that some form of drainage and subsoiling would be highly beneficial.

TOPOGRAPHY—In selecting sites for market gardening purposes the topography of the soil is quite important. Sites with a gentle slope towards the south will aid materially in providing natural drainage and the production of earlier crops. Steep hillsides should be avoided for reasons of difficulty in cultivation operations and erosion of soil during periods of heavy rainfall. If, in selecting the site, it is possible to include a variety of soil types and conditions varying from heavy loams to light sands and mucks the grower is very fortunate as this will enable him to grow a wide variety of crops on the particular soil to which they are best adapted.

SOIL PREPARATION

Well prepared soil is one of the main factors for success with vegetable crops. Thorough preparation may begin with drainage by providing both under and surface drainage if necessary. Deep plowing, in order to give as deep a layer of soil as possible to the feeding roots, is advised. Fall plowing is usually best owing to the action of frost and the earlier date that seeding may be done. This is very important for some crops. Spring plowing should be done as early as possible yet the soil should be dry so that no lumps are formed. Cover crops, such as Rye or Clover, are usually left over winter and plowed down in the spring. Early seeding and planting are best done on fall plowed land. Thorough disking and harrowing followed by rolling if soil is lumpy, and finishing up with a fine smoothing harrow like the Meeker harrow, will produce a fine seed bed. Extra working of soil at this time helps to warm the soil and render more plant food available to the crop. Some soils may become very lumpy and require rolling or the plank drag in order to produce a fine seed bed. Some muck soils are so loose and open that planking and rolling is necessary to compact or firm it before seeding or planting can be done satisfactorily.

SEED

Good seed is necessary for the production of maximum crops. Old seed, unless tested for germination and type, only leads to disappointment. Use only fresh large seed of high germination percentage, which is clean, true to type, and of uniform size. The best grade of seed obtainable from reliable seed houses should be used. The extra charge for good seed is made up many times over in the resultant crops. It frequently pays to make a germination test of the seed, especially if the seed is known to be old and still desired owing to its proved type. As a rule, however, seed sold by good dealers will germinate satisfactorily. A test for germination may be easily made by counting out a certain number of seeds, placing these between two thick blotting papers, which are kept moist in a covered dish in a fairly warm room. This usually requires a few days to be sure of all good seeds sprouting. A count of number of seeds sprouted per hundred will give the percentage of germination.

Seeds kept in storage are best stored in mouse-proof boxes or cupboards where extremes of moisture and dryness and extremes of heat and cold can be avoided.

Constant even moisture as well as even temperature, aid in retaining the vitality of stored seeds. Vegetable seeds vary as to the normal length of time they retain vitality enough for crop production.

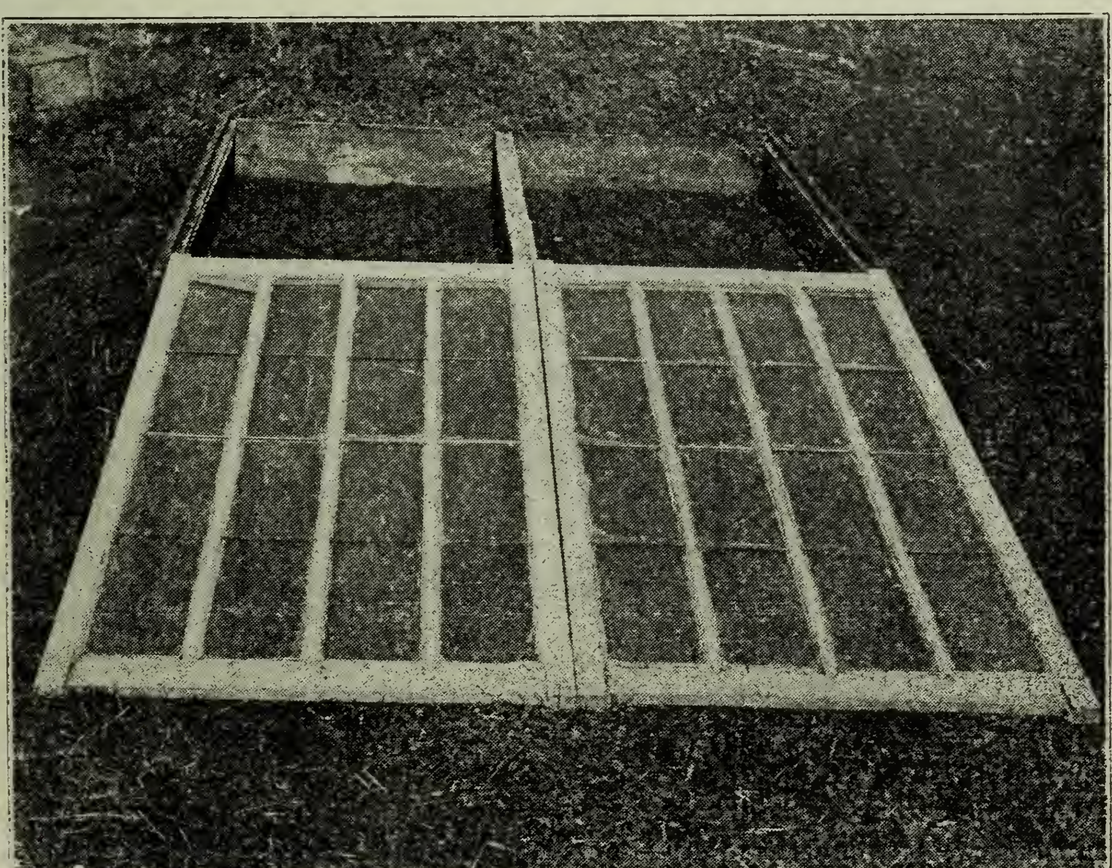
The following table gives the time the various seeds retain germinating strength under good storage conditions.

TABLE OF VITALITY OF VEGETABLE SEEDS

Vegetable	Years	Vegetable	Years	Vegetable	Years
Asparagus	3	Kale	4	Pumpkin	4
Bean	3	Lettuce	5	Radish	4
Beet	4	Muskmelon	5	Salsify	1
Cabbage	4	Okra	3	Spinach	4
Carrot	2	Onion	2	Squash	4
Cauliflower	4	Parsley	1	Sweet Corn	2
Celery	3	Parsnip	1	Tomato	3
Cucumber	5	Peas	2	Turnip	4
Eggplant	5	Pepper	2	Watermelon	5

HOT BEDS

Hotbeds are extensively used by vegetable growers for the production of young plants for early vegetable crops. Seed sowing is conducted from five to six weeks previous to sowing and planting in the fields. The production to maturity of some vegetable crops, requiring a long growing season, is attained by the production of young plants in the hotbed during the weeks before outdoor planting is possible.



LOCATION.—The successful operation of a hotbed demands much attention and an ample supply of water, consequently close proximity to farm buildings and greenhouses is desirable. The hotbed should face the south to secure as much sunshine as possible; be well sheltered from strong winds by artificial or natural windbreaks, and be located on well drained soil.

CONSTRUCTION.—The standard sized frame supporting the sash is composed of one inch lumber. The sides and ends should be eighteen inches high at the high end and twelve inches high at the low end to afford a fall of the sash of one inch for every foot of length of the frame. This arrangement provides a slope to permit the running off of rain from the glass sash, and to obtain rays of the sun. The glass sash, three feet by six feet standard size, is situated tightly on the top of the frame. As many sash as desired can be used in a series of joined single hotbeds by increasing the length of the frame and inserting a three inch piece of wood to support the sash in the centre.

Hotbeds are heated by the fermentation of fresh horse manure, and hot water or steam circulating in pipes situated within the frame.

THE MANURE HEATED HOTBED

Fresh horse manure is the only type of manure which ferments sufficiently to provide the requisite heat. The most satisfactory manure is secured from grain-fed horses, utilizing two parts of manure to which has been added one part of straw. Shavings with manure is unsatisfactory.

About seven days previous to putting in the hotbed frames the fresh horse manure should be placed in a compost pile, four feet high and four to five feet wide. If dry at piling time the manure should be moistened to inaugurate fermentation. After two or three days the manure commences to steam, indicating the beginning of fermentation. At this time the manure should be forked over into another pile, arranging the outside of the first pile in the inside of the second pile. When fermentation again commences, usually two or three days, the manure is suitable for use in the hotbed. Should the manure fail to heat, open a hole in the manure and pour in boiling water.

On the site of the hotbed this fermenting manure is piled to a depth of eighteen inches to two feet and extending a foot from the sides and ends of the frame; and tightly tramped as each six inches of manure is added. If no flats are to be used in growing young vegetable plants, four to six inches of compost soil is placed on top of this manure. When flats are used two inches of soil are placed on the manure and then the flats, containing compost soil, are placed on the two inches of soil. At this time the sash is set into position on the frame. Additional manure is piled around the entire frame, extending to the top, and aiding in retaining heat in the hotbed.

Subsequent to this preparation the hotbed should not be disturbed for four days except to slightly ventilate several hours a day, thereby allowing the escape of noxious gases from the manure.

When the soil is levelled and the temperature of the soil is between 80 to 90 degrees F. sowing or planting can commence; or the flats containing plants or seed can be inserted into the bed.

When numerous hotbeds are used growers frequently haul manure during autumn and winter, covering the soil of the site of the hotbed preventing the soil from being frozen. At the hotbed forming season this manure is replaced by fresh manure which acts as the heater of the bed. This method provides for the use of less manure under the frames.

To save manure the hotbed pit is used. When satisfactory soil drainage exists a pit eighteen inches deep may be made in the soil and filled with fresh horse manure on which the frame is placed.

THE HOT WATER HOTBED

The hot water for this bed may be heated by the greenhouse boiler. If no greenhouse exists a small upright boiler can be placed into a boiler pit in the soil. The depth of the pit must be adequate for satisfactory water circulation; while the other dimensions must provide sufficient space for firing the boiler, containing a coal supply and removing ashes. A tile drain should be at the floor to remove any water which may happen to enter the pit. The soil of the site of the bed must be well drained.

Attached to the top of the boiler is a three inch flow pipe which conducts warm water to the two inch flow header, nearest the boiler in the hotbed frame. From this two inch flow header the water flows through the entire length of the hotbed in three — one and one-quarter inch flow pipe. The two outside flow pipes are situated six inches from each side of the hotbed frame. Six inches from the end of the bed farther from the boiler is situated a two-inch header to which the flow pipes and the one and one-quarter inch return pipes are connected. The one and one-quarter inch return pipes carry the water from the two-inch header, situated at the end of the bed farther from the boiler, through the entire length of the bed to the two inch return header, situated directly under the two inch flow header pipe. From the two inch return header pipe the water is conducted to the bottom of the boiler by a three inch return pipe. The one and one-quarter inch flow and return pipes in the bed are spaced about twelve inches apart from centre to centre. A six foot wide hotbed requires six one and one-quarter inch pipes, three flow and three return pipes.

The header pipe, situated at the end of the bed farther from the boiler, should be eight inches higher than the flow header near the boiler to create a satisfactory circulation of water. In this header farther from the boiler are two stop-cocks to allow the escape of air when filling the pipes with water.

The hot water pipes are covered with five to eight inches of soil in which the plants grow. The top of this soil corresponds with the top of the soil in the manure hotbed so that the frame and sash of the manure hotbed can be used for the hot water heating.

Hot water pipes are sometimes placed on the inside of the hotbed frame above the soil.

Watering of hotbeds should be conducted during bright days in the morning to afford complete drying of plants before sundown as an important means of preventing disease.

Ventilation is conducted by raising one end or the side of a sash and supporting it by a piece of wood. The end or side facing the wind should not be opened in order to prevent moving by the wind and severe cold air on the plants. Since an excess of cold air will check the plants, the nature of the weather governs the amount of air admitted to the hotbed. On cold days a lath or shingle supporting a sash provides sufficient ventilation; while a warmer sunshiny day permits of a larger opening. Ventilation subsequent to watering should be conducted to prevent scalding of plants.

COLD FRAMES

Cold frames are required to carry along young plants for a few weeks before setting in the open. Usually no heat is provided except the heat of the sun. The size is the same as for hotbeds and may run to considerable lengths. A saving of lumber may be made by making double cold frames. The sash are supported at the ridge by means of short posts, the frames being twelve feet wide and any length. The location should be in a sheltered place convenient to the greenhouse or hotbeds and to the water supply. Well made cold frames will protect plants safely against quite cold temperatures especially if some covering is provided over the glass. Good soil may be placed in the cold frames in which to grow the plants, but as a rule flats are transferred direct from the hotbeds or house to the cold frames and no loose soil is needed. Later in the season when warmer weather comes cotton may be used in place of glass, to increase frame space. Many growers make a second use of the cold frames. After the plants are taken to the field the frames are partly filled with soil and decomposed manure and young cucumber or melon plants set in and forced along for a time, later the sash are all stripped off and the plants are allowed to grow naturally. Early celery and lettuce are other crops which may be grown in the same manner. Large permanent frame yards often handle two lots of plants and follow this with a permanent summer crop for which irrigation lines are erected. Thus the space is made use of over the season, even if the glass is not.

The ventilation and watering of cold frames filled with young plants is much the same as for hotbeds. Watering early in the day to avoid damp foliage at night is advised. Ventilation should be gradual so as to avoid sudden extreme changes in temperature.

A number of well built and arranged cold frames together with a small greenhouse make a very desirable method of producing young plants ready for the field.

SOIL STERILIZATION

Fresh compost soil as a rule will not require sterilization; yet where trouble is experienced with damping off of seedlings it would pay well to sterilize the fresh soil. Old greenhouses and old garden soils are usually full of damping off fungi. It is necessary to sterilize this type of soil if one is to escape serious loss of the young seedlings. Sterilization is best done by steam and on the small scale a tight board box built to hold a dozen or more flats of soil piled in so as to permit steam to pass all around the flats makes a cheap and satisfactory method. Steam, under good pressure, is turned into the bottom of the box and after two hours the soil should be well sterilized. Where steam is not available, formalin may be used at the rate of one pint of formalin to ten gallons of water and apply this solution at the rate of one gallon to one square foot of soil. Cover for two days and do not plant until ten days after treatment. The soil for either treatment should be dry. Steaming on a large scale in greenhouses is done by turning steam into tile drains buried twelve inches deep and two feet apart. With good pressure and volume of steam a large bed can be sterilized in two to four hours. Thorough steaming kills all fungus and bacterial organisms with the exception of some spore forming types. Nematodes and other insects are killed. Care should be observed to avoid reinoculation of sterilized soil by disease organisms. Boiling water may be used to sterilize soil, but is just as expensive as steam and is much more trouble to use and as a rule not as effective.

IRRIGATION

Sufficient water for efficient amounts of moisture in the soil to assure continuous growth of vegetables, so requisite for high quality, is only definitely provided by some form of irrigation. Irrigation also controls the amount of moisture at such vital phases of vegetable production as immediately after seed sowing; or planting or growing in dry weather. More abundant vegetable crops are produced in Ontario with irrigation than without an assured supply of water.

Sub-irrigation arranges for the delivery of water to the roots from below. This system is used in some areas of muck and other lands by conveying the water in ditches from which it moves through the soil sideways and upward to the roots. In a few instances a tile drain system is used in conveying the water. Sub-irrigation is unsatisfactory with porous sub-soil or where a hard pan exists near the soil surface. An abundance of water is necessary.

Surface Irrigation is only used where abundant amounts of water and a suitable slope of land prevails, very slightly in this Province.

Overhead Spray Irrigation.—This system is the most commonly used in Ontario as water is supplied to the surface soil in the form of a spray or mist, much resembling a gentle rain. This method requires a small amount of labour to operate; provides for water economy, more uniform distribution of water; causes no washing of soil; and can be used on any type of land.

This system comprises pipe situated in parallel lines about fifty feet apart and supported on posts about six and one-half feet above the soil surface. Small nozzles at three foot intervals in all pipes discharge a small stream of water which alights on the crops and soil in the form of fine spray. Pressure forces the water through the pipes and nozzles, the pipes being automatically turned to provide the desired spray, uniformly over the entire irrigated area. Occasionally posts one and one-half to three feet high or wires attached to posts support the pipe lines.

Portable pipe lines equipped with nozzles are transported from one area of the crop to another. These pipes are laid on the soil surface between the rows of vegetables when irrigating; and attached to some pumping system which supplies pressure for forcing the water through the nozzles. The cost of installation of the portable system is less, and the cost of operation greater than with the Overhead Spray method. However, the Portable system does not use soil space as does the Overhead plan.

The cost of these systems and their details of installation can readily be secured from manufacturers of this irrigation equipment.

GREEN MANURING CROPS

To have a comprehensive picture of this subject the consideration of a plant and its functions is of some utility. The plant secures its food from the atmosphere and the soil. From the atmosphere the carbon is taken into the leaves; and from the soil water hydrogen and oxygen are secured. These three substances, carbon, hydrogen and oxygen are manufactured into sugars, starches and cellulose by the small green bodies in the leaves, called chloroplasts, and the power of sunlight. The other part of the dry substance in the plant consists of nitrogen, phosphorus, potash, lime magnesium, sulphur, and iron which are secured from the soil through the roots. These materials combine with the sugars to form proteins and other substances in the plant. A continuous supply of all of the essential elements of plant food is requisite because the absence or inefficiency of any one element prevents the complete development of the plant.

A soil is composed of mineral and organic matter. The organic matter comprises decaying plants and some animals. The ploughing down of green manure crops and barnyard manure is a common method of replenishing and adding organic matter to our soils.

The beneficial physical effects of organic matter in the soil are of fundamental importance. Organic matter loosens up clay soils into a granular condition, facilitating cultural operations; while sandy soils are prevented from blowing and drying. Organic matter greatly increases the water-holding capacity of both soils, particularly near the soil surface where most of the roots of vegetable crops reside. Thus the organic matter causes the soil to be in a satisfactory physical condition affording an extensively rooted plant capable of absorbing ample foods which produce vigorous plants. Also the growing green manuring crop, subsequent to a vegetable crop, utilizes soluble plant food remaining in the soil from a previously grown fertilizer crop; and thus prevents severe leaching of these costly plant food elements.

Chemically, organic matter functions principally as a storehouse for nitrogen, one of the most necessary plant foods in the soil. The bacteria in the soil, to obtain food, break down the complex compounds in organic matter and eventually change them into available plant food. Notably nitrogen in the organic matter is changed by bacteria into nitrates which are nitrogen plant food for our vegetable crops. Too, the organic matter must be in the soil to afford the mineral matter in organic matter, soils and fertilizers to be transformed into soil for the growth of crops. Throughout the decomposition of organic matter all of the mineral elements residing in the organic matter are changed into plant foods. Also during the decay of the organic matter carbon dioxide is produced with water. This gas with water forms acid which renders the minerals in the soils and fertilizers into plant food for the vegetable crops.

Organic matter functions principally as a storehouse for nitrogen. Concerning the nitrogen supply from a green-manuring point of view we have two classes of crops. namely legumes, and non-legumes. Legumes as clovers and vetches possess nodules on their roots. In these nodules are bacteria which have the power of converting the nitrogen of the air in the soil into plant tissue. Non-legumes, as rye and oats, do not possess these nodules. Consequently when we plough down a legume we place back into the soil all of the mineral elements taken from the soil to produce the legume and in addition free nitrogen taken from the atmosphere. Thus the legume has afforded an increase in nitrogen to the soil. The ploughing down of a non-legume puts pack into the soil all of the mineral elements taken from the soil in the growth of the non-legume but no additional nitrogen. Hence legumes are superior to non-legumes as green manuring crops.

Crops.—With crops such an onions, parsnips and tomatoes occupying the soil for almost the entire growing season, and when producing two crops of vegetables in succession on the same land during one growing season, winter rye is practically the only suitable crop. At the conclusion of harvesting the full season crop or the last crop in the one year succession this rye is sown at the rate of 2½ to 3 bushels per acre. Winter rye sown September 1st to 15th, will produce about six inches of growth before the usual freeze-up in November; and can be ploughed down as early as the first week in April in many sections of the country when about 8 inches in height. When sown in October 1st to 15th, a suitable growth is obtained by the middle of the following May.

At the conclusion of early sweet corn, early potatoes, early cabbage, late peas and early cauliflower, Biennial Sweet Clover and Hairy Vetch sown separately, a combination of oats and peas or a combination of Vetch and Winter Rye may be sown as green manuring crops. The clover, vetch and peas are legumes and benefit the soil and succeeding crops as already explained.

1. The Sweet Clover is sown at the rate of 20 to 30 pounds per acre about July 20th, and is ploughed down during the following May when about 12 inches high.

2. Hairy Vetch winters over and is ploughed down in the early spring. Whether sown alone or with Winter Rye, Hairy Vetch should be seeded during the latter part of July and not later than the first week in August. Vetch is sown alone at the rate of 60 to 80 pounds per acre; and when sown with Winter Rye, Vetch at 20 pounds per acre and Winter Rye at $1\frac{1}{2}$ bushels per acre.

Growing and ploughing down green manuring crops subsequent to vegetable crops as already mentioned, prevents leaching of soluble plant foods in the soil which have not been used by the immediately preceding vegetable crop. The green manuring crops as Hairy Vetch, Winter Rye and Sweet Clover prevent erosion of land in the fall, winter and spring months, and afford earlier cultivation and planting than does bare land because the leaves give off a great deal of water secured from the soil.

3. Previous to the vegetable crops of late cabbage, late celery, late potatoes, green manuring crops, sown as early as possible in the spring, can be ploughed down when no green manuring crop has occupied the land during the winter months. However, this plan is not as satisfactory as having the green manuring crop immediately follow the vegetable crop in the autumn because, as just mentioned, the leaching of plant foods in the winter months would be detrimental to succeeding vegetable crops. For this particular plan of cropping a combination of oats at two bushels per acre and peas at one bushel per acre is suitable.

All green manuring crops should be ploughed down when in a succulent growing state, particularly when spring ploughed. The ploughed down green manure, unless thoroughly incorporated into the soil at ploughing down time will provide a very detrimental layer of organic matter in the soil which will prevent the rise of capillary water from the lower soil layers to the roots of the vegetable crops in the surface soil. To overcome this detrimental condition ploughing should be conducted so that the furrow slice is on edge to promote the mixing together of soil and organic matter. Immediately after ploughing down the soil should be packed with a heavy roller or culti-packer and then thoroughly disked. Oftentimes beneficial results are secured by thorough disking prior to ploughing to cut the green manuring crop before incorporation into the soil and thus secure more rapid decay.

BARNYARD MANURES

The importance of manure in market gardening can scarcely be over estimated. Its value is in part, attributed to its fertilizer qualities but perhaps as much to the fact that it is an ideal source of organic matter to maintain the large supply of humus in the soil which is so essential to crop growth.

When manure is obtainable at relatively low cost, per ton, heavy annual applications, as high as 40 tons or more, per acre, are often made. With the increasing use of fertilizers at lower prices and the growing scarcity of manure with attendent increased cost, per ton, vegetable growers are much concerned as to what extent green manure crops and fertilizers can replace farmyard manure. Experiments at the Rhode Island Experimental Station have shown that commercial fertilizers in a green manure rotation can be substituted to a great extent for manure with a consequent larger net financial return, per acre. Similar studies are now under way at several points in Ontario and definite information on this question will soon be available.

It is impossible to place a money value on the total effect of manure applied as there are so many variables entering into the question. As a source of humus, the effect will be much greater on soils deficient in organic matter than on soils well supplied with organic matter.

The various beneficial effects which manure exerts on the soil may be classified as physical, chemical and biological.

The physical effects of manure on heavy soils are, that it renders it more porous and friable, assisting drainage, aeration, ease of cultivation and, in general, creating a very favorable medium for plant growth. On light sandy soils the organic colloids in the manure tend to bind the particles of sand together, making the soil more compact, thereby increasing water-holding capacity and preventing the leaching of plant nutrients. Large amounts of organic matter tend to impart a dark color to the soil which increases its heat absorbing capacity.

The fertilizer value of farmyard manure is chiefly due to the amounts of nitrogen, phosphoric acid and potash added to the soil and then liberated by the subsequent decomposition of the manure in forms easily assimilated by the plant. During the process of decay the organic materials produce many acid compounds which increase the availability of the mineral plant nutrients in the soil.

Organic matter is the home of soil micro-organisms which are actively engaged in the breaking down and building up of organic and inorganic plant nutrients in forms which the plant can assimilate them. Farmyard manure acts as an excellent medium for their development, supplying both food and favorable environments. Light applications of manure on newly broken peat or muck lands usually give marked increase in plant growth by acting as a source of quickly available energy for beneficial bacteria that hasten decomposition of the organic matter with consequent release of plant nutrients.

Characteristics and Composition of Manure

The composition of manure is very variable, depending upon the class, age and function of animal producing it, source of feed, amount of care used in its conservation, amount and source of litter for bedding, and degree of decomposition.

The following table prepared by Dr. F. T. Shutt, Experimental Farm, Ottawa, presents the approximate average composition of fresh, solid and liquid portion of manure produced by farm animals in percentages and pounds, per ton.

Approximate Average Composition of Fresh manure From Various Animals (after Shutt)

Kind of Animal	Relative proportions of solid excrement. liquid excrement and bedding in manure.	Pounds per Ton	Nitrogen		Phosphoric Acid		Potash	
			P.C.	Lbs.	P.C.	Lbs.	P.C.	Lbs.
Horse	Solid Excreta	1200	0.53	6.60	0.36	3.60	0.40	4.80
	Liquid "	300	1.35	4.05	Trace		1.25	3.75
	Bedding material	500	0.50	2.50	0.15	0.75	0.60	3.00
	Total mixture	2000	0.66	13.15	0.22	4.35	0.58	11.55
Cow	Solid Excreta	1260	0.40	5.04	0.20	2.52	0.10	1.26
	Liquid "	540	1.00	5.40	Trace		1.35	7.29
	Bedding material	200	0.50	1.00	0.15	0.30	0.60	1.20
	Total mixture	2000	0.57	11.44	0.14	2.82	0.49	9.75
Pig	Solid Excreta	990	0.55	5.44	0.50	4.95	0.40	3.96
	Liquid "	660	0.60	3.96	0.10	0.66	0.45	2.97
	Bedding material	350	0.50	1.75	0.15	0.42	0.60	2.10
	Total mixture	2000	0.56	11.75	0.30	6.03	0.45	9.03
Sheep	Solid Excreta	1206	0.75	9.04	0.50	6.03	0.45	5.43
	Liquid "	594	1.35	8.02	0.05	0.30	2.10	12.47
	Bedding material	200	0.50	1.00	0.15	0.30	0.60	1.20
	Total mixture	2000	0.90	18.06	0.33	6.63	0.95	19.10
Poultry	Solid Excreta	1900	1.00	19.00	0.80	15.20	0.40	7.60
	Bedding material	100	0.50	0.50	0.15	0.15	0.60	0.60
	Total mixture	2000	0.97	19.50	0.77	15.35	0.41	8.20

From a study of the table the following points are outstanding: (1) That manure contains more nitrogen and potash than phosphoric acid, hence is an unbalanced form of fertilizer. (2) That the liquid manure is exceptionally rich in nitrogen and potash. (3) That valuing nitrogen at 12 cents, per pound, phosphoric acid at 7 cents and potash at 5 cents, per pound, the monetary value of fertilizing constituents in manure, per ton, from each class of animal is in the following order: poultry, sheep, pig, horse and cow.

Application of Manure

Many growers prefer to apply the manure on the land during the winter or early spring in order to save time and labour. Providing the manure is not too strawy or the land too heavy or rolling this is a good practice. However, large quantities of fresh strawy manure, turned under, will result in a depletion of available nitrates in the soil, prove harmful to the young growing crop and necessitate applications of some form of readily available nitrogen, especially if quick growth is desired. The effect on heavy soils would be to retain excessive moisture in the soil keeping it cold and wet and retarding early growth. On very rolling land there is danger of much loss of plantfood by erosion during the early spring rains.

Fresh vs. Well Rotted Manure

The majority of vegetable crops are grown on light, sandy loams. Moreover, the grower desires to obtain relatively immediate results from the manure applied. To procure this it is desirable to apply well rotted instead of fresh, strawy manure. In the process of rotting manure, fermentation decomposes the more resisting forms of litter, rendering the plantfood more readily available to the growing plant. However, during the process of decay there is a large loss of organic matter which is of important value on soils low in humus.

A ton of well rotted manure contains more plantfood than fresh manure, as shown in the following table prepared by Dr. F. T. Shutt of Ottawa:

Pounds Per Ton

	Nitrogen	Phosphoric Acid	Potash
Fresh manure	7.5	3.6	9.0
Rotted "	10.3	8.5	15.9

On heavier soils or when applied to slow growing plants, fresh strawy manure may be of greater value than well rotted manure.

Conservation of Manure

Often it is necessary to keep large quantities of manure several months. If so, care should be exercised in building the pile so that excessive drainage or leaching is prevented. Also it is of paramount importance to keep the pile as compact as possible in order to prevent large losses of nitrogen, potash and organic matter. If the above is an annual practice the grower would be well repaid to construct a concrete container of suitable size. This will prevent loss of valuable nutrients. If there is excessive heating some convenient form of watering should be arranged for.

ARTIFICIAL MANURES

In consequence of the universally recognized necessity for livestock manure and its decreasing supply with attendant higher prices, attention is turned towards the possibility of supplementing the supply of stock manure with manure manufactured from straw, corn stalks and other waste residues. Experiments have proved that well-decomposed, artificial manure of this type compares very favorably with farm manure on crop growth, crop yield and soil conditions in general.

During the war a process for manufacturing manure from waste was developed and patented at the Rothamsted Experimental Station, England, and the necessary chemicals sold under the name of "Adco". Recent investigations in this country show that very satisfactory decomposition can be brought about in three months, providing the main factors are present, namely: moisture, a source of soluble nitrogen and phosphorous, and neutral or alkaline conditions.

The investigations indicated, however, that owing to the labor involved, the large amounts of water necessary, and the cost, the method is only practical where intensive farming is practised. A satisfactory mixture of chemicals consists of 45 pounds ammonium sulphate, 40 pounds of finely ground limestone, and 15 pounds super-phosphate, applied at the rate of 150 pounds, per ton, of straw or refuse. The method of procedure is to make a compact layer of straw or refuse about 6 inches deep, wet thoroughly with water, and spread the reagent on it at the rate of 150 lbs., per ton. Repeat this operation layer by layer, until a height of 6 to 8 feet is obtained. Successive layers may be added as waste material accumulates. It is important that the pile be kept as flat as possible. Fermentation soon starts and the temperature rises. Frequent watering is necessary to control the temperature, replace losses by evaporation and drainage and maintain bacterial activity; a moisture content of about 75% is required to be maintained. While the decomposition is proceeding, it is necessary to fork over the mass two or three times at intervals during the period of decomposition. After some three months, depending upon conditions, a decomposed mass of material, resembling well-rotted farmyard manure, is obtained. It is claimed that one ton of straw or refuse will make from two to three tons of rotted manure.

Summarizing, the essentials are as follows:

1. Proper care in building the pile; 2. Proper treatment with chemicals; 3. Adequate watering; 4. Subsequent watering and forking over to keep down the temperature and facilitate decomposition.

By depending upon the normal rainfall, the same results may be obtained, but a much longer period of time will be required.

The cost per ton of dry material may be estimated as follows:

68 lbs. ammonium sulphate at $45.00 per ton	$1.53
22 " superphosphate at $20.00 per ton	0.22
60 " limestone at $5.00 per ton	0.15
Total	$1.90

It is estimated that approximately 800 gallons of water is required per ton of straw; to this must be added the value of straw and labour, which will vary with localities.

FERTILIZERS (1)

The market gardener must have a very thorough knowledge of the principles and use of commercial fertilizers. He grows a wide variety of high cost per acre crops that are very sensitive to conditions of soil and source and amount of plant nutrients. Furthermore, slightly unfavorable conditions, which may be in the soil, in the source, amount, time or method of application of fertilizer will upset the delicate balance required for maximum growth. Another important point is that science has greatly multiplied the number of sources of plant food nutrients offered for sale, each with specific characteristics and varying prices per unit of plant food. Often the investment for fertilizers may be materially reduced by buying a cheaper source of plant nutrients that may be as well or better adapted to the soil and crop requirements.

The primary function of a commercial fertilizer is to supply plant nutrients, but the addition is usually made to supplement the soil constituents rather than constitute a major source. The crop, even though fertilized, continues to depend on the soil for a large proportion of its mineral substance. Besides supplementing the nutrients already present in the soil, another function is expected of the fertilizer added. It should establish a proper proportion between the essential elements of nutrition which is important in order that an under or over-stimulation of the crop does not occur, and abnormal developments are not encouraged. Ideally, the fertilizer added should supplement the soil nutrients so as to provide for the plant the correct proportion of nitrogen, phosphoric acid and potash to produce a large and normal growth. In practice this is very difficult because the soil is more or less an unknown quantity as to the probable availability of its constituents. Moreover, it is difficult to forecast reactions that may occur in the soil, to what extent the fertilizer may remain active and available in the soil and what the seasonal conditions may be, which will affect the whole relationship between the soil, fertilizer used and crop response. Nevertheless, the ideal should always be the objective. Much depends, therefore, in fertilizer practice on the good judgment of the grower, his ability to anticipate conditions influencing the amount of kinds and methods of applying fertilizer, his own experience of the past, his neighbours, and always keeping in mind results obtained from the many experimental stations.

Of the ten elements known to be essential for plant growth only three, namely, nitrogen, phosphoric acid and potash are usually necessary to be added in the form of commercial fertilizers. Calcium in the form of calcium carbonate (Agricultural Limestone) is necessary if the soils are acid. It acts partly as a plant nutrient, but more particularly as a source of basic material in order to counteract toxic conditions present within the soil. Soil Science is finding that very small amounts of other elements such as magnesium, manganese, sulphur and boron prove exceptionally beneficial under certain conditions for some crops and many fertilizer companies are attempting to take care of these conditions by including them within the fertilizers offered for sale.

To use fertilizers intelligently and judiciously, it is necessary not only to understand the characteristic requirements of the soil but it is essential to have a thorough knowledge of the function of the three fertilizer constituents, nitrogen, phosphoric acid and potash, and understand the characteristics of the many different sources of these constituents in order to be in a position to select and apply the most economical form to the crop grown.

NITROGENOUS FERTILIZERS

Of the three elements usually applied in commercial fertilizer, nitrogen seems to have the quickest and most pronounced effect on plant growth. Its primary function is to promote above the ground vegetative growth and it imparts to the plant a deep green colour. It also tends to give succulence, a quality particularly desirable in many vegetable crops. Soils that are abundantly supplied with nitrogen are usually dark in color, as there is a direct relationship between the amount of organic matter in the soil and their total nitrogen content. If the soil is sandy or grayish in colour, strongly acid, low in available phosphoric acid, subject to long periods of flooding, or extremely dry, and if there has recently been heavy applications of strawy manure or organic materials having a wide carbon-nitrogen ratio the soil is probably low in available nitrogen.

Of the three constituents nitrogen is the only one when added in excess that will give pronounced harmful effect on the growing crop, which may be exhibited by the following conditions: (1) Delaying of maturity by encouraging excessive vegetative growth and danger of loss by early frosts or winter killing. (2) Weakening of the straw or stems of tall plants, causing lodging. (3) Lowering of the quality of fruits or seeds by promoting the development of a watery condition.

(4) Decreasing resistance to disease, probably due to a change in physiological condition within the plant, causing a thinning of the cell walls and allowing the more ready entrance of disease germs. However, in the case of spinach, lettuce and grasses, heavy applications of nitrogen are not considered harmful and may be used quite freely with safety, the cost of material being the only limiting factor.

Deficiencies of nitrogen in the plant may be indicated by the following signs: (1) Plants grow slowly and leaves are pale green in color. (2) The leaves of plants are shed prematurely, the growth is stunted and bears little fruit. (3) Plants tend to "fire," that is, leaves die from midrib outward to edge. (4) Plants tend to produce fruit prematurely.

The effects of nitrogen fertilizers on growth are more subject to seasonal conditions than any of the other plant nutrients. Consequently the grower should acquaint himself with the conditions under which nitrogen fertilizers are especially effective. If any of the following seasonal conditions prevail, very cool and wet, very dry, or abundance of sunshine, application of nitrogen fertilizers will be very effective. It is generally accepted that there is no residual effect of readily available forms of nitrogenous fertilizers the second year.

Nitrogen fertilizers may be divided into two classes, inorganic and organic forms.

Sodium Nitrate secured from Chile, often referred to as Chilean Nitrate of Soda, is a form of natural inorganic nitrogen which is readily soluble in water and can be immediately absorbed by the growing plants. It contains 15.5 percent of nitrogen, is shipped in waterproof bags, and is a fine granular or pellet form, making it very easy to apply. There is also a synthetic form of sodium nitrate containing the same amount of nitrogen in the same form. Recent experiments have shown that one form is as effective as the other in promoting growth. Applications of 250 pounds per acre may be used with safety but heavier amounts should be applied in two or more applications in order to prevent loss of nitrate nitrogen by leaching especially in open porous soils.

Ammonium Sulphate is a greyish-white crystalline salt, usually containing 21 percent nitrogen. It is chiefly made synthetically from the atmospheric nitrogen but also obtained as a by-product from the manufacture of coke. At present it is one of the cheapest sources of nitrogen on the market and is used extensively in mixed fertilizers and applications for top or side dressings. Under normal conditions, it is available to all plants within a few days. For many plants, it acts as an immediate source of nitrogen as they have the ability to utilize either ammonia or nitrate nitrogen. Providing care is taken, heavy applications, up to 250 or 350 pounds per acre, may be made without great danger or loss by leaching, except on very light sandy soils. Long continued use of ammonium sulphate will increase soil acidity but this effect may be counteracted by periodical applications of ground limestone. Its efficiency is somewhat decreased on very acid soils where possibly a basic source of nitrogen such as nitrate of soda, cyanamid or nitro-chalk would be more satisfactory.

Calcium Cyanamid contains 22 percent nitrogen and calcium equivalent to 70 percent lime in the hydrated form. It is black in colour and may be secured in two forms, powder or small pellets. The latter is a recent form of manufacture and the improved physical condition greatly aids application. Until recently Calcium Cyanamid has been used altogether as a part source of nitrogen in mixed fertilizers, but is now sold retail for use as a top or side dressing. Experiments have shown it to be a very desirable form of nitrogen but care must be exercised in application otherwise injury will result from burning and germination will be decreased. The nitrogen is slowly available throughout the growing season and applications up to 250 pounds per acre may be made with safety provided it is applied a few days before seeding. Experiments have shown that continued use of cyanamid on acid soils reduces the acidity.

Nitrochalk contains 15.5 percent nitrogen, half as nitrate nitrogen and the remainder in the ammonium form. It also contains 51 percent lime calculated as the carbonate form. This is an excellent source of nitrogen in the form of grayish white crystals, easy to apply and readily available. The lime content is very valuable on acid soils. It may be used the same as nitrate of soda.

Calcium Nitrate or Nitrate of Lime is a much similar product to nitrochalk. It contains 15.5 percent nitrogen and 28 percent. lime, calculated as the hydrate, and is sold in small pellet form. The nitrogen is water-soluble and immediately available and may be used to an advantage on acid soils.

Urea is a water-soluble source of organic nitrogen and readily becomes available to the plant. It occurs in the small pellet form and is the most concentrated of all forms of nitrogen fertilizer containing 46 per cent. Owing to its concentration, it must be used with care, but may be used continuously without detrimental results to the soil.

Dried Blood Meal is a natural organic source of nitrogen obtained from abbatoirs. It contains 12 per cent nitrogen, which is rather slowly available in cool, wet soils, but relatively quickly available in light, warm soils. It may be used with safety in large amounts on all crops and there is no immediate loss of nitrogen by leaching.

Tankage is also a natural source of organic nitrogen obtained as a by-product from the abbatoirs and containing from 5 to 10 percent nitrogen, and 8 to 12 percent of phosphoric acid. The nitrogen is slowly available and will last over the growing season. It may be applied in relatively large amounts per acre, without danger of loss through leaching or injury to the growing plant. The phosphoric acid content also adds to its value. It is a relatively economical source of nitrogen and phosphorus especially for slow growing plants. Its rate of availability is medium.

There are many other sources of nitrogen in combination with phosphorus and potash, such as ammophos and nitrophoska, which will be discussed under the section dealing with concentrated fertilizers.

PHOSPHATE FERTILIZERS

Many of our soils are deficient in phosphoric acid, and, since manure is low in this constituent, the addition of phosphoric acid is usually attended with increased production and betterment of growth. It is difficult to state the exact functions of phosphorus in the plant but cell division, formation of proteins, fats, starch and sugars cannot proceed without it. The close connection between phosphorus and cell division may account for the large amount of phosphorus compounds stored up in the seed, and also the relatively large amounts of phosphorus taken from the soil during the early stages of plant growth. In general heavy soils and mucks are usually deficient in easily soluble phosphates and respond to heavy applications. Light, sandy loams also respond to phosphatic fertilizers, but, continued applications of this material alone would soon bring about a condition where nitrogen and potassium become limiting factors.

Phosphoric acid deficiency in soils is usually present if the soils are heavy, fairly well to well drained, medium to low in organic matter, strongly acid and if there is a deficiency or excess of available nitrogen.

The outstanding external effect of phosphoric acid on the plant is (1) Hastening maturity, which is of special value in wet seasons, cold climates and short seasons, and, (2) Root development, especially the lateral and fibrous rootlets, which are greatly increased by applications of phosphoric acid, thus reducing winter injury to fall sown crops and aiding those of restricted growth in search for water and plant nutrients; also providing a readily available supply for their rapid development in the early spring; (3) For cereals or tall growing plants phosphates will tend to stiffen the stems and produce plumper seeds; (4) Also, it is well known that the food value of crops is greatly improved and that plants are more resistant to disease which is probably brought about by a more normal cell development, thus counteracting the influence of excessive nitrogen.

The following conditions appearing in plants are indicative of phosphorus deficiency:— stunted growth, leaves pale green to grayish in colour, slow rate of maturity and small yield of seeds in proportion to straw. Young tomato plants deficient in phosphorus have a stunted, constricted, ridged appearance with very few hairs on the stem.

The climatic factors that increase the efficiency or the demand for phosphoric acid are a cool, moist season that favours rank vegetative growth, or, if the early spring is moist but followed by drought, later in the season.

Phosphoric acid does not leach from the soil except in very minute quantities, hence continued heavy annual applications of high phosphatic fertilizers tend towards an accumulation of phosphates in the soil with possible detrimental results, especially on soils where nitrogen and potash are limiting factors. In extensive agriculture, phosphoric acid should be the predominating constituent in fertilizers. In intensive farming, where heavy annual applications of fertilizers are made, which is usually on light soils and mucks, nitrogen and potash are often of equal or greater importance than phosphoric acid.

There are many forms of phosphatic fertilizers on the market, each having their valuable characteristics according to soil conditions and kind of crop grown. However, considering the cost of producing market garden crops and their value per acre, the cost of the fertilizer used is only a relatively small percentage of the total investment, hence, it is very desirable to use forms that are immediately available to the plant.

Superphosphate (Acid Phosphate) is a grayish material, sold either in the powder or granular form and contains 16 or 20 percent phosphoric acid (P_2O_5), which is in a form immediately available to the growing plant. It is practically the only source of phosphoric acid in mixed fertilizers. It may, by suitable methods of application, be applied alone at rates up to 2,000 pounds, per acre, without injurious effects. Superphosphate is more efficient when applied on soils well supplied with lime. When applied on acid soils, it will help to overcome the toxic conditions usually present in lime deficient soils.

Treble Superphosphate is a grayish material sold in the granular form. It contains 45 percent phosphoric acid, which is approximately three times as concentrated as superphosphate. It may be used quite safely instead of superphosphate providing the same number of pounds of plant food are applied. The phosphorus is in the water soluble form and readily available to the growing plant.

Steamed Bone Meal contains 1 to 2 percent nitrogen and 22 to 25 percent phosphoric acid. It is a relatively expensive form of phosphoric acid, which is rather slowly available in the soil. However, large quantities may be applied to the soil with safety and used continuously without injurious effects. When used it should be applied to slow growing plants or those that have a strong feeding power for phosphorus.

Rock Phosphate contains about 30 to 35 percent phosphoric acid in a difficultly soluble form. It is a very cheap form of phosphoric acid, about half the price per pound of plant food as compared with superphosphate. This form of phosphate is very slowly available and for vegetable crops is not generally recommended, except as a means of building up the phosphate stock in soils at a low cost. Rock phosphate is most effective when applied on muck soils or mineral soils high in organic matter and quite acid in reaction, and sown to crops that have a strong feeding power for phosphorus. There are other forms of phosphatic fertilizers on the market but these are not generally used by vegetable growers.

POTASSIUM FERTILIZERS

All mineral soils contain relatively large amounts of potassium, especially those of high colloidal content.

Muck soils contain very small amounts and as a rule fertilizers high in potassium should be used on this type of soil. Sandy soils contain considerably less potassium than clay soils and in a much less available form. Therefore, considering that the majority of vegetable crops are grown on light, sandy and muck soils, potassium forms a very important constituent of the fertilizer. Potassium does leach from the soil but not in excessive amounts, therefore, marked residual effects are often noted.

Potassium produces distinct effects on plant growth, namely:

(1) Improved health and vigour of the plant, thereby increasing resistance to disease and increases the efficiency of the leaves for synthesising and translocation of carbohydrates.

(2) It plays an important part in the growth of legumes and formation of seeds and fruit.

(3) Potassium tends to decrease the rate of maturity thus counteracting the effects of excessive phosphoric acid. Similar to phosphoric acid, excess potassium in the soil is not considered harmful.

(4) In general it exerts a balancing effect on both nitrogen and phosphorus and should be seriously considered when selecting the fertilizer mixture for the crop.

Plants deficient in potassium may be indicated as follows:—

(1) Susceptibility to disease.

(2) If leaves die prematurely from edges toward midrib.

(3) Stunted appearance and failure to reach maturity.

(4) Shrunken seeds.

(5) Leaves become dull in colour and blotchy. Tomato and potato plants having very dark, unhealthy green, thick, heavily wrinkled leaves with edges turned down and brownish in color, indicates potassium starvation.

The seasonal conditions in which potassium is very effective are cool and cloudy weather, warm with plenty of rain and high humidity, periods of hot, dry weather following rain.

SOURCES OF POTASH

The two principal sources of potash used are potassium sulphate and potassium chloride, which are imported from Germany and France, and used extensively as a source of potash in mixed fertilizers. Occasionally the carbonate or nitrate forms of potash are used.

Potassium Sulphate (Sulphate of Potash) occurs in the powder form, colour variable but usually light brown and containing from 48 to 50 percent potash (K_2O) in a water soluble form. It may be applied quite safely in applications up to 1,000 or more pounds per acre.

Potassium Chloride (Muriate of Potash) occurs in a granular form of variable colour, ranging from grayish white to grayish black and contains from 48 to 50 percent potash (K_2O) in a water soluble form. It may be used similarly to potassium sulphate.

In general, muriate of potash is used more extensively than the sulphate form. However, there are certain crops which seem to be injuriously affected in yield and quality by the use of chloride of potash. These crops are tobacco, potatoes and sugar beets, with tobacco showing the greatest evidence of injury. Marked improvements in yield and quality of these crops have been obtained when the source of potash was derived wholly or in part from sulphate of potash.

Potassium Carbonate occurs in a white floury form, containing about 50 per cent. potash (K_2O) in a water soluble form. It is not used very extensively.

Wood Ashes is an excellent and one of the oldest sources of potash and at one time valued very highly and carefully saved. Unleached, hardwood ashes contain from 10 to 12 percent potash in the carbonate form and about 40 to 45 percent lime. If subject to leaching, approximately half of the potash is lost. Coal ashes have practically no manurial value but act mechanically on the soil.

There are many more sources of potash, such as sulphate of potash-magnesia, Kainit, Kemfert, Hard Salt and Kelp, which are not used very extensively but are discussed in Ontario Department of Agriculture Bulletin No. 364.

CONCENTRATED FERTILIZERS

Fertilizers may be conveniently divided into three groups (1) ordinary fertilizers containing less than 20 units of plant food; (2) high analysis fertilizers containing between 20-30 units of plant food; (3) concentrated fertilizers containing 30 or more units of plant food.

Within the past few years, science has developed processes whereby the manufacture of concentrated fertilizers is made possible through the production of (1) nitrogen salts through fixation of atmospheric nitrogen by chemical means; (2) the production of very high analysis phosphates. Potash salts of high concentration are available in the form of muriate and sulphate of potash.

New sources of synthetic nitrogen fertilizers containing nitrogen in the nitrate or ammonium forms in combination with basic or acid materials, such as calcium or sulphates, provide a wide range of choice of materials to suit any condition of soil and plant.

By means of spraying liquid ammonia or nitrate nitrogen in combination with potassium into high analysis superphosphate, a series of concentrated ammonium-phosphate and nitrate-phosphate-potash fertilizers are manufactured. The ammonium-phosphate fertilizers called "Ammo-Phos" are sold in two grades, A and B, carrying 11% N and 48% P_2O_5 and 16½% N and 20% P_2O_5, respectively, and diammophos containing 20% N and 47% P_2O_5. Ammophos is a creamy grey granular material which is in excellent mechanical condition. The phosphate occurs as phosphate of ammonia which is in a highly soluble form and readily available to plants. Recent experiments have shown the phosphorus in the form of ammophos to be in a more mobile form than in superphosphate and will, in a short time, move down to the region of plant roots, thereby increasing its efficiency.

The nitrate-phosphate-potash series are complete mixtures of concentrated fertilizers. They are sold under the trade name of "Nitrophoska" and the following analyses are at present on the market, the constituents being all in a water-soluble form:—

Nitrophoska

No.	% N	% P_2O_5	% K_2O
1.	15	30	15
2.	16.5	16.5	20
3.	15.5	15.5	19
4.	15.1	11	26.5

Providing certain precautions are taken high analysis fertilizers offer many advantages to the market gardener who practises applying large amounts of fertilizers per acre. The most important point to remember is that they are very concentrated forms of plant food. Therefore, care must be taken to apply the materials on the basis of equal number of pounds of plant food, and not on equal number of total pounds of material. Thus it is important that the fertilizer distributing apparatus of the machine must be in first class working condition and capable of applying the reduced bulk very uniformly, otherwise, injury to germination or growing plants will result. Recent experiments have shown that where these precautions have been taken very satisfactory results have been obtained. The advantages of using high analysis or concentrated fertilizers are (1) that the actual cost per unit of plant food is much less; (2) they are usually in an excellent mechanical condition, and (3) less labor in handling of material is involved.

METHOD OF APPLICATION OF FERTILIZERS

A little fertilizer well placed is worth double the quantity improperly applied. The time and method of application of fertilizer will be determined by the nature of the fertilizer materials, soil type, climatic conditions, kind of crop and economic factors. Experiments have proved that the nearer the fertilizer can be placed to the seeds or roots without causing injury, the more effective will be the results. With many crops, row or hill application of fertilizers have given equal or better returns with less than half the quantity applied broadcast.

The amount of fertilizer to apply for any crop will be governed by the previous manuring and the total acre value of the crop. As with all things, the law of diminishing returns applies to rates of applications of fertilizers, and although larger returns may be had with excess amounts, the extra cost of fertilizer may be greater than the value of the increased crop.

To obtain the greatest return from the investment in fertilizers, soil fertility should be the only limiting factor. The necessity of putting the soil in the best possible condition for plant growth is paramount, which means that adequate drainage, lime, organic matter, tillage and even the best source of seed sown at the right time is essential.

HOME MIXING

Some vegetable growers desire to mix their own fertilizers. This can be done quite satisfactorily providing certain precautions are taken. One of the chief advantages in home mixing, is that the grower can make any formula which he thinks suits his particular conditions. For small amounts, it certainly does not pay to go to the trouble, but if many tons are used by a grower or group of growers, it may be profitable. The disadvantages of home mixing are amount of time and labor involved with the possible use of incompatable materials and consequent result of poor physical condition, loss of available plant food, also an uneven mixture. By taking advantage of cash discounts and co-operative buying by the carload, the price of the ready mixed fertilizers can be reduced to a point where the amount saved by home mixing would not be appreciable.

Details on how to mix fertilizers can be secured in Bulletin No. 364, entitled "Manures and Fertilizers".

IMPORTANCE OF LIME

Soil reaction is an important factor to consider in the production of vegetables. If the soil is too acid the actions of beneficial soil organisms that bring about decomposition of organic matter, formation of nitrates and fixation of atmospheric nitrogen are diminished.

The efficiency of fertilizers, especially ammonium sulphate and superphosphate, are greatly reduced on acid soils and injurious soil borne diseases of plants, such as club root of cabbage, etc., flourish.

The majority of vegetable crops prefer a neutral to alkaline soil reaction as they have a weak feeding power for lime. Crops can be classified in their ability to thrive on soils according to their reaction. The following list contains some of the important crops classified according to their toleration of soil acidity.

Relative Sensitiveness of Plants to Soil Acidity (F. E. Bear).

VERY TOLERANT	TOLERANT	SENSITIVE	VERY SENSITIVE
Beans	Carrot	Brussels Sprout	Asparagus
Potato	Corn	Cabbage	Beet (red)
Radish	Cucumber	Cauliflower	Celery
Watermelon	Endive	Chard	Leeks
	Pea	Egg Plant	Lettuce
	Pumpkin	Horse radish	Onion
	Rhubarb	Muskmelon	Parsnip
	Strawberry	Turnip	Pepper
	Tomato		Salsify
			Spinach

Considering the slight expense in time, labour and purchase of a Reactosoil test kit for testing, every grower should test the soil to determine its lime requirement. If lime is necessary, use some form of finely ground limestone at the rate recommended as shown by the test. The Reactosoil test kit can be secured from the Department of Chemistry, Ontario Agricultural College, for twenty-five cents. Instructions are enclosed enabling any grower to test his own soil. For a further comprehensive treatment on this subject, the reader is referred to Bulletin No. 313, entitled "Soil Acidity and Liming" issued by the above Department.

The choice of fertilizers, especially forms of nitrogenous fertilizers, should be governed by the soil reaction. If the soils are acid, nitrogenous fertilizers leaving an alkaline reaction in the soil, such as nitrate of soda, nitro-chalk, calcium nitrate or calcium cyanamid, are desirable. Ammonium sulphate and other fertilizers leaving acid residues lose much of their effectiveness on acid soils and may be used to much better advantage on soils that are alkaline or received applications of lime.

FERTILIZER RATIOS

In considering the individual effects on plant growth of the three fertilizer elements, it is observed that they are complementary to one another. This interrelationship of influence of one nutrient upon another is very important in the economical utilization of fertilizers.

The ideal condition is to apply fertilizers of the right kind and amount to supplement soil deficiencies, taking into consideration the feeding characteristics of the crop to be fertilized, the whole blending together in the right ratio to form a balanced ration for the crop. A deficiency of any one nutrient will seriously interfere with the absorption of the others. If added in excess, detrimental results may follow in the form of an unbalanced growth and what is known as luxury consumption—that is, the plants consume more than they actually require.

In making recommendations of fertilizers for various crops, it has been the custom to name specific analyses, e.g., 4-8-10 or 5-8-7, etc. To name specific analysis only prevents freedom of choice of similar analyses, and thereby places undue emphasis on a definite mixture. For instance, 4-8-4, 5-10-5, and 10-20-10 all supply a similar relationship of nitrogen, phosphoric acid and potash. If 2,000 lbs. of 4-8-4 is recommended, the grower can apply precisely the same amount of ingredients (N-P_2O_5-K_2O) in 1600 lbs. of 5-10-5 or 800 lbs., of 10-20-10.

It is thought that this method of statement of the kind of fertilizer required will be more convenient to the grower. It gives the ratio which is thought to be best and does not limit him to buy one definite mixture. If a 1-3-1 fertilizer is advised, it may be chosen from any one of the following analyses: 4-12-4, 5-15-5, 6-18-6, 10-30-10. The objective is to keep the ingredients in the ratio of 1 of nitrogen to 3 of phosphoric acid to 1 of potash.

Fertilizer recommendations for various crops discussed in this bulletin will include both types of statement, giving primary attention to the ratio of ingredients so as to give elasticity to choice of suitable analyses of fertilizers. With the aid of the double system of ratio and analyses, the choice of double and triple strength fertilizers may be made.

ASPARAGUS

The underground part of the asparagus plant is comprised of a running underground root stock attached to which are numerous fleshy roots which continue to increase in length for some years. During each growing season new fleshy roots are produced. Numerous small fibrous roots grow each spring on these fleshy roots and die the following autumn. The fleshy roots are for food storage and are able to absorb food materials from the soil; while the fibrous roots take food from the soil. Attached to the running root stock are buds from which stems with leaves are produced. There are two types of asparagus plants, one having only male or staminate flowers, and the other having only female or pistillate flowers. When harvesting of a crop ceases the stems and leaves are produced and these leaves manufacture food which is stored in the fleshy roots and the running root stock for the following spring crop.

Soil for Permanent Beds.—Very slightly acid or neutral soil is used for this crop. Any soil should be naturally or artificially well drained. A deep loose soil is necessary to allow the natural root development to be adequate and the roots to penetrate the soil.

Light sandy loam soils and heavy sand loam soils are preferable to light clay loams. However, light clay loam soils are suitable for asparagus provided they allow proper penetration of roots and do not bake. Soils possessing a hard-pan subsoil are unsuitable for asparagus unless the subsoil is loosened for penetration of roots before planting. Soils possessing a gravelly subsoil should not be used.

The soil should be thoroughly prepared as the crop occupies the soil commercially for ten to fifteen years and sometimes from fifteen to twenty years if good fertility is conducted. However the ten to fifteen years is the most common. For preparation of the soil for the permanent bed the soil should be well plowed to the depth of eight inches to permit the roots to penetrate the soil as the roots are naturally deep and spreading and must have ample opportunity to penetrate the soil. Disking and harrowing should be conducted after plowing.

Cultivation and Care of the Permanent Bed.—At the end of the cutting season the plant naturally produces stems and leaves which manufacture the food which is stored in the roots to be used for the production of the crop harvested the following early summer. These stems and leaves should be allowed to remain on the plant until dead and the leaves have dropped to the ground. Considering that some rust might be present these stems should be burned in the autumn. Endeavouring to disk these stems into the soil in the spring when only fibre and few minerals remain in them although adding some organic matter to the soil, makes subsequent summer cultivation difficult and may cause some spears to be crooked. Large stems cannot be successfully worked into the soil.

Some weed control and the incorporation of manure and fertilizer into the soil are secured by cultivation.

As soon as soil conditions permit during each spring the bed is disked and harrowed throughout taking every precaution not to injure the buds and crowns. When using the disc harrow examination of buds and crowns of the plants should be made by the operator to make certain that no damage has been done. A shallow harrowing is conducted after the disking. Shallow frequent cultivations with a cultivator are made between the rows previous to, during, and subsequent to the cutting season.

Production of Young Plants.—The type of asparagus root to plant in the permanent bed is of much economic importance. The best type has four or five large buds above the average size of the lot, spaced apart from each other, and distributed on the crown; while two or more bud clusters should be present on the crown. The large bud is productive of the large spear—the edible leafstalk—throughout the life of the asparagus bed. Also the root to be planted must possess a well developed system of large fleshy roots because a poorly developed root system produces small spears.

The size and yields of asparagus spears are inherited. Hence to grow a large percentage of high producing crowns the seed must carry to the young plants the characteristics of the high producing plants. This seed is secured by mating high producing plants. Asparagus plants are of two types—one possessing only male or staminate flowers, and the other type having only female or pistillate flowers. The male flowers are yellowish green and conspicuous, while the female flowers are less conspicuous. The seeds are enclosed in a berry which becomes red at maturity. Bees carry pollen from the male to the female flowers.

To effect the mating of high producing male and high producing female plants the following method is conducted. During spring in the commercial bed permit a few high producing male and high producing female plants—one male to five or six females is a satisfactory proportion—to produce stems and leaves by cutting no spears. This procedure allows the mating of the staminate and pistillate flowers of high producing plants and effects the production of seed previous to the development of flowers on the low producing plants. The seed secured by mating high producers has very good possibilities of possessing the desirable high producing qualities of its parents. The seed should be harvested when the berries are red; the berries mashed; and the pulp washed out in a container of water. The seed is dried by spreading over a screen or cheesecloth; and then stored in a cool place. The size of the seed influences the size of the plant, consequently the larger seed should only be used for the production of young roots.

A few weeks before danger of frost is over the following spring this desirable seed is sown in a sandy loam or light type of soil rich in plant food material. The light type of soil is superior to heavier types because the young roots penetrate the light type with more ease, and because the fleshy roots can be more readily removed from sandy soil than a heavier type. Since the fleshy root system should be well developed and the roots not broken damaging at digging should be maintained at the minimum.

Germination of asparagus seed is decidedly slow, requiring two and more weeks in the soil at usual prevailing outside temperatures. The slow germination at low temperatures is considered to be due to the meagre rate of water absorption. Soaking the seed in water at a temperature of 86° F. for four days has the best effect in hastening germination. Subsequent to the removal from the water spread the seed on a canvas; stir until the water disappears from the surface of the seed; and then sow at once in moist soil. Of course if one desires to wait for slower germination in the soil he may do so.

Seeds should be sown singly since the grouping of seeds at sowing makes detrimental thinning necessary, and causes the intertwining of roots. The separation of the different plants at digging is costly and damages the roots. The depth of sowing is about an inch. The rows should be 24 to 30 to 36 inches apart and the seed in the row 4 to 5 inches apart to provide ample space for the correct development of the young plants which should be 4 to 5 inches apart in the row. This spacing of seed makes thinning unnecessary; and may be accomplished by hand or a disc type of hand seed drill containing an asparagus seed disc. For soaked seed a special disc is required to accommodate the increased size due to soaking.

Should a grower unfortunately desire to not space seed at sowing, thinning must be done before the second above-ground shoot appears and previous to the commencement of the development of the fleshy root system. After the fleshy roots have commenced to develop thinning must be conducted by digging out the young plant because the above-ground shoot usually breaks at the crown when the plant is pulled. This digging causes injury to adjacent undug plants.

Frequent cultivations should be conducted during the season of seed sowing effecting thorough weed control. Late during the autumn of the seed sowing season the young roots are dug or plowed up, usually, so that all of the root system remains on the plant. These young plants are placed in a cellar with the tops removed and covered slightly with soil, placing some soil around the roots of each plant. The soil is kept moderately moist; and the temperature in the ventilated cellar quite near 40°F., preventing the roots from drying out. If the cellar is not available the young plants can be placed in soil in a cold frame and the frame filled with straw to prevent alternate freezing and thawing as much as possible.

In the spring before planting they should be sorted to secure only the desirable plants for the permanent bed as already mentioned.

Experimenters have discovered in Massachusetts and California that male plants produce about 25 percent greater yield by weight than the female plants, and that the female plants produce larger spears. In Eastern Canada and United States the plants do not blossom the first year and consequently it would not be possible to select the male plants unless the young plants were two years of age. As one-year-old plants are much preferred to two-year-old plants the selection of only staminate plants would not be possible when planting the desired one-year-old plant. One should also consider that field run plants consist of an average of 50 percent females and 50 percent males.

Planting.—Planting should be conducted only in the early spring. Subsequent to the thorough preparation of the soil V-shaped furrows should be plowed out. The rows are spaced from four to six feet apart, five feet being a good average. The common method of spacing between the plants in the rows varies from eighteen to twenty-four inches. There is no conclusive experimental evidence concerning these distances but experimenters think that the greater spacing would produce more large spears and perhaps a larger yield.

At planting the fleshy roots are carefully spread out by hand. The centre of the crown is placed on a small mound of earth and the roots rest on the soil. Only two inches of loose soil is placed on top of the buds at planting time. As the young shoots grow up through this soil more soil is added around but not on top of the young shoot. Cultivation of the land accomplishes this method. During the growing season the furrow is filled with soil. Covering the soil the full depth of planting at planting time smothers the buds and young shoots.

The depth of soil over the young plants finally when the furrow is completely filled should be six inches in sand soils and four inches in clay soils.

Weed control and cultivation should be maintained during the season of planting.

Providing some fertility and organic matter in the soil previous to planting of the permanent bed is a good plan; and may be secured as follows: On sod land plow under manure at the rate of ten tons per acre in the spring and grow some short season crop. Subsequent to harvesting this crop plow under ten tons manure; and plant some cover crop. The following spring add ten tons of manure. Thus, thirty tons of manure per acre is well incorporated into the soil in preparation for permanent asparagus bed. The thirty tons of manure per acre plowed under immediately before the plants are planted would not permit thorough mixing with the soil as no ploughing is done usually in the permanent bed. If this plan could not be entirely conducted an application of ten to twelve tons per acre plowed in as early as possible in the spring before planting would aid the situation.

Market Preparation.—Cutting asparagus is commenced at the beginning of the third season after the plants have enjoyed two full growing seasons in the permanent bed. This practice permits the necessary ample development of roots for food storage. During this first cutting season two to three weeks of cutting is the average cutting, depending on the average size of the spears. Throughout all subsequent harvesting seasons cutting shoould cease about June 25th to July 1st. When at any time during a harvesting season a considerable quantity of spears becomes small in diameter cutting should cease as the small spears indicate a shortage of plant food in the roots which should not become entirely drained of plant food.

When cutting, the young shoot or spear should be cut an inch or two below the surface of the soil by inserting a sharp ordinary butcher knife straight down along the side of the young shoot, and then turning to cut. By keeping the knife close to the spear the buds and spears below the soil surface are not injured.

Salt.—Salt is not essential in the growth of asparagus. Experimental evidence goes to show that it has little or no effect, especially when muriate of potash is used.

Varieties.—Mary Washington is a good variety to plant; and is the most generally planted at the present time as it is highly rust resistant.

Fertility.—Subsequent to harvesting a large amount of healthy vigorous stems and leaves should materialize. These leaves until frozen manufacture food; and this food is stored in the roots and root stalks. This supply of food is utilized for the production of spears—the edible asparagus—during the following spring and early summer. Consequently we wish the plant food in the soil to be available for the asparagus plant at the end of the cutting season and throughout the remainder of the summer.

During the usual spring disking manure at the rate of 8 to 10 tons per acre is incorporated into the soil. This manure adds organic matter as well as nitrogen, phophorus and potash; and aids in holding water in the soil after it is decayed into the form of humus.

Fertilizers.—On light sandy loam soil, an application of fertilizer with an approximate ratio of 1-1-2 will be satisfactory when broadcasted and worked into the soil at the rate of 75-100 pounds of nitrogen and phosphoric acid and 150-200 pounds of potash per acre. Fertilizers between 5-8-7 and 6-8-12 analyses would approximate this ratio. The above fertilizers at 1500 to 2000 pounds per acre will supply about the right amount of nitrogen, phosphoric acid and potash. One-half of this could be applied at the commencement of the cutting season and the remainder immediately at its conclusion. On heavier soils that are well manured, the nitrogen and potash may be reduced to 50-75 pounds of nitrogen and 100-125 pounds of potash per acre, but the phosphoric acid increased to 100 to 125 pounds, giving a ratio of approximately 1-2-2, which is supplied in 1250 to 2000 pounds of a 4-8-8 fertilizer.

In addition to the above fertilizer treatment, 30 to 60 pounds of readily available nitrogen should be applied during the cutting season, depending on vigour of growth. Two years experimental work (1931-1932) indicate that 250-500 pounds per acre of calcium cynanamid, applied as a source of nitrogen for top dressing during the cutting season, will promote vegetative growth and control most weeds, thus saving a great deal of labour.

BEANS

Numerous types of beans are produced in Ontario gardens; and the most used specimen is the common bean (*P. vulgaris*). This bean is an annual and possesses a taproot and rows of small roots arising from the base of the stem. The principal root area is between the depths of three to eight inches from the soil surface with some roots about two inches deep.

Soil and Cultivation.—Early snap beans demonstrate a preference for sandy loam; while heavier loamy soils are most suitable for dry beans and string beans. A fairly rich soil is desirable; yet a comparatively poor soil is satisfactory; and a very rich soil produces an excessive vine growth. Good drainage and a neutral to alkaline soil reaction are necessary. Shallow cultivation is practised, but never in wet vines as an assistance to the control of disease.

Fertilizers.—In general, beans are heavy feeders on phosphorus and potash but for early beans or when grown on soils low in fertility some nitrogen is essential.

Early beans usually grown on light, sandy loams require a 1-2-1 to 1-2-2 ratio fertilizer, supplying approximately 35 pounds of nitrogen, 70 pounds of phosphoric acid and 35 to 70 pounds of potash, per acre. This amount of plant-food is supplied in 750 pounds of a 5-10-5 or about 900 pounds of a 4-8-8 fertilizer mixture.

Late beans grown in the field in the regular crop rotation for canning purposes require much less fertilizer. On light, sandy loams from 250 to 400 pounds of a 1-3-2 ratio fertilizer, corresponding to a 3-10-5 or 4-12-6 mixture will give good results. On heavy soils a 2-12-6 of similar rates will be satisfactory.

Beans are very sensitive to fertilizer injury and applications above 150 pounds, per acre, should be applied broadcast.

Market Preparation.—Beans are harvested by hand picking and are required to be clean and free from disease and bruising. Eleven and six quart climax baskets and occasionally hampers are used for shipping.

The seed is sown 4 to 6 inches apart in rows 2 to 3 feet apart, about 1½ to 2 inches deep on heavy soils and 2 to 3 inches on lighter soils after danger of frost is over as they are frost tender.

Varieties.—Wax or Yellow Podded Bush Beans: Earliest type of Wax Beans, Early Stringless Wax. Other early varieties are Unrivalled Wax, Golden Wax, Kidney Wax and Pencil Pod Black Wax which is the most satisfactory of the black seeded varieties. Green Podded Bush Beans—White Kidney. Pole Beans—Kentucky Wonder.

BEETS

The beet is a biennial, producing a thickened root and leaves the first year and seed the second year. The commonly known beet seed is a fruit, containing two to six seeds which may retain their germinating power for about five years. The root system is comprised of a taproot from which small branches develop. Numerous roots are produced from the bottom of the beet, while near the soil surface many roots extend horizontally through the soil. The small lateral roots have many smaller branch roots. Much of the lateral root development exists in the surface three to four inches of soil.

Soil and Cultivation.—A moderately deep, moist, well-drained, easily crumbled soil with plenty of organic matter, slightly neutral in reaction, is best to allow unhindered expansion of the beet during growth. Early commercial crops are grown principally on sandy loams; while for the winter crop, requiring large yields, a silt loam is very satisfactory. Late beets may be grown well on muck soil. Heavy compact soils usually produce misshapen beets, checking their symmetrical development. The soil for seed sowing should be smooth, loose and well prepared. Quite shallow cultivation is desirable.

Fertilizers.—When well rotted farmyard manure is applied in the autumn at 15 to 20 tons, per acre, a 1-2-2½ ratio fertilizer is suitable, supplying a total of about 60 pounds of nitrogen, 120 pounds of phosphoric acid and 150 pounds of potash per acre. This is the amount of plantfood contained in 1500 pounds of 4-8-10 mixture or its equivalent. When little or no manure is applied the quantity of nitrogen and potash should be increased.

On muck soils a 1-4-8 ratio fertilizer is suitable when applied at rates to supply about 20 lbs., of nitrogen, 80 pounds of phosphoric acid and 160 pounds of potash, per acre. This amount of plantfood would be supplied in 1000 pounds of a 2-8-16 mixture or its equivalent. If the soil is very acid in reaction or season cool and wet top dressing with about 15 - 20 pounds per acre of some form of readily available nitrogen is advised.

Applications of fertilizer are broadcasted and worked into the soil previous to planting. It is advisable to apply about 100 to 150 pounds of the total quantity used in the row at time of seeding.

Seed Sowing and Planting.—For the early outdoor sown crop seed is sown in the garden with the garden seed drill at the conclusion of severe frosts at the rate of four to six pounds per acre in rows fourteen to eighteen inches apart to a depth of three-quarters to one and one-quarter inches, varying with types and conditions of soil.

To obtain marketable beets about ten days to two weeks earlier than the early outdoor sown crop seed is sown in the soil in flats or on benches about March 1st. The seedlings are transplanted to other soil in flats, spacing one and one-half inches apart each way. When the soil in the field is suitable for preparation and hardening-off has been conducted transplanting to the field in rows fifteen to eighteen inches apart and four inches apart in the rows is conducted.

The late crop for winter storage is sown during July, as late as the last week in some communities.

Thinning is necessary for the seed sown field crop because more than one seed is in each fruit; and hence the young plants grow in clumps. All plants except one in each clump should be removed spacing about two to three inches. When the sufficiently sized beets are harvested the small ones, spaced about three to four inches apart in the row, are left to secure suitable size.

Market Preparation.—The early bunching beets with fresh tops and cleanly washed are suitable for market when one-and-one-half to two inches in diameter.

For autumn use, and winter storage the beets are harvested previous to frost. The beets should be placed in small piles in the field and covered with their tops for a few days to permit sweating and drying previous to storing.

Varieties.—For the early crop Early Egyptian and Crosby's Egyptian also called Early Wonder. For the main crop—Detroit Dark Red.

BROCCOLI

The Sprouting Broccoli, slightly grown in this country, produces leaves, more ragged in appearance than those of the cauliflower; and develops a longer stem. The central head or cluster of green flower buds, three to six inches in diameter, is formed at the top of the main stem. After the central head is removed other heads, two to four inches in diameter, are produced on lateral shoots growing from the axils of the leaves. These small heads are produced for a number of weeks. The stems are green and the heads are dark blue green in colour for the best types. Cool weather for field growing conditions is best as warm weather is negative to the best development of heads.

The soil and cultivation requirements are practically the same as those suitable for the cauliflower. The fertilizers are those as suggested for early cabbage.

As one hundred to one-hundred-and-twenty-five days are necessary from seed sowing to heading the young plants are grown in the greenhouse or hotbed in a manner quite similar to cauliflower, requiring about seven weeks from seed sowing to produce the plant suitable for transplanting to the field. The seed is sown about the same time as that of early cauliflower, and in the same manner, but a longer growing season is required for the Broccoli.

The plants are planted in rows in the field eighteen to twenty-four inches apart in the row, with rows thirty-six to forty inches apart.

Market Preparation.—This Broccoli should be harvested when the buds of the flower bud clusters are well developed, and previous to the appearance of the flower petals. This is the essential stage for marketing because the more advanced development causes over-maturity with tough and hollow pithy stems. Harvesting is conducted by cutting the stem immediately below the branches of leaves and flower bud clusters.

Varieties.—The Italian green sprouting type is recommended in preference to the white-sprouting or purple-sprouting varieties.

BRUSSELS SPROUTS

The plant is a biennial possessing an erect unbranched stem eighteen inches to two feet in height at the top of which are large leaves nearly as long as broad. It is grown for the small edible sprouts, lateral buds or small heads about an inch in diameter situated on the erect stem in the axils of the leaves. The root system is similar to that of the cauliflower.

Climatic, Soil and Field Cultivation requirements are practically the same as those of the cauliflower. The fertilizers are those as suggested for early cabbage.

The young plants are produced in practically the same manner as are those of the late cauliflower.

The plants are set in the field three by two-and-one-half feet.

Market Preparation.—About three months after setting in the field harvesting commences. The sprouts, about one and one-half inches in diameter, at the base of the stem mature first and are harvested when the leaves just commence to become yellow. At picking time the leaf, in the axil of which the sprout grew, is removed from the stem. Numerous pickings are conducted. The stem increases in length and forms sprouts in conjunction with the removal of the lower sprouts and leaves.

At the commencement of freezing weather the plants are pulled or cut at about the surface of the soil and then stood upright in a cool cellar or shed, packed tightly together and covered with hay. Freezing is not injurious if thawing is gradual while alternate freezing and thawing is disastrous. The sprouts are picked as desired, the outer yellow leaves removed and sold in quart berry boxes considerably.

CABBAGE

The cabbage plant is a biennial, producing a short stem and a terminal bud or "head" the first year and branches bearing seed the second year. The leaves are somewhat ovate and circular. Usually the taproot is injured in planting; and then a main root usually grows in a downward direction into the soil. From the bottom of the stem numerous well branched laterals with fibrous roots grow. When half grown the roots have been found to be as deep as twenty-two inches; the soil, well filled with fine branching roots at a depth of fifteen inches; lateral roots extending eighteen inches from the plant; fine roots filling the surface soil within a radius of twelve inches from the plant. At maturity some roots were three feet deep in the soil; the roots, well filling the soil to a depth of thirty inches; the principal lateral roots growing nearly horizontally, some to the length of three feet from the plant.

Climate.—Cabbage is a cool season crop, demanding plenty of moisture.

Early Crop

Soil and Cultivation.— A well drained, rich sandy loam is preferable to secure warmth and earliness. However, sufficient soil moisture is always necessary. Preferably the soil should be fall plowed, then spring plowed, disked and harrowed to secure good tilth. Immediately after planting a fairly deep cultivation is given to loosen up the soil for easy penetration of the roots. Subsequent cultivations are quite shallow, effecting weed control. A careful examination of the proximity of the roots to the soil surface and cultivated area at each cultivation with this and every vegetable crop will materially aid in preventing damage to the roots by undue deep cultivation.

Fertilizers.—Cabbages are heavy feeders of all three important plant food constituents, especially phosphoric acid. For early cabbages on light, sandy soils from 20 to 25 tons of well rotted manure should be applied in the autumn and well worked into the soil. At time of planting a basal application of fertilizer of a 1-3-2 ratio, supplying 50 pounds of nitrogen, 150 pounds of phosphoric acid and 100 pounds of potash, is advised. This amount is supplied in 1250 pounds of a 4-12-8 fertilizer. Side dressings with 15 to 30 pounds of available nitrogen are also advised, especially if insufficient manure is available or the season is cool and wet.

On heavier soils for late cabbages, receiving 15 to 20 tons of manure, a 1-6-3 fertilizer ratio is advised, applying 30 pounds of nitrogen, 180 pounds of phosphoric acid and 90 pounds of potash per acre, which is supplied in 1500 pounds of a 2-12-6 fertilizer. Side dressings with 15 to 30 pounds of available nitrogen per acre will be beneficial in a cool, wet season or if manure is scarce.

For cabbages grown on muck soils a basal fertilizer of an 0-1-1 ratio, supplying 100 to 150 pounds of phosphoric acid and potash, will be suitable. This is equivalent to 1000 to 1500 pounds per acre of an 0-10-10 fertilizer. If the soil is acid in reaction, or the season cool and wet, additional side dressings of 15 to 30 pounds per acre of available nitrogen will be beneficial.

When applying fertilizers for cabbages it is advised to place part within the row mixed with the soil beneath the plant, and the remainder applied around the plants after setting and hoed in the soil.

Production of Young Plants.—In the greenhouse or hotbed about March 1st seed is sown in moderately rich soil in flats in drills about two inches apart and about one-quarter of an inch deep and covered with sand. At once subsequent to sowing and a thorough watering these seeds are provided with a temperature of 70°F. From the time the two seedling leaves are produced until the first transplanting fifty-five degrees F. are maintained for the plants.

The first transplanting is performed soon after the first true leaf appears. The first two leaves produced are seedling leaves, and all subsequent leaves are called true leaves. At this transplanting the seedlings are planted into moderately rich compost soil in three inch clay pots where they develop into plants suitable for field planting. Instead of using pots the seedlings may be planted two inches apart each way in the compost soil in flats. When the young plants in these latter flats meet between the rows they are again transplanted to compost soil with plenty of fibrous material in other flats three inches apart each way. Both of these two methods are satisfactory. Immediately after the first transplanting and until placing into a cold-frame 50° F. is applied to the plants.

"Hardening off" cabbage, vegetable plants or other plants is a term referring to a treatment which hardens the tissues of the plants to withstand unfavourable conditions after transplanting into the field. These unfavourable conditions may be frost injury, whipping, drying winds, disease or insect injury and other unsuitable conditions. Well hardened, stocky young plants are necessary instead of soft tender plants. Hardiness is increased by a material check in growth. Plants are hardened by either of the following methods:

Method One.—Subjecting them to comparatively low temperatures for a week or ten days before transplanting to the field.

Method Two.—Permitting the soil in which the plant grows to become dry.

Method Three.—A combination of methods one and two by the application of comparatively low temperatures and the withholding of water.

Low temperatures are obtained by heat reduction and increased ventilation in the greenhouse or hotbed. Considering that hardening is secured by checking the growth of the plant by any method low temperature is not necessary for hardening. Thus placing plants in coldframes is not necessary because hardening can be secured in the greenhouses or hotbed by withholding water as satisfactorily as by placing the plants in the low temperature of the coldframe.

Planting.—Well hardened cabbage plants can withstand a temperature of ten to fifteen degrees of frost for a few days and thus quite early spring planting is conducted, about the first of May. The plant possesses five to six well developed leaves at planting time. Early plants are set about eighteen inches apart in rows thirty inches apart. Machine transplanters are used for large areas. Hand transplanting is conducted by using a dibble or trowel.

Late Crop

This crop matures in October.

Soil and Cultivation.—A large yield is the chief aim. Silts and clay loams, neutral-alkaline in reaction, are preferable as these heavy soils are rich and retentive of the necessary soil moisture. Muck is used satisfactorily for this crop. Spring plowing is done to conserve all possible moisture for the crop. Cultivation subsequent to planting is the same as for the early crop.

Production of Young Plants.—A moderately rich, loose, well prepared soil in the field or garden should be used to grow the plants. Seed sowing thinly is conducted with a garden seed drill on this soil about five to six weeks previous to field planting. The seedling rows are about fifteen inches apart and the small seedlings are often thinned to about one-quarter inch apart in the row. The young plants are allowed to remain in the seedling row and grow until transplanting to the field, about the last week in June. Only the well developed plants should be planted.

Planting.—Distances vary from two to two-and-one-half feet apart each way.

Market Preparations.—Late cabbage is permitted to attain full size and the desirable hardness before cutting with a knife at the top of the stem just below the head. If selling immediately or storing remove the leaves which do not fit firmly about the head at time of cutting.

Cabbage Varieties.—The earliest variety is Jersey Wakefield which has small pointed firm heads.

Golden Acre is the principal and most largely planted early commercial variety, producing a moderately sized, firm, round headed cabbage, and is only a few days later than the Wakefield.

Copenhagen Market is later and larger than the Golden Acre. The head is round and compact. This variety is now used as a mid-season and quite early autumn crop.

Short Stem Danish Ballhead is grown for the main crop for winter storage because it keeps more satisfactorily than any other variety. The head is medium in size, round and distinctly solid.

Glory of Enkhuizen is a flat, large, moderately solid head, and is grown as a fall crop. However, the Danish Ballhead variety is more satisfactory.

The Red Rock is usually grown as a late fall red variety, with a firm, medium-sized head, much resembling that of Danish Ballhead.

The Savoy varieties possess distinctly wrinkled, dark green leaves. The quality of this cabbage is superior to the smooth leaved varieties; but is grown to a comparatively limited extent.

Chinese Cabbage.—Chinese Cabbage is an annual and not a true cabbage. The Petsai varieties have a similar appearance to Cos lettuce, with its compact, elongated head, with green, thin, fully veined, somewhat wrinkled leaves. This is a cool season crop and is grown in spring and autumn. As a spring crop the seed is sown and plants grown similarly to early cabbage. However, no growth checks must be allowed, and usually field planting is conducted about four weeks after seed sowing. The seeds for the autumn crop are usually sown in the soil on which the crop is produced about the middle of July. When good sized seedlings are present thinning about twelve inches apart is conducted. Rich sandy loam, medium clay loam and muck soil well retentive of soil moisture are suitable.

Harvesting.—At the full development of the heads cutting from the stem similar to cabbages is conducted and the loose outer leaves removed.

CARROTS

The carrot is a biennial. The first season a thickened root and a large well-branched system of numerous fine roots, well distributed through the soil; and leaves comprise the plant. The second year stems, flowers and seed are produced.

Soil and Cultivation.—A moderately deep, moist, well-drained, easily crumbled soil with plenty of organic matter (slightly acid in reaction is best to allow unhindered expansion of the carrot during growth. Early commercial crops are grown principally on sandy loams; while for the winter crop, requiring large yields, a silt loam is very satisfactory. Late carrots may be grown well on muck soil. Heavy compact soils usually produce misshapen carrots, checking their symmetrical development. The soil for seed sowing should be smooth, loose and well prepared. Quite shallow cultivation is desirable.

Fertilizers.—On well manured sandy loams and silt soils fertilizers of a 1-2-2 ratio, supplying 50 lbs. of nitrogen and 100 pounds each of phosphoric acid and potash, per acre, are recommended. This would be equivalent to 1000 pounds of a 5-10-10 or 1250 pounds of a 4-8-8 mixture.

On well worked muck soils a 1-4-8 ratio would be suitable, applying approximately 40 pounds of nitrogen, 160 pounds of phosphoric acid and 320 pounds of potash. This amount of plant food would be contained in 2000 pounds of 2-8-16 or its equivalent.

Fertilizers for carrots should be applied broadcast and well worked into the soil previous to planting. If possible a small portion of the total application could be applied in the row at time of sowing the seed.

Seed Sowing and Planting.—Seed for the early outdoor sown crop is sown after severe frosts have concluded at the rate of about two-and-one-half pounds per acre in rows varying from twelve to eighteen inches apart to a depth of one-half inch. For the late storage crop seed sowing is done at the middle or latter part of June. For home use a succession of sowings may be conducted as late as the middle of July. Weed control is very important. Shallow cultivation is practised and loose earth is maintained over the crops of the carrots to control this colouring and sunburn.

Market Preparation.—Bunched carrots are pulled when the top ends have attained a diameter of one-half to three-quarter inches. A part or the entire amount of leaves is allowed to remain on the carrots, which, when perfectly clean by washing, are tied in bunches of uniformly sized eight or twelve specimens. For the late storage crop they are usually hand-pulled after partly ploughing out and topped with a knife.

Varieties.—Chantenay: A satisfactory bunching carrot for early or late crops in the home or commercial garden. Stump end is bluntly rounded; colour, orange-red, with a lighter colour towards the core. Coreless or Nantes: Used for home and market gardens, possessing a very small core; colour, orange with yellow at the core; shape, cylindrical with a blunt rounded stump end. Danvers: Satisfactory for market garden and home use. Core very distinct; color, orange, yellowing at the core; distinctly tapering from shoulder to stump end, which is pointed. Guerande or Ox-heart: used slightly. Having a medium to large core; color orange; short and blunt ended.

CAULIFLOWER

Cauliflower is a biennial. Terminating the main stem is the edible head or curd composed of fleshy flower parts. Attached to the main stem at various intervals underneath the head are cabbage-like leaves. The taproot is usually injured in transplanting so that the large branching root system is composed of many laterals and a network of smaller roots, extending two-and-one-half feet in depth and about two to two-and-one-half feet on all sides of the plant.

Climate.—Correct conditions of climate are more important than efficient soil characteristics. Cauliflower grows best in a comparatively cool, moist atmosphere. In the field, extremely low temperatures throughout the early growth of the plant; and unusually warm weather and drought cause premature heading or "buttoning". Extremely high temperatures during the formation of the heads may cause them to become spreading, and ricey—unsatisfactory marketable specimens. A well distributed rainfall or irrigation is requisite to supply sufficient moisture in the soil to provide the necessary uninterrupted, steady growth. In Ontario early crops are grown to have the heads form previous to the hot mid-summer weather; and the late crops are produced to have heading commence with the lower temperatures of September and October.

Soil and Cultivation.—A rich, moderately deep, loamy moisture retentive soil is desired. The early crop is usually grown on rich sandy loam with an abundance of organic matter. The late crop is produced on the above sandy loam and silt loams in preference to clay loams which, however, produce satisfactory crops if well supplied with organic matter. Muck soils are also used with satisfaction.

At transplanting time to the field and throughout the entire life of the plant in the field an ample amount of soil moisture is requisite for the required steady continuous growth. Consequently, a large amount of organic matter should be present in the soil as a water-holding power. Organic matter also aids in loosening up heavy soils and making the sands more compact. Efficient drainage is very necessary. The organic matter should be well decayed before planting so that late fall or real early spring plowing is conducted to aid in saving the moisture in the soil.

Cultivation should commence immediately after the plants become established in the field following planting; and, be conducted until the plant shows signs of heading or until the leaves are broken off by the cultivator between the rows. The first cultivation after planting is moderately deep. The subsequent cultivations should be more shallow than each previous cultivation so that quite shallow cultivation is conducted as the plants reach maturity to prevent root injury. Hoeing is necessary to aid in the control of weeds and loosening the soil.

Fertilizer.—In general, fertilizers as recommended for cabbage can be applied to the cauliflower crop.

Early Crop

Production of Young Plants.—The seed is sown from March 1st to 15th, as the early crop requires about eight weeks from seed sowing until transplanting into the field. The plants are more tender than those of cabbage. Sowing is conducted in moderately rich soil in flats in the greenhouse or hotbed in rows about two inches apart and one-quarter to three-eighths of an inch deep, and covered with sharp sand.

Immediately after sowing place the flats in a temperature of 70°F. and with a fine spray water thoroughly which usually provides sufficient water to germinate seed and meet the growing needs of the plants until the first transplanting is conducted when the two seedling leaves are fully grown or immediately after the appearance of the first true leaf. When the plants have come through the soil temperatures of 55° - 60°F. are maintained until the first transplanting.

After this first transplanting the seedlings are planted into good loam soil in flats two inches by two inches or into two and one-half or three inch pots, preferably into pots, where they remain until planted in the field. However, some growers prefer to conduct this first transplanting into good loam soil in flats, spacing about two inches apart; and there allowing the plants to remain for about three weeks, when the second transplanting is performed into good loam soil in two-and-one-half inch pots where the plants grow until field planting. After the first transplanting while in the greenhouse or hotbed until transferred to the coldframe temperatures of 55° - 60°F. are maintained. Moderate unchecked normal growth from seed sowing to field planting is important.

About a week or ten days before field planting the plants are "hardened off" as discussed with cabbage.

Field Planting.—Planting is performed late April or early in May when danger of hard frost is past. The rows are usually two and one-half to three feet apart; and the plants eighteen to twenty-four inches apart in the row. Retain as much soil around the roots as possible.

Late Crop

Production of Young Plants.—The seed is sown outdoors in a moderately rich well plowed and harrowed seed bed with a garden seed drill at the rate of about an ounce to four hundred or five hundred feet of length of row. A real rich soil is liable to produce too rapid growth. The seed sowing date varies from May 1st to 20th, as the plants will be ready to plant in the field in five to six weeks from time of seed sowing. The plants are allowed to remain where the seed is sown until transplanted into the permanent field for the crop.

Field Planting.—Plants are set into the soil at distances usually twenty-four inches apart in the rows which are three feet apart.

Market Preparation.—The market demands a pure white, solid, compact head showing no spreading, ricey or leafy heads. The overmature head is characterized by the parts of the head separating from each other or spreading. The ricey head is granular in appearance and lacking in compactness, caused by the lengthening of the tiny stalks bearing the flower buds. The badly spread head is of less market value than the ricey head. Small green leaves grow between the parts of the head, usually due to poor seed or unfavourable growing conditions.

All sunlight must be excluded to obtain the white head. When the head is small in size the inner leaves curve over it and protect it from the sun. When the inner leaves first commence to lift themselves, thereby exposing the small head—about two to four inches in diameter—to view when looking down on the plant the outer leaves are brought over the head and tied with string, raffia or strong rubber bands. During the warm weather the heads may be suitable to harvest two to four days subsequent to tying; while cool weather may lengthen this time to one or two weeks.

Harvesting must be conducted when the head is white, compact, solid, showing no overmaturity indicated by spreading or riciness of the head. Do not sacrifice the correct stage of maturity and harvesting to secure size. Medium sized, compact, white heads possess more marketable merits than the large somewhat spreading heads lacking the white colour. The stem is cut to have eighteen to twenty leaves. The leaves are cut so that they project one to one-and-one-half inches above the head. These circles of cut leaves protect the head from injury in the various phases of shipping and marketing. Cauliflower are best packed in one tier crates for shipping.

Varieties.—Snowball, especially the Extra Early variety is the recognized early commercial cauliflower. Early Dwarf Erfurt is about twelve days later than the Snowball. These are the two principal varieties grown either as a late or early crop.

CELERY

Celery is a biennial. Throughout the first year a comparatively short stem is grown; and during the second year stems two to three feet high produce flowers and seeds. With certain growth conditions the plant produces flowers and seeds during the first year, described as "Premature Seeding". If not transplanted the plant has a taproot with side roots. Transplanting in the production of the young plants destroys the taproot, and in its place numerous lateral roots, well covered with fine roots throughout their length appear. When the taproot has been destroyed by transplanting the greatest amount of root system is in the surface six inches of soil with numerous roots at from two to three inches from the soil surface—a few extending to a two foot depth. A large part of the root system is within a radius of six to eight inches from the plant—the longest radius being twelve inches.

Early Crop

Soil and Cultivation.—The most satisfactory quality celery is produced by providing conditions of fertility and water supply for continuous growth. A well-drained sandy loam soil, well supplied with organic matter, and watered by irrigation, is correct for the early crop. The requisite continuous growth occurs most satisfactorily on well-drained muck land, naturally possessing plenty of organic matter, strong water-holding power, and a good physical condition. Muck soil is used for the early crop; but for this early crop heavier soils than sand or muck should not be used.

The soil should be prepared by deep plowing during the autumn previous to the early crop. Throughout the spring until planting frequent harrowing is done to control weeds. The necessary fine state of cultivating of the soil for planting is obtained by thorough disking and harrowing and rolling or dragging.

Shallow cultivation is always desirable particularly near the plants due to the close position of the roots to the surface of the soil. Thorough weed control should always be maintained. Immediately after planting and frequently afterwards shallow cultivation is performed to maintain a soil mulch, but the soil must not be placed into the heart. Cultivation ceases at blanching time.

FERTILIZERS.—Celery is a heavy feeder on nitrogen and potash, hence, large quantities of these plantfoods in readily available form should be supplied. When planted in rows $2\frac{1}{2}$ feet x 8 inches apart in the row, on light sandy or gravelly loams receiving 20 to 40 tons, per acre, of manure, applications of 50 pounds nitrogen, 100 pounds phosphoric acid and 100 pounds of potash, which is a 1-2-2 ratio, is advised. This can be supplied in 1250 pounds of 4-8-8 or 1000 pounds of 5-10-10. If little manure is obtainable the amount of fertilizer should be increased by one-half. During the early growing season it has been found profitable to side-dress the celery with 50 pounds of available nitrogen, and again in two weeks with 50 to 75 pounds of available nitrogen.

On muck soils an 0-1-3, 1-4-8 to 1-4-10 ratio, which may be supplied in an 0-8-24, 2-8-16 or 2-8-20 fertilizer, has given good results. The rate is usually 2000 pounds per acre. If growth is slow, side-dressing with 40 to 50 pounds of available nitrogen is recommended.

When celery is planted in block—8 inches square, approximately, twice the above amount of plantfood should be supplied.

PRODUCTION OF YOUNG PLANTS.—Celery seed is not sown on the site of crop production because transplanting is essential to secure a satisfactory plant to grow. Sowing seed for the early crop is conducted during the last week in February or the first week in March. The soil for seed sowing should have plenty of plantfood; be well pulverized; and should not pack nor harden. A good sandy compost soil or a field muck soil in the greenhouse or hotbed is used. One should always purchase the best quality of seed.

The seed is sown in rows two inches apart in this soil in a flat to a depth of about one-sixteenth of an inch; and covered with fine sand. Sowing in rows facilitates watering and weeding compared to broadcasting. A very fine spray of water is used in a thorough watering immediately after sowing. Germination proceeds slowly.

At once after sowing the flats are placed in a temperature of 70°-75°F. After the young plants come through the soil they are kept in a temperature of 65°-70°F. until field planting. Transplanting of the seedlings to another flat, containing the same kind of soil as that used for seed sowing, at about one-and-one-half inches apart each way is conducted when the seedling possesses three true leaves. This transplanting accomplishes the breaking off of the taproot which produces the desirable lateral fibrous roots.

Every attention to watering is required after seed sowing and throughout the growth of the young plants, not allowing the soil to dry out, and yet not permitting a soaked condition of soil.

PREMATURE SEEDING OF CELERY.—This term is applied to the development of flowers and seeds during the first year in the field, and thereby preventing its proper maturity for marketing.

In Cornell University, Ithaca, N.Y., Bulletin No. 480, published May, 1929, Dr. H. C. Thompson, Professor of Vegetable Crops, discusses six years' experiments with this problem.

During the three year test placing the young plants before field setting in temperatures averaging between 45° to 50°F. for thirty days always resulted in the development of a large percentage of seed stalks. Producing the plants for from fifteen to twenty days in temperatures of from 45°-50°F. resulted in from 11.65% to 47.33% to 65.80% premature seed development each year. In a temperature of 45°F. to 50°F. for ten days 8% of the plants went to seed. Not a single plant, which was always grown in an average temperature of 62.7°F., 65.2°F., and 71°F. until field planting went to seed in the field. All of these plants were produced under the same growing conditions in the greenhouse and field except for the ten to thirty days in the coldframe. Having the plants in temperatures averaging from 40°F. to 50°F. for from ten to thirty days results in premature seeding, in spite of the fact that the plants are afterwards grown in favourable growth conditions.

Additional experiments conducted entirely in the greenhouse indicate that celery plants produced for two to three months in temperatures averaging between 50°F. to 55°F. go to seed the first year.

This information distinctly demonstrates the danger of growing celery plants for two or three months in a cool greenhouse or hotbed and then placing them in a coldframe for ten days or two weeks in a low temperature of 40°F. to 50°F. "Hardening-off" celery plants in the coldframe is dangerous in regard to premature seeding and is not necessary.

"Hardening-off" vegetable plants has already been discussed under "Cabbage".

PLANTING.—Just previous to planting the soil containing the young plants should be thoroughly watered to have as much soil as possible attached to the roots at field planting time. The growing point or heart must not be covered with soil and yet the roots must be well and firmly surrounded with soil. Holes in the soil for the plant are made with a pointed wooden dibble.

Celery is planted six to eight inches apart in the row with rows two-and-one-half to four feet apart. Sometimes for a close method the rows are eighteen inches apart. A solid bed, six to ten feet wide with plants eight inches by eight inches is also used so that the plants exclude the light for blanching except the outside rows which are blanched with boards.

BLANCHING.—Blanching is attained by excluding the light from the leaf stalks during the growing of the plants to secure the desirable white colour and flavour. For the early crop only paper or boards are used. Soil is unsafe to use for this purpose with the early crop as this arrangement in hot weather is likely to cause rot. A specially prepared paper for celery is satisfactorily used and is held adjacent to the plants by wire hooks. Twelve inch width boards are also staked up beside the plants instead of the paper.

MARKET PREPARATION.—The early celery is usually washed and the roots carefully trimmed off and tied in bunches and shipped in clean boxes.

LATE CROP

SOIL AND CULTIVATION.—Any rich but well-drained loam soil produces satisfactory celery if the moisture supply is adequate. Heavy clay is not satisfactory. The necessary continuous growth to produce good celery is better attained on muck soil than on other soils due to the organic matter in the muck soil, making a better physical condition and a strong water-holding power. The well-drained muck soil is most largely used for the late crop.

Cultivation is the same as that for the early crop.

PRODUCTION OF YOUNG PLANTS.—The plants for the late crop are grown in coldframe in good sand compost or field muck soil; or, in specially prepared beds in the muck or real fertile sand loam field by having the soil in a very fine state of cultivation and high fertility. The seed is sown during last two weeks in April or first week in May. In the coldframe it is sown in rows about three inches apart and the plants thinned to about one inch part in the row; while in the outdoor bed the rows are often about twelve inches apart with plants about an inch apart in the row. The young plants are taken directly from the seed bed in the coldframe or the outdoor bed to the fields for planting.

Considering that the plants are grown in the seedbed from seed sowing until field planting with no transplanting often the taproot is cut back to promote lateral root development. This cutting back of the taproot is accomplished by running a knife or a cutting bar (mounted on wheels and propelled by pushing the handles) along the row about one-and-one-half to two inches below the soil surface about a week before field planting.

Some growers sow the seed in flats in rows two inches apart and then transplant to soil in coldframes at the development of the first true leaf.

Planting.—Distances of planting are similar to those of the early crop.

Blanching.—Blanching is attained by boards, paper or soil.

Market Preparation.—Late celery is now shipped in standard sized celery crates. The roots may or may not be removed from the plant at harvesting or crating; and usually no washing is conducted. Every attention should be paid to preparing a firm high quality product and particularly when cold storage is to be conducted.

Varieties.—"Paris Golden Self-Blanching", also called "Paris Golden Yellow". With foliage of yellowish-green. The heart is large. The stalks are crisp, of medium height, and blanch to a creamy-white. This is an early and late variety.

The old strain of this variety produces short, thick stalks and a well developed heart. The tall strain grows more vigorously and is taller and more spready than the old strain.

"Golden Plume" also called "Wonderful" and "Early Fortune" is similar in colour and flavour to "Paris Golden Self-Blanching", and is about one week earlier than that variety. The "Golden Plume" is more erect, vigorous, and produces a better heart than the dwarf strain of the "Golden Self-Blanching". "Golden Plume" is an early or late variety.

"Giant Pascal" is a late variety, much used for autumn and winter purposes. The green leaf stalks are thick and blanch slowly to a creamy-white colour. The quality is very fine.

"Fordhook Emperor" possesses a spreading habit of growth with very short leaf stalks which blanch to a nearly white colour. It is a winter variety.

"Utah" a green stalked variety of vigorous growth, heavy heart, thick leaf stalks and an excellent table quality. Suitable for winter storage.

CITRON

The citron much resembles a small watermelon, round in shape, and of light green colour. The flesh is not edible and the rind is canned. The cultural requirements are practically the same as those for Watermelon.

SWEET CORN

Sweet corn is an annual, and is offered on the market quickly after harvesting to prevent deterioration of flavour and quality.

Soil and Cultivation.—Early corn is requisite for profit for market gardening. Therefore, a well-drained sandy loam soil, possessing plenty of decayed organic matter and fertilizer, is demanded for this early crop. Profitable canning factory sweet corn demands a high yield in preference to earliness; and thus rich moisture retentive silt and clay loams are better than sandy soils for the canning crop.

The soil should be fall and spring ploughed, and then disked and harrowed to effect thorough preparation. As an aid to the destruction of early young weeds and loosening the soil surface a weeder or a spike tooth harrow is sometimes operated over the field previous to the coming up of the corn. Subsequent cultivation should be shallow to control weeds.

Fertilizer.—Corn responds well to applications of farm manure, which should be well rotted and applied in the autumn at rates of 15 to 20 tons per acre.

A fertilizer having a 1-3-2 ratio, supplying 15 pounds of nitrogen, 45 pounds of phosphoric acid and 30 pounds of potash, will be satisfactory. To supply this amount of plantfood, apply 400 pounds of a 4-12-8 or about 500 pounds of a 3-10-5 or its equivalent, per acre. To obtain the best results it is recommended that the fertilizer be applied in the hill over an area of 10-12 inches long by 6-8 inches wide and hoe it in the soil.

Planting.—Frost injures sweet corn; and planting should be conducted after frost danger is over unless one desires to take chances to secure high prices for the early market. If hills are used six seeds per hill are sown and allowed to grow. The hills are spaced 2′ x 2½′ or 2′ x 3 feet apart for the small growing variety; and 2½′ x 3′, 3′ x 3′ or 3½′ x 3½ feet for the large growing varieties. When drilled the seeds are planted singly and the plants are thinned to grow 10-15 inches apart, depending on the size of the variety. Planting can be performed by hand but usually by the hand planter. Machine planters are used with large acreages.

Suckering is the removal of suckers from the base of the plant. Experiments conducted for five years in New York State with Golden Bantam and Stowell's Evergreen by Dr. H. C. Thompson indicate that the removal of suckers tends to decrease the yield and does not appreciably hasten maturity or increase the size of the ears. The leaves of the suckers aid in the manufacture of food for the plant.

Varieties.—Early: Golden Gem, Banting, Golden Sunshine, Golden Bantam. Main Crop: Stowell's Evergreen.

CUCUMBER

The cucumber plant is an annual resembling the melon plant in formation.

Soil and Cultivation.—Nearly any type of soil is satisfactory for cucumbers. For the early crop a sand or sandy loam soil is necessary. However, where high yields and a comparatively long producing period are the objective the heavy sand loam or clay loam is used to the best advantage, due to the presence of moisture and plant food supply. The soil should always be well drained but retentive of moisture, particularly for the late crop. Any of these types of soil should contain plenty of organic matter.

Frequent cultivations should be shallow, and are practised until the growth of the plants between the rows prevents. Weed control is essentially effective by cultivation with frequent hand hoeing.

Fertilizers.—When manure is plentiful applications of 30 to 40 tons, per acre, applied broadcast and worked into the soil is a common practice. This is further supplemented by complete fertilizers high in phosphates in order to balance the nitrogen and potash in the manure. Fertilizers having a ratio of 1-3-1, supplying about 20 pounds of nitrogen, 60 pounds of phosphoric acid and 20 pounds of potash, per acre, will be satisfactory. This will be supplied in 500 lbs. of a 4-12-4 mixture or its equivalent.

Many growers prefer to conserve the manure and apply it, at rates of 4 to 6 tons of well-rotted manure per acre, in a trench beneath the row of plants and cover with about 4-5 inches of soil. This should be supplemented with a fertilizer having a 1-3-2 ratio and supplying about 40 pounds of nitrogen, 120 pounds of phosphoric acid and 80 pounds of potash, per acre. This is equivalent to 1000 pounds of a 4-12-8 mixture, or about 1300 pounds of a 3-10-5 fertilizer, per acre. The fertilizer should be applied in the row and mixed with the soil on top of the manure before planting.

Production of Young Plants for the Early Crop.—This crop is grown only when a high price is anticipated. About six weeks previous to field planting the seed is sown in sand loam soil in 2½ or 3 inch clay pots, berry boxes, paper bands or in sods as for cantaloupes. When the seedlings have developed to the production of the first few leaves all but two well developed plants are cut off; and these two good plants are developed for field setting. Temperature and watering demands for the growth of young plants for the early crop are the same as for the cantaloupe early crop. Cucumber young plants are more easily transplanted than those of cantaloupes but have the same size at field planting time.

The Main Crop.—The cucumber plant is usually killed by frost, and it grows best during the warm summer weather. Seed is usually sown out-of-doors about May 24th, as a warm soil is requisite for good germination.

Drills and hills are used for the production of this crop. Drills are now more generally used than hills. When the drill plan is utilized the seeds are sown by a garden seed drill in a continuous row at the rate of 2 to 3 pounds to the acre. The rows are from 4-6 feet apart; and when the plants are good sized seedlings thinning is conducted to effect a spacing of 15 to 18 inches apart in the row. Hills are spaced from 4-6 feet apart each way. A number of seeds is sown in each hill and then the seedlings are thinned to two healthy plants per hill.

Harvesting.—For slicing cucumbers this crop is picked when from 6 to 10 inches in length. Frequent pickings provide this marketable product with distinctly green colour, showing no ripening, with the stem attached to the fruit.

Varieties for Slicing.—Early Forcing and Early White Spine possessing a rich dark green colour about 9 inches long with firm white flesh. Davis Perfect—Early White Spine type. Ten to twelve inches in length; dark green colour with crisp white flesh. Vaughan—A main crop, white spine variety, about 10-12 inches long, dark green colour, firm white flesh.

EGGPLANT

The eggplant is an annual plant distinctly sensitive to frost and is grown in the Province only where long seasons occur.

Soil and Cultivation.—Well-drained, warm, well-manured soil is usually used for this crop. Cultivation is the same as that for the Tomato.

Fertilizer.—Eggplants belong to the same family as the tomato, hence, their fertilizer requirements are much similar. They require warm dry soils such as well drained sandy loams that are well supplied with organic matter. They respond to heavy manuring and fertilizing. The manure should be supplemented with about 1000 pounds, per acre, of a 5-10-5 or its equivalent. Part of the fertilizer should be applied in the row just before the plants are set and the remainder applied broadcast and worked into the soil just previous to planting. In cool wet seasons from 15 to 30 pounds of available nitrogen applied as a side dressing during the early growing period will be beneficial.

Production of Young Plants.—Seed sowing indoors is necessary during the last two weeks of February; and the seedlings are produced as are those of the early tomato crop. The transplanting is conducted when the rough leaves occur into four inch pots where they are grown until field setting. No check in growth must be allowed.

Field Planting.—When the warm weather is prevalent and frost danger concluded planting is conducted using distances of 30 to 40 inches between the rows and 24 to 30 inches between the plants in the row.

Preparation for Market.—The fruit should be well coloured and is cut from the plant to have the calyx and a small part of the stem attached to the fruit. The fruit is picked when about half grown or slightly later as it is used in an immature condition. If allowed to remain on the plant until fully ripened the flesh usually becomes dry and tough.

LETTUCE

This is our most important salad crop. With successive crops during summer and greenhouse production in winter months, Ontario lettuce is available on our market all the year. The lettuce plant is an annual and will grow to seed maturity in one season; but its leaf is used as a salad; and the quality, tenderness and flavour depends on growth conditions. The roots of the lettuce plant are fibrous and small, so require special preparation of the soil before seeding or planting. It is a cool season crop, growing best during the spring and fall months. It requires moist soil; and will not develop properly during the hot dry summer days unless given special attention as to irrigation and possibly shading.

Soil and Cultivation.—Any rich, moist soil, slightly acid to neutral in reaction, will produce a good crop of lettuce; but for extensive plantings a sandy loam (for earliness) a silt or clay loam, or a rich muck soil is best. The soil should be fertile, contain a high percentage of humus, and be well drained. If the soil has been well prepared little cultivation is required during the growth of the crop. Cultivation should be shallow and just sufficient to control weeds.

Fertilizers.—On sandy loam soils receiving 15 to 20 tons of manure per acre the previous autumn, a fertilizer of, approximately, a 1-2-1 ratio giving a total of 50 to 75 pounds of nitrogen and potash and 100 to 150 pounds of phosphoric acid, per acre, will be suitable when broadcasted and worked into the soil. This is equivalent to 1000 to 1500 pounds of 5-10-5 or 1250 to 1875 pounds of 4-8-4 fertilizer. With small applications of manure or in cool wet seasons, top dressing of 15 to 30 pounds per acre of nitrogen would be advisable.

On muck soils a fertilizer ratio of 1-4-5 is more suitable applying a total of, approximately, 30 pounds of nitrogen, 120 pounds per acre of phosphoric acid and 200 pounds of potash. This amount of plantfood is equivalent to 1500 pounds of 2-8-10 mixture. For the early crop from 15 to 30 pounds of available nitrogen, applied as a side dressing, would be beneficial, especially on very acid soils.

Early Crop Leaf and Head Lettuce

Seeding and Planting.—Usually, the first outdoor crop is grown from plants produced in the hotbed or greenhouse. Seed is sown eight or nine weeks before field planting in a good compost soil, composed of equal parts of sandy loam sod and farmyard manure. Oftentimes for seeding this compost soil is mixed with coarse sand, equal to one-quarter of the total amount of compost soil. The seed is preferably sown in rows about two inches apart and about one-eighth of an inch deep in the soil in a flat. Coarse sand is a very satisfactory covering for the seed; but the soil may be used for this purpose. Watering thoroughly after seeding, and shading with paper to prevent too rapid drying if the sun is bright, are important features of seeding. A temperature of 65° - 70°F. is provided until the seedlings have appeared through the soil. At this time a temperature of 50° - 55°F. should be afforded to aid in providing a stalky plant. The young plant is grown at these latter temperatures.

When the first true leaf appears the seedlings are transplanted to flats containing the compost soil, (not diluted with sand) and at 2 inches by 2 inches apart. The soil should be carefully firmed around the roots to enable them to make a quick continuation of growth; while the water should be added to the soil to thoroughly soak in. Subsequent watering of the transplanted plants in the flat should be conducted to have a moderately moist soil to prevent the addition of too much water or drying out of the soil. An excess of water, too high a temperature, or a combination of both, produces tall, leggy plants. Ventilation is quite important. The young plants must be hardened off for for about ten days before field planting. Young plants for the early leaf and early head lettuce crops are produced in this manner.

Late Crop Leaf and Head Lettuce

Later crops are sown in the field by a hand-drill with rows from 15 to 18 inches apart. The young seedlings of the leaf lettuce are thinned to stand 8 inches apart in the row; while the head lettuce is spaced 10 to 12 inches apart in the row. The same space is provided for transplanted plants. Leaf lettuce is produced in hotbeds and coldframes in the spring to a large extent. Head lettuce seed is sown about the middle of July for late September harvesting.

Market Preparation.—The lettuce heads are trimmed closely to remove very loose leaves and stem when a well formed, preferably solid head, is produced. For local markets the heads are placed loosely in hampers and sold by the dozen. For shipping the heads are packed in a crate, lined with heavy waterproof paper, which is situated on the total interior surface of the crate, and fastened around the lettuce tightly after packing at the top. Layers of heads are tightly packed in the crate with stems up to prevent water from melting ice entering the head. Cracked ice is usually placed between the layers of the product. If shipped in iced refrigerator cars the cars should be thoroughly cooled previous to loading, re-iced to full capacity in transit to destination, and about a foot of ice placed on top of crates in car at loading.

VARIETIES.—Leaf Lettuce--Grand Rapids has decidedly crumpled leaves with much frilled borders and is the most largely grown variety of this type. Black Seeded Simpson is used to some extent, especially in warm weather.

Head Lettuce—New York. The head is firm and round. The leaves are dark green in colour and tightly over-lapping one another. The broad leaves have fine frilled borders, are crumpled and heavily veined. It is the most largely grown variety. Buyers and shippers mention "Iceberg" in referring to this variety.

Hanson—(Non-pareil). It is similar to New York but the leaves are a much lighter green in colour.

Iceberg is quite similar to New York. However, the edges of the leaves are reddish-brown in colour. It is little grown.

Butterhead lettuce—May King is an early smooth leaf cabbage heading type with a golden buttery colour with a rich flavour.

MUSKMELON

The cantaloupe or muskmelon has developed into an important crop. It is grown extensively in several areas and is found in all small gardens. The season extends from early August until late in the fall. The fruit is perishable and does not store well, so the season is limited as the crop cannot be grown during the winter months successfully in the greenhouse. This is one of our most tender vegetable crops and requires special care. The plant is an annual whose root system consists of a short, fairly thick tap root from which extends, at considerable length, many lateral roots, equipped with fibrous roots, about six inches below the soil surface.

CLIMATE.—An abundance of sunshine with warm days and nights is necessary.

PRODUCTION OF YOUNG PLANTS.—It is necessary to grow the plants in the greenhouse or hotbed and transplant to the field about May 24th or June 1st for the earliest melons. The young plants, unless transplanted as young seedlings, should not be transplanted, as the new roots develop very slowly. The seed is sown about April 15th to 20th in hotbeds or greenhouses in good compost soil, situated in paper bands, clay pots or inverted sods. The sods, preferably of fertile, sandy loam soil, about four inches square and three inches thick, are placed inverted immediately adjacent to one another. Usually three or four seeds are planted in each pot or sod and thinned to leave two good plants when they have commenced to develop the first true leaf. These two young plants are not removed from the soil in the pots, paper bands or sods, but allowed to grow in this soil until suitable for field planting. At this time the soil is maintained around the roots by careful watering, so that the removal to the field location does not disturb the roots.

The young plants are grown in temperatures of 75°F. on bright days and 70°F. at nights and cloudy days. Watering must be carefully done in bright weather early in the day. Hardening off is conducted in the hotbed or greenhouse by plenty of ventilation and a minimum water supply; while field planting is done at the development of four true leaves after frost danger.

Soil and Cultivation.—Well-drained. light or medium heavy, sandy loam soils with plenty of organic matter are best and usually used. However, well-drained light silt and light clay loams, warm and rich in humus, will grow the later crops of melons if climate is suitable. With any soil the plant must be warm with plenty of sunshine. An early location is desired, such as a sheltered field or a south side of a ridge, where the soil warms up early and where late frosts are not likely to injure the young plants. Cultivation should be shallow and only frequently enough to keep down young weeds; and should be discontinued as soon as the vines are well spread. Weeds which grow later should be pulled by hand.

Fertilizer.—Melons are heavy feeders on nitrogen and potash and as sandy soils are usually low in these constituents fertilizers applied should be balanced accordingly.

Manurial treatment for cucumbers will be very suitable for melons. Fertilizers are best when applied in the hill and with applications of 4 - 6 tons of manure, per acre, in trenches. A fertilizer having, approximately, a 1-2-1 ratio will be very satisfactory. From 500 to 750 lbs. of a 5-10-5 or its equivalent, when applied in the hills previous to planting, will give good results. If little or no manure is available, a 1-1-1 ratio, supplying about 75 to 100 pounds of each constituent, will be more suitable.

Planting.—Some growers sow seed in an open field soil near the end of May and thin out the young plants. This plan succeeds well on early ground and the crop usually ripens before frost unless it is a very late variety. Field planting distances with two plants at one planting spot consist of 3½ by 5, 4 by 5, 4 by 4, 5 by 3 feet and sometimes 6 by 6 feet.

Market Preparation.—The quality of melons depends on uniform growth and proper ripening. Melons picked too green or immature will not ripen with good flavour and texture. Melons should ripen on the vines for local markets. The stem will separate from the melon with a light pull, when ready for market. Melons for distant markets may be picked just before the stem separates easily. It is best to pick over the patch every day, preferably in the morning, as melons are cool then and will keep longer than if picked during the heat of the day. The melons are graded as to size and packed in crates for distant shipments. Large baskets or hampers are used for local markets. Melons taken off diseased or dead vines usually lack quality and are undesirable.

Varieties.—Sugar Sweet and Golden Champlain—are two early varieties of fair quality, but are soft and poor shippers. Early Osage—is another early one favoured by many. Burrell's Gem and Bender's Surprise constitute a large percentage of the main crop. Hale's Best, and Honey Rock are new ones of medium size and may become popular.

ONION

The onion is one of our most important truck crops, both as to acreage and the value of produce. Large areas are devoted entirely to onion growing in Kent and Essex, as well as in other sections of the Province. Many small growers also have considerable acreage of onions.

The fibrous roots of the full grown bulb are largely in the surface six to eight inches of soil and extend about six inches from the plant with a considerable percentage of the roots at three inches from the soil surface. The roots require a soil always possessing moisture; while the early growth particularly demands an ample supply of water in the soil.

Soil and Cultivation.—A well worked muck soil is most desirable, but any loose, friable soil, containing plenty of plant food and neutral to alkaline in reaction, will produce good crops of onions. Heavy clay soils are not suited to onion growing. Large applications of manure or plowing down heavy cover crops will put the heavy soil in condition to grow onions in the course of time. Thorough preparation of the soil previous to planting or sowing is more important than with most other crops. A fine seed bed—six to eight inches deep—is necessarily prepared previous to seed sowing to allow the contact of the seed and small fine roots with the soil so as to secure plant food and moisture. Fall plowing combined with spring disking and harrowing followed by rolling or plank dragging are employed to make the soil fine, smooth and firm for seeding. Cultivation should be shallow, especially late in the season, when the cultivator should be kept away from possible bruising of the bulbs.

Fertilizers—From 15 to 20 tons of well rotted manure should be worked into the soil in the autumn. Previous to planting, a fertilizer of a 1-2-2 ratio, supplying approximately 40 pounds of nitrogen and 80 pounds of phosphoric acid and potash, per acre, applied broadcast and worked into the soil, will be satisfactory. This amount of plantfood would be equal to 1000 pounds of a 4-8-8 or 800 pounds of a 5-10-10 fertilizer per acre.

On well decomposed muck soils a 0-1-1 ratio fertilizer, applied at rates equivalent to 1000 pounds of an 0-10-10 mixture, will be satisfactory. On new muck soils or during a cool, wet season, when growth is not too rapid, a top dressing with a 15 to 30 pounds of available nitrogen per acre may be helpful, especially if the soils are acid in reaction.

Recent work indicates the advisability of higher percentages of potash in the fertilizer for muck soils and fertilizers of an 0-1-2 or 0-1-3 ratio, such as 0-8-16 or 0-8-24, are suitable at rates of 1000 to 1500 pounds per acre.

The Dry Bulb or Main Crop.—This crop is mostly used for table stock and winter storage; and usually produced from seed. The seed should be sown as early in the season as the soil can be prepared to the depth of a half an inch, with rows about sixteen inches apart, at the rate of four to six pounds per acre. Sowing thinly and thus omitting the expensive operation of thinning is much preferable to the combination of thick sowing and thinning. Thinning, when conducted, is preferably done before the onions have obtained the size of a leadpencil. The soil should be moist during thinning. When large, uniform bulbs are desired, a three-inch space between the onions is provided. Sets are used to a limited extent with the main crop, providing an earlier crop than that produced from seed but costing more.

Yellow Globe Danvers, Southport Yellow Globe, and Ebenezer, all with yellow outer scales and white firm flesh, are the principal varieties for this crop. Red Globe, Red Weathersfield, and White Globe are other varieties grown in much less quantity.

Spanish Type of Onion.—Large, mild-flavoured onion, varieties of this type comprise the Prizetaker, Denia, and Riverside Sweet Spanish. To attain the natural size the seed is sown in flats early in March in rows two or three inches apart. Transplanting of the seedlings to one inch apart to another flat is best but not necessary. When the seedlings are about four inches high the tops are clipped back; and the clipping is conducted weekly to maintain that height until planted into the field in May to produce a well-rooted plant. The young plants are set about five inches apart in the row, with rows sixteen to eighteen inches apart.

Dutch Sets.—The seed of the Ebenezer variety is recommended for the production of sets. The seed is sown on fertile, sandy land, during early spring at the rate of forty to eighty pounds per acre in rows three to four inches wide and about twelve inches apart. The crowded field conditions produce small bulbs or sets. Maturity of the sets ensues in late summer when they are cured and stored for use the following spring.

Onion sets are used for the production of green onions in the spring, usually planted in rows sixteen inches apart and about half an inch apart in the rows. They, too, are used as mentioned in producing a crop of mature bulbs.

Pickling Crop.—The pickling crop is grown from seed sown very thickly in the field, using up to sixty pounds per acre. Wide rows about sixteen inches apart are used; and the crop is timed to have the small bulbs ripen during the warm, dry period of mid-summer. Silver Skin and Barletta are common varieties for pickling onions.

Green Bunching Onions.—Are young onions with fresh green tops and partly blanched stalks. The first crop of green onions comes from bulbs planted closely in greenhouses. The first outdoor green onion comes from either the Egyptian tree or Top onion or the White Welsh onion. Both are hardy and make very early growth in spring. The sets of the top onion are planted in early fall and will make good growth the following season. The older clumps give the earliest green top growth. The Welsh onion is propagated by seed and division of the clumps. No bulbs and no top sets are formed. Welsh seed sown in late summer will produce good green onions the following spring. Dutch Sets are also used for green bunching onions, and follow the perennial or hardy type.

Preparation for Market.—Green onions are pulled, washed and bunched as soon as large enough. A good length of blanched or white tender stalk is desired. Only a limited amount is harvested at a time. A continuous supply is desired and plantings are arranged accordingly. Picklers are pulled and dried in field if weather permits or in sheds if weather is bad. Shallow trays are used and the tops are rubbed off after they become well dried. Care must be taken to prevent the bulbs from becoming greened by exposure, to the sun. A bright white skin is desired on pickling onions and they should be graded for size, one-half to one inch in diameter being most popular sizes. Onion Sets are harvested in much the same way except that exposure to sunburn is not so serious. The dry bulb onion or main crop, of course, is not harvested until fall or when the tops ripen down. Frequently the tops are rolled down to hasten ripening, but this is of doubtful value as injuries to the necks may cause rot later. The bulbs are pulled usually by hand and placed in windrows to cure and dry for a day or two. They are then placed in trays, stacked up in field to finish drying when they are taken to the topping machine and tops removed and bulbs run over graders, where the different grades are put in sacks to go to storage, to complete the curing process or may be placed directly on the market.

PARSLEY

This is our best known garden herb, being extensively used both in the fresh and dried forms. It is easily grown from seed and the young leaf stems are the parts used for garnishing and flavouring. As the plants grow older seed stalks are sent up and a crop of seed is formed.

Seeding and Culture.—Parsley seed germinates slowly. For the first crop seed may be sown in house and the young plants set out early as they are quite hardy. Seed may be sown in the open and the young plants thinned out to stand four to eight inches in the row. This is a cool season crop and the best yields are obtained off young vigorous growing plants. Well grown young plants are put into a cool greenhouse for winter production. The season for fresh parsley may be extended well over the winter by this means.

Preparation for Market.—Only a few of leaf stems are taken from a plant at a time. The leaves are tied in small bunches and washed and sent to market.

Varieties.—Moss Curled, Extra Double Curled and Curled Dwarf are all good varieties. Vigorous growth with thick curled leaves is desired.

PARSNIP

The parsnip is one of our root crops grown as an annual, but is biennial in habit of growth. The roots are hardy and will live over winter in the soil. Considerable quantities of Parsnips are used during the winter months but this is not as profitable a crop as most of our root crops. As the roots grow deeply a loose open rich soil of good depth is best. Heavy soils prevent proper development of the roots.

Fertilizers.—On sandy soils that are well supplied with humus, fertilizers having a 1-2-2 ratio are very suitable, when applied to give a total of about 50 pounds of nitrogen and 100 pounds of phosphoric acid and potash, per acre. This is equivalent to 1000 pounds of a 5-10-10 mixture or 1250 pounds per acre of a 4-8-8 fertilizer.

On heavier soils a 1-2-1 ratio will be more suitable. A 5-10-5 or its equivalent, applied at 750 to 1000 pounds per acre, will give good results.

Seeding and Planting.—Parsnip seed is sown at a depth of one-half to three-quarter inches in spring as early as soil can be prepared and rows are made to accommodate either hand or horse cultivation; and the young plants are thinned from two to five inches apart. Cultivation should be very shallow at first and only enough to keep down weed growth. A rich deep soil is necessary because a shallow soil causes crooked and branched roots.

Preparation for Market.—The roots may be dug in the fall as needed. Most or all may be taken up just before winter, and stored in cool cellars or pits, where they are available for marketing over the winter months. Roots dug in early spring are fresh and usually better than stored roots. For market the roots are trimmed and washed and packed in baskets or bags as desired. Parsnips left in soil over winter quickly lose their quality when warm weather comes and the tops start into growth. There is no evidence that the roots become poisonous during this stage.

Varieties.—Improved Hollow Crown is the common variety. Guernsey is another popular one. Early Short Round is a turnip shaped, early variety.

PEAS

The pea is one of our important canning crops as well as a popular truck crop, where pickers are available to harvest the crop. Peas are usually included in the backyard garden. This is an annual crop, the immature or green seeds being the part of the plant used for food.

Soil and Cultivation.—Peas like a sandy loam soil for the early crop, but any well drained, rich, clay loam will give maximum yields. A cool moist season favours the development of this crop. The seed bed should be well prepared pre-vious to seeding as little or no cultivation can be given afterwards even when planted or sown in rows. A naturally moist soil will give better yields during a dry season, but peas will not thrive in water-soaked soil. Shallow cultivation is conducted until the vines are of sufficient size to cause damage.

Fertilizer.—Peas grown in the market garden will respond to any good complete fertilizer having a 1-3-2 ratio, such as a 4-12-8 or 3-10-5, applied at rates to give about 30 pounds of nitrogen, 90 pounds of phosphoric acid and 60 pounds of potash.

When grown in the regular farm rotation less fertilizer is used. On sandy loams that are in a good state of fertility a fertilizer having a 1-3-2 mixture, applied at rates to supply 10 pounds of nitrogen, 30 pounds of phosphoric acid and 20 pounds of potash, will be sufficient. A 4-12-8 or 3-10-5 mixture applied at rates of 250 to 350 pounds per acre will provide this amount.

On heavier soils, which are better adapted to the growing of peas for canning factory, a phosphate-potash fertilizer of an 0-2-1 ratio supplying about 40 pounds of phosphoric acid and 20 pounds of potash per acre will give good results. This is equivalent to about 300 pounds of an 0-14-6 or 333 pounds of an 0-12-5 fertilizer per acre.

Seeding.—Early seeding is practised for the earliest crop and this is followed shortly with additional plantings, of other varieties to extend the season. Early seeding favours early development as well as giving the crop the benefit of the cool early moist season. Seeding for the canning crop is done by drills, broadcast, and for the truck crop the seed is sown in rows thirty inches apart. The seed is sown at a depth of one to one and one-half or nearly three inches in dry soil for late planting. The thickness of sowing varies, usually one to one and one-half inches apart or on the small scale, much thicker seeding than this will give good results. No training is practised on large scale production but in small gardens brush is used to support the tall varieties or a wire mesh fence or twine may be used to good advantage.

Market Preparation.—The peas reach maturity quickly and with some varieties rather unevenly, so for the truck or market crops hand picking in the field must be done. Usually two pickings at least are made before the crop is finished. Varieties which mature evenly or uniformly are used for the canning crop as only one harvest is made, the entire vine being taken up and the peas separated by machinery. Green Peas are taken to the market in the pod in baskets, or may be shelled and sold for so much a quart.

Varieties.—Alaska, Perfection, Horsford Market, Lincoln, and Horal are canning varieties covering the season. Other varieties suitable for garden and market crops are Pilot, Laxton Superb, Blue Bantam, Thomas Laxton, Lincoln, Alderman, Stratagem, Telephone, Quite Content and Sutton's Acquisition.

PEPPERS

Peppers are increasing in popularity and now are considered an important truck and market garden crop. The fruit is used mostly in the green stage but ripe or red fruits are in good demand. The sweet large type is most popular but the hot or pungent varieties are grown to a considerable extent. The season extends from mid-summer to late fall and sound fruits can be held for a time in storage. The pepper is a warm season plant and requires an early start and a long growing season to be successful. The plants are handled much the same as tomato plants. Peppers do best on a warm early rich soil and should never be planted on heavy wet soil.

Fertilizers.—Peppers are similar to tomatoes in their soil and fertilizer requirements. When grown on well manured sandy loam soils applications of 1000 pounds per acre of a 3-10-5 or 750 pounds of a 4-12-6 fertilizer will give good results. If little manure is available the amount of nitrogen and potash should be increased. It is advisable to apply not more than half of the fertilizer in the row previous to the setting of plants. The remainder should be applied broadcast and worked into the soil before planting.

Seeding and Planting.—Pepper seed should be started early some time in March. Usually the seed is sown just previous to early tomato seed. The seedlings are transplanted once or twice and grown similarly to tomatoes until planting time which will be about June 1st. The plants should be well developed and may have some fruits set. The plants are spaced eighteen inches in rows and rows may be two to three feet apart.

Cultivation.—Clean shallow cultivation should be given.

Market Preparation.—The fruit may be harvested either in the green stage or left until ripe or red. A larger yield is secured if all fruits are picked green but usually the price is higher for the red ones. Ripe hot ones command the highest price of any but the size and yield is lower than most sweet varieties.

Varieties — Sweet or mild.—Harris Earliest, Harris Early Giant, California Wonder, Ruby King, Chinese Giant, Oskosh (yellow) and Sunny-brook.

Hot Varieties.—Hamilton Market, Chille, Long Red Hot.

POTATOES

The potato is one of our most important food crops, and is widely grown throughout the Province of Ontario. The distinct early districts extend through portions of the Counties of Peel, Wentworth, Lincoln, Norfolk, Elgin, Kent, Essex and Lambton. The main crop is also well grown—north as far as Cochrane, West to Kenora and Rainy River districts. Many small gardens are planted in whole or part to potatoes. Our best main potato crop sections are found in Middlesex, Dufferin, York, Ontario, Wellington and Simcoe.

Potato seed sprouted in the light and illustrating the proper stage for planting.

Soil.—A good well-drained loam soil, rich in humus and plant food, will grow a good crop of potatoes. The lighter soils suit better for earliness. Preparation of the soil before planting should be given special attention. Provide as deep a bed of mellow soil as possible and avoid fresh manure.

Fertilizers.—For maximum yields, potatoes require large amounts of readily available nutrients. In practice, applications range from 750 to 3000 pounds per acre of a well balanced fertilizer. Applications up to 2000 pounds per acre should always be applied in the row either slightly beneath the seed or at each side on the same level. For heavier applications, part of the fertilizer should be applied broadcast and well worked into the soil previous to planting and the remainder applied in the row at time of planting.

On sandy loam soil, well supplied with humus, a fertilizer of a 1-2-2½ ratio will be suitable, supplying a total of about 80 pounds of nitrogen, 160 pounds of phosphoric acid and 200 pounds of potash. Such amounts will be supplied in 2000 pounds of a 4-8-10 fertilizer. On heavier loam soils a 1-3-2 ratio will be more suitable, supplying a total of 60 pounds of nitrogen (N), 180 pounds of phosphoric acid (P_2O_5) and 120 pounds of potash (K_2O), which is supplied in 2000 pounds of a 3-10-6 mixture.

On well decomposed muck soils a ratio of approximately 0-2-3, supplying a total of 160 pounds of phosphoric acid (P_2O_5) and 240 pounds of potash, per acre, will give good results. This is supplied in 2000 pounds of 0-8-24 mixture. If the muck soil is comparatively new or extremely acid, some readily available nitrogen in the fertilizer will be beneficial.

Potatoes do best on a slightly acid soil in order to prevent scab and, if the soils are alkaline, fertilizers leaving an acid reaction are recommended.

Planting.—Potatoes are cut into pieces of nearly two ounce size and should have two eyes per set. Sometimes small sized tubers are planted without cutting to good advantage to prevent rotting, in the event of unfavourable weather. The usual distance of planting is from twelve to fifteen inches in the row with rows thirty inches apart. The best depth is from four to five inches. For the early crop the potatoes may be sprouted by placing them in a light room in moderate temperature for several days (two or three weeks). Short stubby green sprouts are formed which will withstand the cutting and handling. A much earlier maturing crop is secured by this method. Shallow planting is followed for the earlier crops, riding and hilling up are done to give necessary depth of soil over the roots. Cut potato seed should be planted a soon as convenient but if necessary to hold for a time it should be dusted with gypsum or land plaster.

Sprouting Potatoes for Seed.—This practice is conducted by exposing the potatoes some two weeks before planting time to the light. The potatoes are spread out along the floor or in flats or shallow boxes in a greenhouse or a well-lighted barn or room where they will not freeze. Young sprouts soon develop and these grow thick and become firmly attached to the tuber. In length they should not be more than about half an inch. With careful handling and hand planting these sprouts may be planted intact with the sets and should produce a crop ten days to two weeks earlier than the unsprouted sets. Where cut seed is to be held over, the best material to treat it with is wood ashes or gypsum. It is best, however, to plant potato seed as soon after cutting as possible. Treating with lime may tend to encourage scab development.

Cultivation may be deep and thorough at first but later should be shallow and only sufficient to control weeds and to give the necessary ridging or hilling to protect the tubers.

Harvesting begins with the early crop, often before it is mature and continues in some sections until the late crop is all out. The late crops are usually allowed to come to full maturity before digging. As the potato is a cool season crop, best development and tuber formation takes place mainly during the late summer months. The early crop develops previous to the extreme heat of mid-summer. A digging fork is used for small plots but a plow or regular potato digger is used for large areas. The tubers should be handled carefully to avoid bruising.

Varieties.—Irish Cobbler is the most popular early white variety. It has good cooking qualities and also carries some resistance to disease. Early Ohio is a pink tuber and is popular as an early variety for home use. Green Mountain and Dooley are the two main or late crop varieties.

PUMPKIN, SQUASH, MARROWS

Pumpkins are usually grown in limited quantity as the demand varies. The small pie pumpkins being most popular on the market. Canning factories sometimes contract for considerable quantities but this demand is irregular. Squash are of more importance on the market and meet with greater demand. There are many varieties and a fairly wide use is made of them and they store well. Squash are grown in considerable quantity by most gardeners. Marrows are quite popular and are used mostly during the summer season.

Planting.—Seed is usually sown outside either in hills six to twelve feet apart or some seed may be put in the corn hills when planting corn. Seed may be sown in rows and the young plants thinned to the desired distance. Any good well-drained soil will produce good crops of pumpkins, squash and marrows.

Varieties.—Pumpkin: Pie (various strains) Connecticut Field.

Squash.—Summer: Crookneck, Table Queen; Winter: Warted and Golden Hubbard, Boston Marrow, Delicious, Kitchenette; Marrow: Common Vegetable Marrow, either green, cream or striped forms; Bush Marrow: either cream or green. The marrows are usually listed as squash but are more closely related to the pumpkin as are also the Scallop and the Table Queen squash.

RADISH

As this is one of our earliest spring crops it is grown quite extensively by the truck gardener as well as the home gardens. It is one of our easiest and quickest crops to reach maturity requiring a sandy loam soil, moisture and warmth enough to encourage rapid growth. Earliest crops are grown in frames and in protected outdoor lots.

Fertilizers.—For the early crop, light sandy loam soils are preferred, but, cool moist soils are more suitable for the late crop. Preparation for radishes is similar to other root crops, as they are sown very early in the spring, and quickly available forms of fertilizers should be used. On most good soils that have been well manured a 5-8-7 fertilizer, applied broadcast, at the rate of 750 to 1000 pounds, will give good results. If the weather is very cool and wet additional readily available nitrogen, at 15 to 30 pounds per acre applied as a top dressing will be advisable.

Seeding.—Seed is sown thinly in shallow drills in well prepared soil making the rows about eighteen inches apart. No thinning is done except when first ones are ready to pull, the larger ones are taken first making about three pullings. Successive plantings will give a continuous supply of radishes. Seed of the summer radish is sown medium early and develops to best stage during the early summer. Both the winter and summer radishes are much larger than the ordinary or spring radish. Seed of winter radish may be sown about the first week of July for best results. These are thinned and make most growth late in the season and are harvested in fall and may be stored.

Varieties.—Early Spring: Sparkler, Scarlet Turnip White Tipped, Rosy Gem; Summer; Chartier, Icicle; Winter: Long Black Spanish, China Rose, Long White Spanish.

RHUBARB

This is one of the perennial vegetable crops and is found in every garden and truck farm. It produces the first food material harvested from the garden and during the early summer months large quantities of rhubarb are found on the market. Canning factories buy considerable amounts of the outdoor crop, but this is not a regular canning crop. Most growers prefer to force a large part of their crop. This brings it onto the market during the later winter months and with forcing has better quality and colour than outdoor grown rhubarb.

The underground part of this perennial plant is comprised of somewhat woody rootstalks and a fibrous root system. Adjacent to the soil surface is the so-called crown, from which numerous large leaves arise outdoors in the spring. The thick long leaf-stalks of these leaves constitute the edible portion of the rhubarb. Subsequent to the production of the leaves with their edible leaf-stalks is the formation of a flower stalk three to five feet in length.

Soil and Cultivation.—A deep rich sandy soil is best for the growth of this crop, but it will thrive on a variety of soils. Plenty of humus and clean cultivation will give a good stand of vigorous plants.

Fertilizer.—When manure is available a top dressing of 10 to 15 tons, per acre, applied during the winter would be beneficial. This should be supplemented with a fertilizer of a 1-2-1 ratio, supplying nutrients equivalent to 500 to 750 pounds of a 5-10-5 fertilizer, per acre. This should be applied broadcast in the early spring and cultivated into the soil. If no manure is available the amount of fertilizer should be increased. However, on heavier soils receiving manure the amount may be reduced.

Planting.—Commercially, rhubarb seed is not used to propagate young plants of any variety, because the characteristics of the variety are not accurately reproduced in this manner. Old crowns or plants are dug up and divided to make new plants for commencing new plantings. Each of these new plants must possess one or more good buds, attached to a portion of a root from the old plant. This new plant is placed in a deep furrow with the bud just at or below the soil surface, and well firmed into position. Planting is usually done in spring, but fall planting is often practised. Rows should be four or five feet apart and plants in the row may be two or three feet apart.

All seed or blossom stalks should be removed and no edible leaf stalks pulled for use during the first two seasons.

Harvesting.—In pulling the stalks a side twist with a light pull will separate the stalk from the crown easily.

Forcing Rhubarb.—Large quantities of rhubarb crowns are forced each winter some in house cellars, some in temporary pits and some in permanently constructed cellars. Well grown two year roots make good forcing crowns Older ones are good but if too old the stalks are apt to be small. The crowns are dug up in the late fall and stored where they may be reached at any time. Light freezing is beneficial but severe freezing and thawing weakens them. Crowns put into the forcing cellars before the middle of December, usually do not do as well as roots which are left out for a longer period. The essential conditions required in the cellar are as follows: A temperature near 58° to 60° F., exclusion of bright light and plenty of water. A ground or cement floor will do equally well and sand or fine soil is used to fill in around the roots. It requires from four to five weeks to produce the first growth of stalks and five or six pullings may be made during the following month, when the plants will be exhausted and may be replaced. The forced rocts are usually discarded as it requires a great deal of time to bring them back to normal growth. Plenty of water is required for best success with this crop.

VARIETIES.—Old standard varieties are Victoria a fairly large stalk but often is green in color; Linnaeus: a pink colored but small stalk sometimes called Strawberry. A good variety on account of its tenderness and quality. Ruby: a variety introduced by the Central Experimental Farm, Ottawa, of good quality and remarkable color inside the stalk as well as outside. Macdonald is another high quality rhubarb, a very vigorous grower and carries good color as well. Sutton's Seedless is a very desirable variety of high quality and large vigorous growth. It produces few seed stalks and is considered our best forcing variety.

SALSIFY

This is a well known vegetable often called Vegetable Oyster, resulting from its use in preparing soups resembling oyster soup. It may be used in different ways to make many appetizing dishes. It is a hardy biennial and the tender roots are the parts of the plant used.

PLANTING.—A deep loam soil of good rich substance produces the best and largest roots. Seed is sown early in the season and the young plants are thinned to two or three inches. The plant requires a long growing season, reaching best development after the cool weather of the late fall. The roots may be dug in fall and stored in sand or may be left until spring. The roots are washed, trimmed and bunched for market. Mammoth Sandwich Island is the only common variety of this crop.

SPINACH

This is possibly our most important "greens" crop. Demanding relatively cool weather it is grown extensively as an early spring and late fall market crop as well as being grown under contract for canning factories, in considerable quantities. It is usually found in the home garden. Spinach possesses a distinct taproot which penetrates somewhat deeply into the soil. Major branches from this taproot in about the 6-8 inches of surface soil extend from the taproot about 10 inches or less and then turn downward into the soil. On these major branches are numerous rootlets. As an annual the spinach possesses two distinct stages of growth. Subsequent to germination of the seed a crown is formed adjoining the soil surface. This crown is actually a longitudinally compressed stem. From this stem the edible leaves arise in practically the same plane. After the crown and the edible leaves have developed the stem increases in length, branches, and forms flower stalks. The latter bear leaves and clusters of flowers in the axils of the leaves and stems. This flower stalk production is usually called "bolting" or "shooting" to seed; and concludes the canning and market value of the spinach crop.

SOIL AND CULTIVATION.—A light sandy soil is best for the early spinach crop but any loose friable soil slightly acid to neutral in reaction will produce a good crop. It must be well drained and should contain plenty of humus and available nitrogen. Shallow cultivation is conducted.

Fertilizers.—A basal application of a 1-2-1 ratio fertilizer supplying a total of, approximately, 50 pounds of nitrogen, 100 pounds of phosphoric acid and 50 pounds of potash, per acre, is satisfactory when 15 to 20 tons of manure is applied in the preparation of the soil. This is supplied in 1000 pounds of a 5-10-5 fertilizer. Further side dressing of 25 to 50 pounds of readily available nitrogen in one or two applications during the early growing season is necessary.

On muck soils a fertilizer of 1-2-2 ratio is suitable giving a total application of, approximately, 50 pounds of nitrogen and 100 pounds each of phosphoric acid and potash, which is supplied in 1000 pounds of a 5-10-10 or 1250 pounds of a 4-8-8 fertilizer. An additional application of 25-50 pounds of available nitrogen is advisable in one or two side dressings, especially if the season is cool and wet.

Seed Sowing.— Seed is sown thinly in drills, twelve to eighteen inches apart using from sixteen to thirty pounds of seed, depending mostly on the germination quality of the seed.

Thinning.—The plants may be thinned to stand three to six inches apart. Thinning is not practised with the canning crops. The late or fall crop should be sown in midsummer sometime in August, depending on locality and season. Some growers sow a crop early in September, and winter it over for the earliest spring market. Spinach will not develop properly during the long days of midsummer as the plants quickly develop seed stalks and leaf growth is checked. Harvesting is done by cutting the root just below the crown and removing all spoiled leaves. The remaining leaves are left intact and placed in hampers and handled usually in bulk.

Varieties.—Viroflay: A smooth leaved type, making a rapid development. Best grown early in spring or for late fall crop. Used extensively for canning crops. King of Denmark: A smooth flat leaf type with slow development, being one of the latest to produce seed stalks. A good late spring variety and for home garden. Princess Juliana: This is a savoy or wrinkled type and goes to seed late in the life of the crop. Victoria: This variety has Savoy leaves, good dark colour. Slow growing habit and is a heavy producer. This is a good one for late spring market production as well as early fall crops. Virginia Savoy: This is of the savoy type, but is fast growing, quickly sending up seed stalks in spring. It is best adapted to late fall crops, and for wintering over for the early spring crop. It is also highly resistant to the Mosaic disease.

SWISS CHARD

This is a useful plant for supplying green during the midsummer. The leaf stalks are used in a similar way to asparagus. It is canned like Spinach and is usually found in all home gardens.

Planting.—Seed may be started inside and plants transplanted but mostly the seed is sown directly in soil in rows eighteen inches apart or wider, for horse cultivation. The plants should be thinned to eight or twelve inches apart.

Any good rich soil will produce a good crop of Chard. Only the young tender leaves are harvested, being careful to avoid injury to the centre bud.

Giant Lucullus is the common variety in general use.

WATERCRESS

This is a salad crop and is quite popular on the market at all times. It grows freely in moist places along edges of streams and is often propagated by stem pieces or by seed. A fresh, clean supply of water is essential for best production. The fresh leaves and stems are gathered and sold in small bunches.

WATERMELONS

This is not a large crop in Ontario but is found in many home gardens and in the southern sections, frequently good field crops are produced and sold on the local markets.

Soil and Cultivation.—A light well-drained soil gives good results. It should be rich yet not so rich as to make excessive vine growth. Cultivation should be shallow but thorough until vines cover soil.

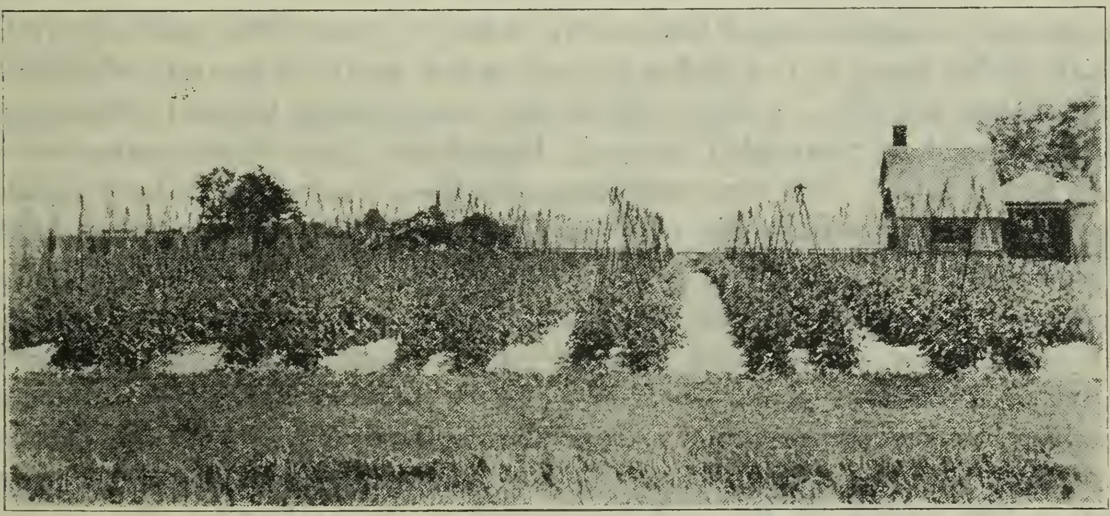
Planting.—As a rule seed is started in beds or greenhouses and the young plants set in field after all danger of frost is past. On protected and more favored plots the seed may be sown directly in drills or hills and the young plants thinned to stand the desired distance, which is from four to eight feet apart.

Harvesting.—The melons are best ripened on the vine and one requires considerable experience to judge when a melon is ready to harvest. The color of the pale spot and the sound on tapping with knuckles, as well as the curling of the stem, are indications.

Varieties.—Cole's Early, Harris Earliest, Kleckley Sweet, Tom Watson.

TOMATO

The tomato is our most popular and most universally used vegetable. Large quantities are canned each season as well as considerable amounts of fresh juice for preparation of drinks. Fresh tomatoes are found on our markets the entire year. Both fresh and canned tomatoes are rich in certain vitamins needed to maintain good health. Tomatoes are grown as a truck and market garden crop. Large acreages are contracted for each year by the canning companies. The tomato is grown in practically all home gardens during the summer season.



Staked Tomatoes.

Soil and Cultivation.—The tomato will do well on a wide range of soils. A light sandy loam is best suited for the early crop, while the heavier sandy or clay loam is desired for the later and canning crops.

Fertilizers.—On well manured, light sandy loams a fertilizer of a 1-3-2 ratio, supplying a total of approximately 40 pounds of nitrogen (N), 120 pounds of phosphoric acid (P_2O_5) and 80 pounds of potash (K_2O) per acre will be satisfactory. This amount of plant food is supplied in 1000 pounds of 4-12-6 or 1333 pounds of a 3-9-6 fertilizer. If little manure or clover sod is used in the preparation of the soil, an additional side dressing of 15 to 30 pounds of available nitrogen will be found beneficial.

On heavy loams to light clays and silts that are well manured a 1-6-3 ratio fertilizer, supplying about 20 pounds of nitrogen (N), 120 pounds of phosphoric acid (P_2O_5) and 60 pounds of potash (K_2O) is suggested. This will be supplied in 1000 pounds of a 2-12-6 or 250 pounds of 4-16-8. If lightly manured, additional side dressings of readily available nitrogen at 15 to 30 pounds per acre will be essential especially in cool, wet seasons.

One of the most satisfactory methods of applying the fertilizer for tomatoes is to thoroughly mix one-half of the quantity with the soil beneath the plant at the time of transplanting and the remainder in a ring around the plant after planting and hoed into the soil.

Production of Young Plants.—The tomato, like several of our other warm season crops, requires to be started inside with transplanting to the open soil.

Early Crop

For the early crop seed is sown as early as the middle of February until March 1st, in well prepared compost soil about one-eighth inches deep in rows about two inches apart or broadcast in soil in a flat. The seed is covered with sand, sifted over the entire soil surface of the flat. Thorough watering with a fine spray immediately after seeding is conducted, and afterwards the soil is kept moderately moist. The seeds in these flats should be placed in a temperature of 70°F.. and never below 60°F. When the seedlings are through the soil plenty of light should be provided; a moderate soil moisture, maintained; and a temperature of about 65°F. with more ventilation.

The first transplanting is conducted when the first true leaf is out into straight compost soil in standard sized flats twelve inches by twenty-four inches by two and one-half inches deep, at two inches by two inches apart, at the rate of thirty,-two to fifty plants per flat. A short time before transplanting the soil containing the seedlings should be thoroughly watered. Immediately after transplanting watering should be conducted. The day temperature for these transplanted plants should be from 60°-70°F. and never below 60°F. at night, with plenty of ventilation, but with no direct draft.

About two weeks after the first transplanting into the flats these plants are again transplanted into straight compost soil in standard sized flats with about eighteen to twenty-four plants per flat to provide more space for root development. Oftentimes for this transplanting a three and one-half to four inch pot or a berry box is used for each plant. At this transplanting the plant should be set quite closely to the bottom of the container to aid in the production of a good root system. Water well immediately after transplanting.

At once after this transplanting and until planting in the field all possible ventilation is provided. Only a moderate amount of water is supplied; while the temperature can range from 50°F. at night to 60°-65°F. in the day.

Hardening off of the plant should be secured gradually throughout the entire time of the growing season as young plants to secure a well developed stocky bushy plant for the field. Throughout the last two weeks in the greenhouse or coldframe only a minimum amount of water should be applied to harden off the plants.

For real earliness the plant should have the first blossoms with a few small fruits formed at field planting time. The root system should be well developed and fresh in appearance. The plant should never have a stunted appearance.

Planting.—Planting in the field should be delayed until danger of frost is passed and until the soil is well prepared. The plants should be well watered previous to going to the field and handled so that the roots are disturbed as little as possible, setting slightly deeper than in the coldframe and firming well in place. Furrows, holes made with spades or trowels are formed for planting. The usual distance of setting for field culture is 4 feet by 4 feet, but many variations from this are found.

Cultivation immediately after field planting at least once and preferably twice per week, until the growth of tops of plants between rows prevents should be conducted. The first cultivation is deep and subsequent cultivations should be shallower with each successive operation to prevent damage to the roots. Hoeing is also done to aid in weed control and the maintenance of a dust mulch.

Staked Tomatoes.—Advantages claimed for staking and pruning tomatoes are early ripening, better quality and smoothness, ease of harvesting. Disadvantages are: extra cost of labour in tying and pruning and quantity of plants. The plants with a staked crop are set in rows 3 feet apart, with 1 foot between each plant in the row. Another plan is to plant two rows closely together with the plants about 1½ feet - 2 feet apart from each other. The two rows are about four feet apart from the other two rows. Steel stakes are set at each four plants and these four stakes tied together at the top with string. Usually the tops of the plants are cut off after the third or fourth fruit cluster is formed. It is considered that the first three clusters determine the value of a staked crop.

Wooden, or iron stakes, are commonly used and if not tied together in fours as above discussed usually require support by means of a top wire anchored to end posts.

The plants are tied to the stakes by string, raffia or by special wire clips. String or raffia is twice tightly placed around the stake to which it is tied securely. Then a loop of string around the single stem just below a leaf stem is made to permit of plenty of space for the expansion of the stem.

Pruning to a single stem is conducted by pinching out all branches upon their appearance at the base of the plant and in the axils of the leaves with the main stem. This operation must be regularly conducted. The single stem method is practically the only one used.

Late Crop

The late or canning tomato crop is usually commenced about April 1st, and is transplanted once as small seedlings into standard flats with about sixty-four to eighty plants per flat. Smaller plants are usually used for this crop.

Market Preparation.—Tomatoes are better allowed to ripen on the plants but most commercial growers pick the early fruit when showing the first red colour. When picking for a canning factory only ripe sound fruit is picked and delivered to the factory in well coloured condition.

Varieties.—The Bonny Best is a standard, smooth, round variety adapted to marketing and factory use. It is not extra early but gives a fair yield. Chalk's Jewel is another smooth, round variety. Marglobe is a large globular fruit of good colour but many of our seasons are too short for its ripening for the whole crop.

For staking Grand Rapids is much used commercially with Sutton's Best of All increasing in use. Bonny Best, John Baer and Chalk's Jewel are also used for staking in the garden for large sized tomato.

The Earlianna or some strain of it is still our earliest variety, but has the fault of being rather rough; and under some conditions will not set the earliest blossoms.

TURNIP

There are two forms of this crop—the summer or white turnip and the winter or rutabaga.

Soil and Cultivation.—Any deep rich well drained, well prepared soil makes suitable medium for the growth of turnips. Clean shallow cultivation is provided to effect weed control.

Fertilizers.—Turnips are heavy feeders on phosphorus and on well manured heavy soils, fertilizers having a 1-6-3 ratio, such as a 2-12-6 applied at 300 to 500 pounds per acre will give excellent results. On lighter soils that are well manured a 1-3-2 ratio is more appropriate. A 3-10-5 mixture at 300 to 600 pounds per acre or 4-12-8 at 250 to 400 pounds will be satisfactory.

The fertilizer should be well mixed with the soil in the row previous to sowing of seed in order to obtain best results.

Climate.—A moderate temperature during the day with cooler nights, together with plenty of moisture tends to produce the highest quality.

Seed Sowing.—Seed is sown in drills for home garden culture about one and one-half feet apart and for field culture the distance apart is increased to permit horse cultivation. Many growers practise sowing the late or rutabaga turnips on top of low ridges or drills, affording easier hand cultivation and an advantage during a wet season.

Thinning.—The plants are thinned early to stand six inches or more apart.

Harvesting.—The crop is harvested mainly by hand pulling and trimming both tops and long roots, leaving a smooth nearly round root. Turnips are sold under grade for size and quality.

Varieties.—Garden: White Milan. Purple Top Milan, and Golden Ball are all suited for home and truck gardens. The Swede or Rutabaga type are Purple Top Swede and Canadian Gem.

VEGETABLE STORAGE

Vegetables breathe during their storage and growing phases of life, taking in fresh air (oxygen) and giving off the gas, carbon dioxide. High temperatures of these products cause their rapid breathing which effects chemical changes inside the vegetables, shortening their natural life. Contrasted to these conditions low temperatures of the vegetables cause their slow breathing which slowly establishes these chemical changes in the vegetable and thus aids in the extension of their healthy existence. Desirable storage temperatures should remain constant throughout the duration of the storage phase of the life of the vegetables.

Vegetables also give off moisture during their growing and storage periods. The proper humidity or the moisture in the air surrounding the vegetables in storage is important. Excessive amounts of moisture in the storage room air provide ideal living conditions for organisms causing decay, while the marked insufficiency of this moisture causes wilting. An earthen floor; the placing of containers of water in the storage; and the dampening of the floors aid in increasing the amount of moisture in the air of the storage.

Air temperatures in common storages are mostly dependent on the prevailing outside air temperatures. With common storages ventilation usually comprises the opening and closing of windows, doors and ventilators. Temperatures of air in cold storages are controlled by the amount of the freezing agent applied to the air in the storage room.

To admit outside fresh air and drive out moisture-laden and impure air from common storage ventilation is conducted to effect the maintenance of uniform temperature and moisture conditions. To maintain constant temperatures as much as possible in the common storage the storage should be opened when the outside temperature is near freezing at any time or at night if warm weather exists. The cool storage should preferably not be ventilated during warm days because the air and products in the storage are heated; and, also the moisture from the warm air, admitted to the cooler storage from the outside atmosphere, will be deposited on the cool products—a distinctly undesirable condition.

Of fundamental importance in storage is the necessity of having the vegetables to be stored entirely free from disease, cuts, bruises and cracks. The most efficient storage environment of temperature and humidity of air surrounding the stored products will not prevent the growth and spread of disease which may exist in these products at commencement of storage.

Storage Conditions.—Beets, Carrots, Parsnips, Salsify, Turnips, Temperature 32°F. to 33°F. with high relative humidity to prevent wilting. Pile in small piles to prevent heating and decay. Parsnips are satisfactory to remain in the field soil all winter. These vegetables are often pitted.

Celery.—Winter varieties of celery for late winter and Christmas markets may be removed from the field before frost occurs with considerable earth adhering to the roots and stored preferably on an earthen floor of a common storage cellar. The roots should be totally covered with soil which must be kept moderately moist throughout storage. The tops of the celery should always be dry; the storage, well ventilated; and the temperature of the air in the storage should be as near 32°-33°F. as possible. The celery can be slightly blanched at the commencement of storage because blanching will be satisfactorily conducted in these storage conditions. When stored under refrigerated conditions every care should be used to place only high quality celery in crates which are maintained in the above temperature in spaced rows and tiers.

CABBAGE.—The Danish Ballhead is the only suitable variety for winter storage. The desirable temperature of the air in the storage is 32°F., combined with a moderate humidity because common storage rots rapidly develop in an excessively moist air; and wilting ensues in distinctly dry conditions. Moisture from the air in storage must never be allowed to condense on the stored cabbage. In the common storage slatted shelves, one above the other, are erected throughout the storage with aisles between so as to hold one layer; and oftentimes two or three layers are placed on a shelf. Previous to placing on shelves the stem and much of the outside leaves are removed. Sometimes, too, long piles of six to eight cabbages in width and height, with two to three feet between the piles are placed in common storage.

PITTING CABBAGE.—This variety is pitted in long narrow pits of soil with five cabbages wide at the bottom tier, gradually sloping to one cabbage wide at the top tier. Ventilation is made at about fifteen feet intervals at the top of the pit.

ONIONS.—The correct preparation of this commodity for storage is of primary importance to enable efficient storage conditions to be successful. Subsequent to pulling and topping the onions are placed two or three deep on slatted trays or in slatted crates. These crates or trays are stacked in piles with air spaces between piles in open sheds or in fair weather in the field for thorough drying. The preparation with sorting aids in producing for storage the necessary well ripened, thoroughly cured, dry, firm onion.

Subsequent to thorough drying these crates or trays are placed in storage. In storage the crates or trays are superior to bags; while bags are preferable to bins. The piles of bags or crates should be separated to permit air circulation. One foot deep of onions is ample in the bins.

Dry air and floor conditions are absolutely necessary for successful onion storage. Consequently ample ventilation is required and accomplished by providing an intake of fresh dry air on the floor and an outlet for the warm moist air at the ceiling. Damp foggy atmosphere should not be allowed to enter the storage. The floors of the storage should be slatted. The storage temperature for onions is 32°F. Onions are not pitted.

POTATO.—The storage temperature is from 38°F. to 40°F. with a relative humidity of about 85%. The requisite ventilation can be secured by the free circulation of air around and beneath bins which consist of slatted floors and double slatted partitions providing an air space between bins. These slatted bins aid in removing from the vicinity of the potato all products formed by its breathing; assist to equalize the temperature within the bins and prevent sweating. Pitting is used satisfactorily for potatoes.

BULLETIN 370

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE
GUELPH, ONTARIO

Testing Milk, Cream and Dairy By-Products on the Farm and in the Factory

By W. H. Sproule
DEPARTMENT OF DAIRY HUSBANDRY

INTRODUCTION

The objects of this bulletin are to furnish the dairy farmer and the manufacturer of dairy products, in the Province of Ontario, simple and concise directions for testing milk, cream and dairy by-products for fat in accordance with approved and practical methods.

It is also intended that these directions may be used as a guide or supplement to dairy instruction to students at the Ontario Agricultural College.

THE BABCOCK TEST

The Babcock test for fat in milk was devised by the late Prof. S. M. Babcock of the University of Wisconsin. A description of the details of this test was first published in July, 1890, as Bulletin No. 24 of that station. The Babcock test superceded other practical tests because of its simplicity, reliability and moderate cost, and it is now the most widely used method of determining the percentage of fat in milk and milk products.

Uses.—The Babcock test supplies the following very important uses in the dairy industry:

(a) To determine the relative fat production of cows in the dairy herd.

(b) As an index to the value of milk and cream at dairy manufacturing plants.

(c) As a means of estimating the extent of fat losses in skim milk, buttermilk and whey.

(d) To detect adulteration of milk, when used in conjunction with the specific gravity value.

Equipment for Testing Milk.—The apparatus necessary for testing milk by the Babcock test consists of the following:

Milk-test bottles, 17.6 c.c. pipette, acid measure, centrifuge, thermometer, water-bath and callipers.

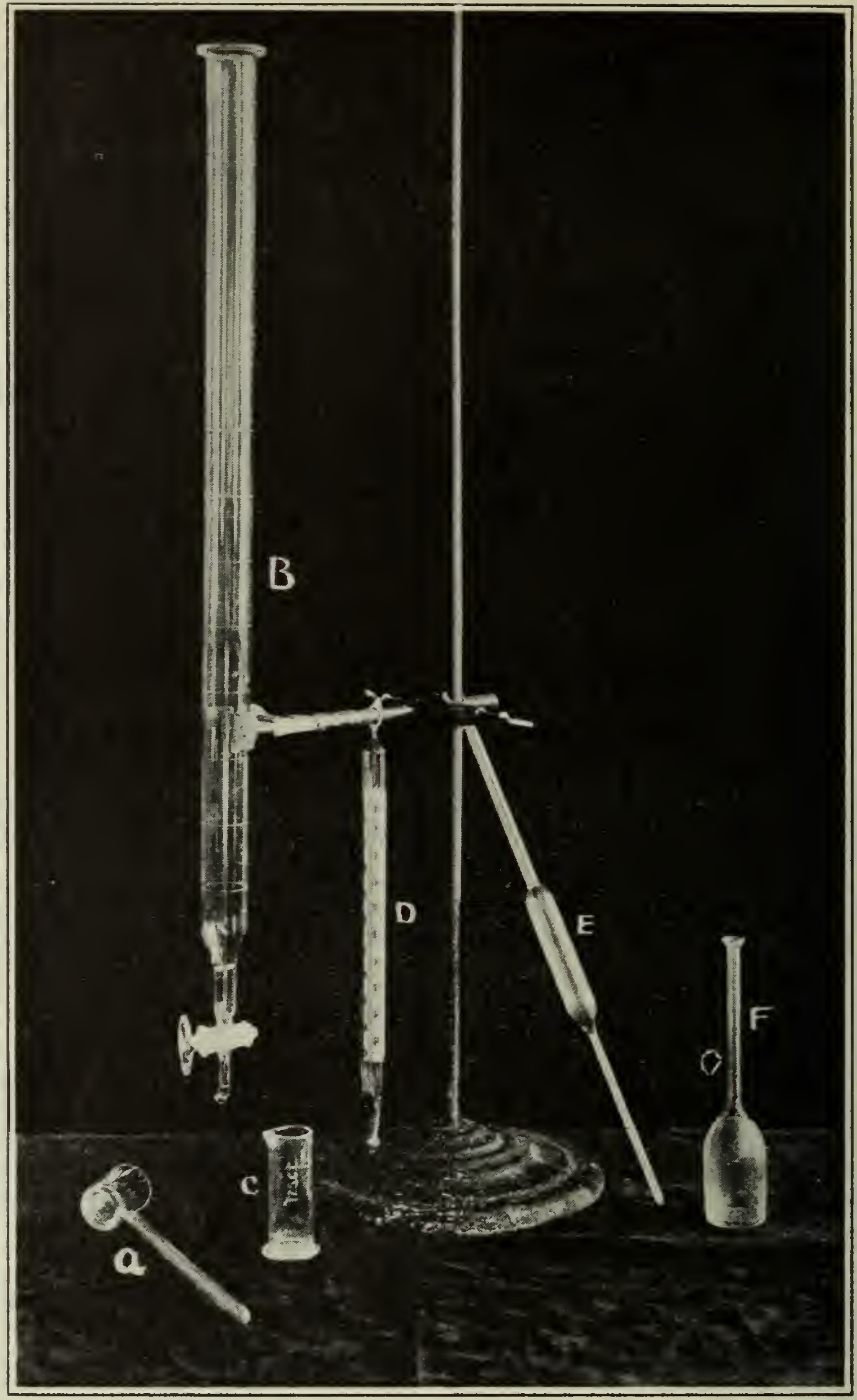


Fig. 1—(a) 17.5 c.c. acid dipper. (b) Acid burette.
(c) 17.5 c.c. acid measure. (d) Thermometer.
(e) 17.6 c.c. pipette. (f) Test bottle.

Accuracy of Glassware.—Test bottles and pipettes used in connection with the Babcock test must be verified by the Standards Branch of the Department of Inland Revenue, Ottawa. Glassware, when verified and found to be correct within a specified limit of error, must be ineffaceably marked with the outline of a crown, having within the initial letter of the reigning Sovereign.

The pipette used for measuring the milk has one graduation; the 17.6 c.c. mark on the upper stem above the bulb.

The Babcock whole milk bottle is divided into either eight or ten one per cent spaces. Each per cent space is subdivided into ten small or one-tenth per cent spaces.

The Centrifuge.—A centrifuge of the required type and capacity should be selected. The large capacity machines, driven by a steam turbine or electric motor, are suitable for the dairy plant, while a small hand-driven machine is satisfactory for farm use. Hand-driven centrifuges, varying in capacity from four to twelve bottles, may be obtained. The centrifuge should be placed level on a solid foundation.

The centrifugal force acting upon the test bottles is dependent upon the speed and diameter of the machine. Therefore, in order that a perfect separation of the fat be obtained, the centrifuge must revolve at a definite speed. The following table gives the speed required to give a complete fat separation in Babcock testers of varying diameters.

*Diameter of Wheel	R.P.M.
10 inches	1074
12 "	980
14 "	909
16 "	848
18 "	800
20 "	759
22 "	724
24 "	693

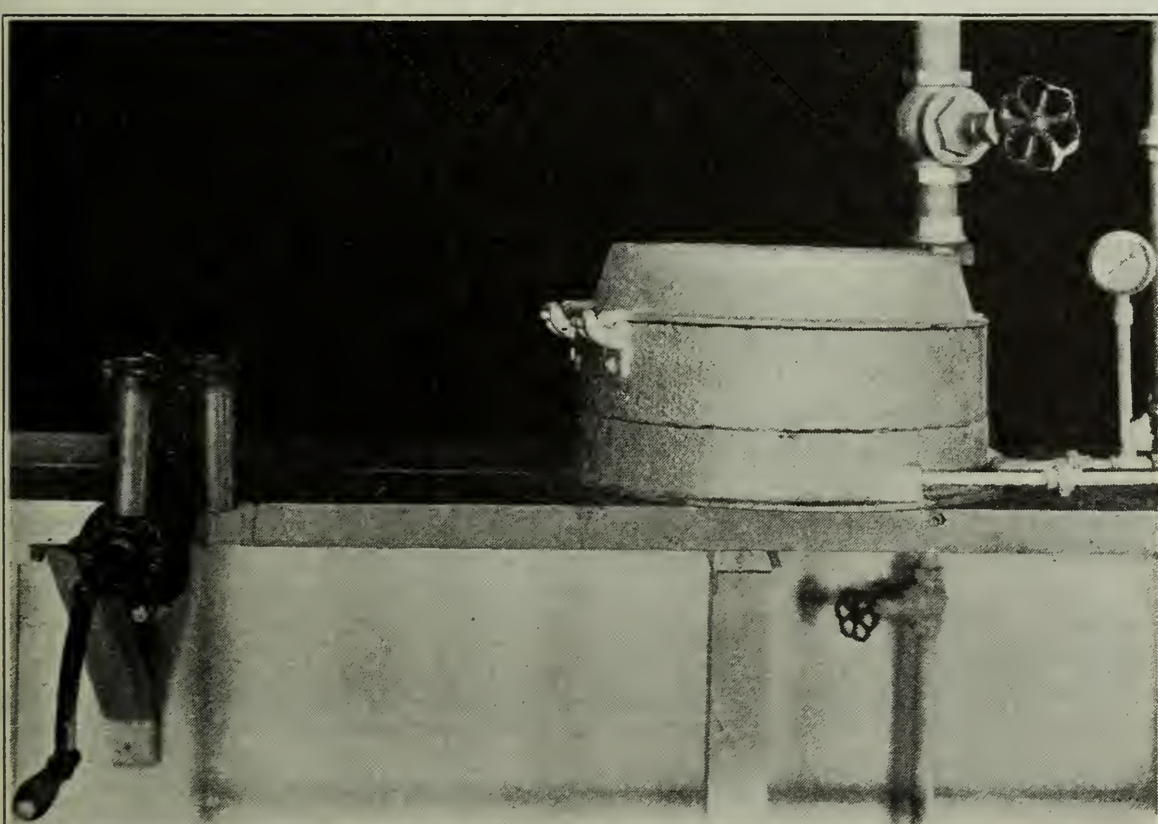


Fig. 2—Hand Centrifuge. Steam Turbine Centrifuge.

Cost of Equipment.—The cost of a small four-bottle hand centrifuge, fully equipped with glassware for cow testing, is about $12.00. The cost increases as the capacity of the centrifuge increases.

Sulphuric acid weighs about 18 pounds to the gallon and costs 2c. to 6c. per pound. A gallon of sulphuric acid will make 250 to 260 tests.

*"Testing Milk and its Products"—Farrington and Woll.

TAKING MILK SAMPLES

This is of necessity a most important part of the work. It demands care and honesty on the part of those taking the samples. The sample **must** represent the average quality of the milk to be tested, otherwise the test will be inaccurate.

To secure a sample of milk from an individual cow, pour the entire quantity from one vessel to another at least three times. Stirring the milk with a stirring dipper is also satisfactory, providing it has been stirred long enough to insure uniformity of fat distribution. The sample is then taken in a small sample jar, either by pouring or by using a sampling dipper.

At the market milk plant, or the cheese factory, a representative sample of milk from each producer is most satisfactorily secured from the weigh can. The pouring of the milk into the weigh can favors thorough mixing, thus assuring a representative sample.

Sour Milk.—Sour, curdled milk should not be tested unless it is absolutely necessary. It is difficult to sample, because the casein is coagulated and much of the fat is locked up in the particles of curd, making an even distribution of the fat impossible. A strong alkali, such as powdered caustic soda, or potash, may be used to restore the consistency of curdled milk. Add a small quantity, mix, and allow to stand until the particles of curd disappear. In testing such a sample add the acid carefully, a little at a time.

Partially Churned Milk.—Partially churned milk should not be tested if it can be avoided. However, if a test must be made, warm the sample to 100 deg. to 110 deg. F., and hold it at that temperature until all the lumps of fat are melted. Then, mix the milk thoroughly, taking the sample for testing quickly before the melted fat has had a chance to rise. Cool the milk in the test bottle to 60 deg. F. before adding the acid. The same procedure will serve when the milk is covered with a thick, leathery cream. Results of such tests should be regarded as only approximately correct.

TESTING WHOLE MILK

Details (in order of procedure).

1. *Have the Milk at a Temperature of 60 Deg. to 70 Deg. F.*

The temperature of the sample is adjusted to within this specified range in order to secure readings of a more desirable quality in color and clearness. Incidentally, this temperature for the milk enhances the mixing of the sample so as to insure even distribution of the fat globules.

2. *Mix the Milk Thoroughly by Pouring Gently from One Vessel to Another Several Times.*

In mixing the sample of milk, care should be exercised in pouring it from one vessel to another in order to prevent the incorporation of air. This can be done by allowing the milk to run down the sides of the vessel, thereby minimizing the agitation of the milk.

3. *With a 17.6 c.c. Pipette Measure this Quantity of Milk into a Whole Milk Babcock Bottle.*

Draw the milk into the pipette, filling it above the graduated mark on the upper stem. Use the index finger to close the pipette. By gently admitting air at the top of the pipette the milk will be lowered to the 17.6 c.c. mark. Insert the lower stem of the pipette into the neck of the test bottle, and so transfer the sample to the bottle. Blow the last drop of milk from the tip of the pipette.

4. Add to the Milk in the Bottle 17.5 c.c. of Sulphuric Acid, Using the Acid Measure.

Commercial sulphuric acid having a specific gravity of 1.82 to 1.83 is used. The temperature of the acid should be at or near the temperature of the milk. When adding the acid to the milk, hold the bottle in a slanting position so that the acid will run down the side of the bottle: this will tend to protect the fat from being burned by the acid. The bottle should be revolved once, as the acid is being added, to wash down any milk adhering to the neck. (See Fig. 3.)

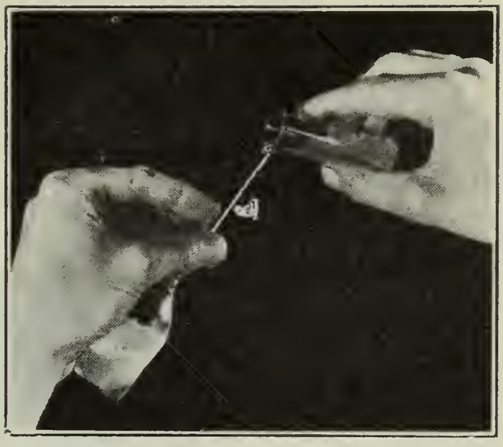


Fig. 3—Adding the Acid.

5. Mix the Milk and Acid by a Rotary Motion.

As the milk and acid are mixed the milk curdles, clots of curd dissolve and liquefy, and the mixture becomes hot, owing to the action of the acid on the water and organic constituents of the milk. The mixing is complete when color has completely changed to a chocolate brown. Care should be taken to prevent particles of curd from rising in the neck of the bottle and also that a layer of acid does not remain in the bottom of the bottle after mixing. (See Fig. 4.)

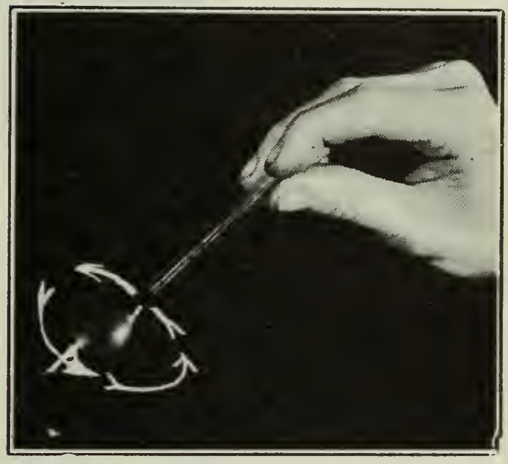


Fig. 4—Mixing Milk and Acid.

6. Place the Bottles in a Babcock Centrifuge and Rotate the Machine at Speed Indicated for Five Minutes.

Have the bottles properly balanced in the centrifuge. If the machine has a lid, close it before starting to rotate. Increase the speed gradually to that recommended by the manufacturer. When the samples have been centrifuged for five minutes, gradually slow up the machine to a stop rather than stopping it abruptly.

7. Add Hot Water (Temperature 160 Deg. to 170 Deg. F.) to the Bottles, Filling them to the Neck, or Base of the Graduation.

Soft, or distilled water is preferable to hard water for this purpose and will give a clearer fat column in the finished test. However, hard water will give good results if a few drops of sulphuric acid is added before the water is heated.

8. Centrifuge the Bottles for Two Minutes.

9. Add Hot Water as Before, to the Bottles, to Float the Fat.

Sufficient water should be added to float the fat well into the graduated neck of the bottle. As only the graduated portion of the neck is calibrated, the fat column must finally be located therein, otherwise the reading cannot be depended upon as being accurate.

10. Centrifuge the Bottles for One Minute.

11. Remove the Bottles from the Centrifuge and Place in a Water-bath at a Temperature of 130 Deg. to 140 Deg. F.

Immerse the bottles to the level of the top of the fat column. The function of the waterbath is to standardize the temperature at which the fat

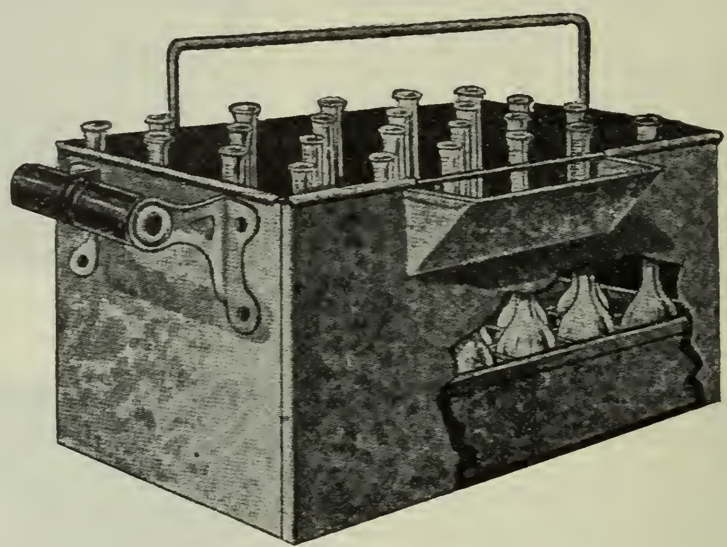
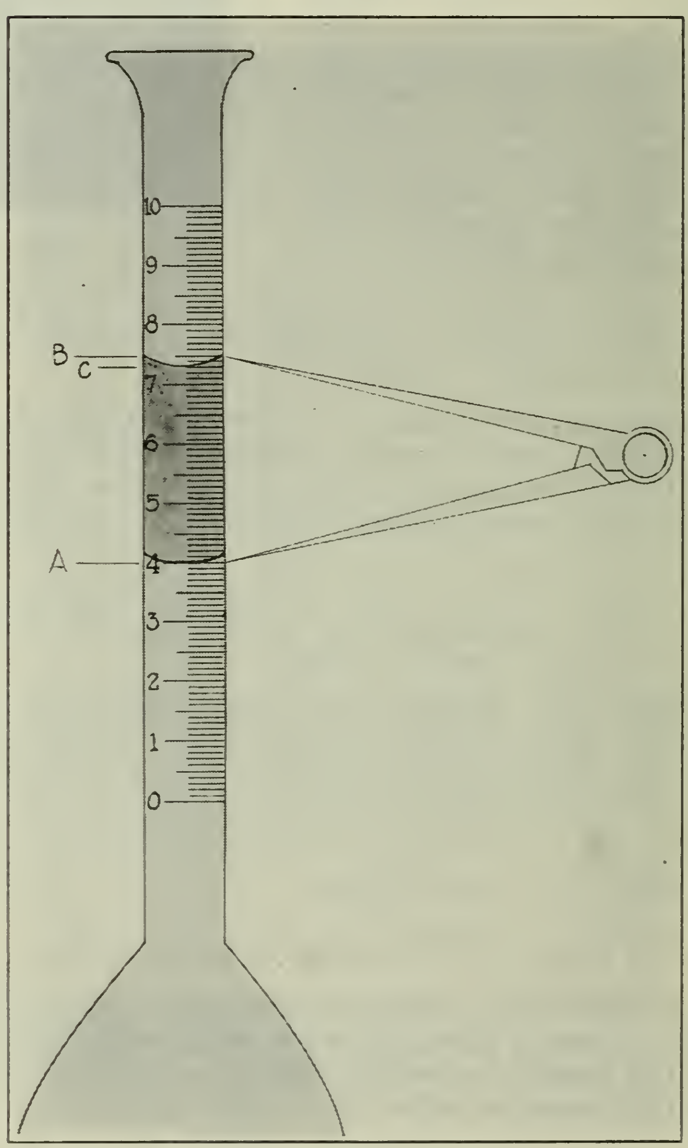


Fig. 5—(a) Water-bath.



(b) Reading the Fat Column.

readings are taken, owing to the effect of temperature upon the expansion of the fat column.

12. Read the Fat Column with the Aid of Callipers.

The bottle should be held on a level with the eye and the reading taken from the extreme points of the fat column. Then, by placing one point of the calliper on the zero mark, the other point will indicate the percentage of fat in the neck. The correct measurement is from A to B, not from A to C. (See Fig. 5 b.)

QUALITY AND APPEARANCE OF THE FAT COLUMN

When the test is made properly and in accordance with the foregoing directions, the fat column is perfectly clear, of a golden yellow color, and the top and bottom curves are sharply defined.

Defective Readings.—Burned readings or the presence of charred and dark, cloudy masses in or under the fat column may be caused by the following:

(a) Too high a temperature of milk or acid.
(b) The use of too strong or too much acid.
(c) Allowing the acid to drop directly on and through the milk.
(d) Allowing the milk and acid to stand too long before mixing.
(e) Interrupting the mixing of the milk and acid after beginning and before completing.
(f) Shaking the bottle too vigorously.

Light or cloudy reading or floating particles of curd are usually caused by the following:

(a) Low temperature of milk or acid.
(b) Weak or insufficient acid.
(c) Careless or insufficient mixing.

Such tests as the above should be rejected, as the readings are prone to be inaccurate.

CLEANING THE BOTTLES

Empty the bottles while hot, shaking to assist in carrying off the sediment at the bottom; rinse with hot water, then wash with hot water and washing soda, using a brush. Again rinse with clean, hot water.

If the bottles have become coated with burnt-on curd, the use of lead shot or equal quantities of sulphuric acid and water, followed by the above treatment, will give satisfactory results.

PRINCIPLES OF THE BABCOCK TEST

The method is based upon the action of two agents:

(1) Strong sulphuric acid upon the constituents of milk serum.

(2) Centrifugal force.

Sulphuric acid acts chemically and physically as follows:

(a) Upon the non-fatty solids, dissolving them and setting free the fat globules.
(b) Upon the water and organic solids, generating so much heat that the minute fat globules lose their individuality and run together, forming larger globules, thereby facilitating more rapid and complete separation.
(c) Sulphuric acid, being more than twice as heavy as milk fat, increases the difference in the specific gravity between the fat and the liquid surrounding it, which also aids in the separation of the fat.

Centrifugal force completes the separation. When the bottles are whirled in the machine they assume a horizontal position. Centrifugal force acts more strongly upon the heavier acid-milk-serum portion, which is forced to the outside (bottom of bottle), and the lighter fat comes to the centre (neck of bottle).

The Fat Reading in Per Cent.—When 17.6 c.c. of milk are measured into the test bottle, the graduated scale on the bottle will show directly the per cent of fat in the milk.

A 17.6 c.c. pipette will deliver 17.5 c.c. of milk. The weight of 17.5 c.c. of milk is $(17.5 \times 1.032) = 18$ grams. 18 grams is the weight of milk required for a test. The volume of the graduated neck of a 10% milk bottle is 2 c.c. The weight of 2 c.c. of melted fat is $(2 \times .9) = 1.8$ grams. Therefore, the ratio of 1.8 (weight of fat) to 18 (weight of milk) is 1:10, or 1.8 grams represents 10% of the original weight of milk taken. Each large division on the graduated neck of the bottle represents 1% of fat, and each small sub-division .1% fat.

COMPOSITE SAMPLES

A true composite sample consists of aliquot portions of milk of several deliveries from the same patron, or several milkings from an individual cow, kept by the use of a preservative; the object being to obtain the average test of the milk over a given period without the necessity of testing each individual lot separately.

The composite sample method is practiced in Ontario cheese and milk plants and also by cow-testing associations.

Bottles for Composite Samples.—Composite sample bottles must be tightly stoppered in order to prevent evaporation of moisture. Jars fitted with ground glass, rubber or cork stoppers give satisfactory results, while paper caps or tin lids do not furnish tight seals and should not be used for this purpose.

The bottles and stoppers must be thoroughly washed and sterilized after each period of use. If troubled with mould, add two or three drops of formalin to each bottle. Mouldy samples are not reliable and should not be tested. The bottles should be arranged on convenient shelves, close to the weigh can, in numerical order according to routes, and properly labeled with the patron's number.

Preserving the Sample.—Corrosive sublimate tablets, obtainable from dairy supply houses, are a convenient and satisfactory form of preservative. One preservative tablet will preserve one pint of milk for about two weeks. Put the tablet into the bottle at the time the first portion of the sample is taken. Shake the bottle by rotary motion to dissolve the tablet, and also following each subsequent addition of the sample, so as to prevent the formation of a tough cream layer around the bottle. A one to three mixture of corrosive sublimate and potassium bichromate will also give very satisfactory results as a preservative of composite milk samples. Use sufficient to give the whole sample a lemon-yellow color.

Taking Composite Samples.—The cone-shaped or one-ounce dipper is commonly used for sampling, owing to its greater convenience. While this method is not mathematically correct as compared with samples taken with the McKay Sampler, or graduated pipette, experimental data shows that the results average practically the same. The sample is taken from the weigh can, as it has been shown that such a sample is representative of the average quality of the milk, due to agitation on the wagon and pouring into the weigh can.

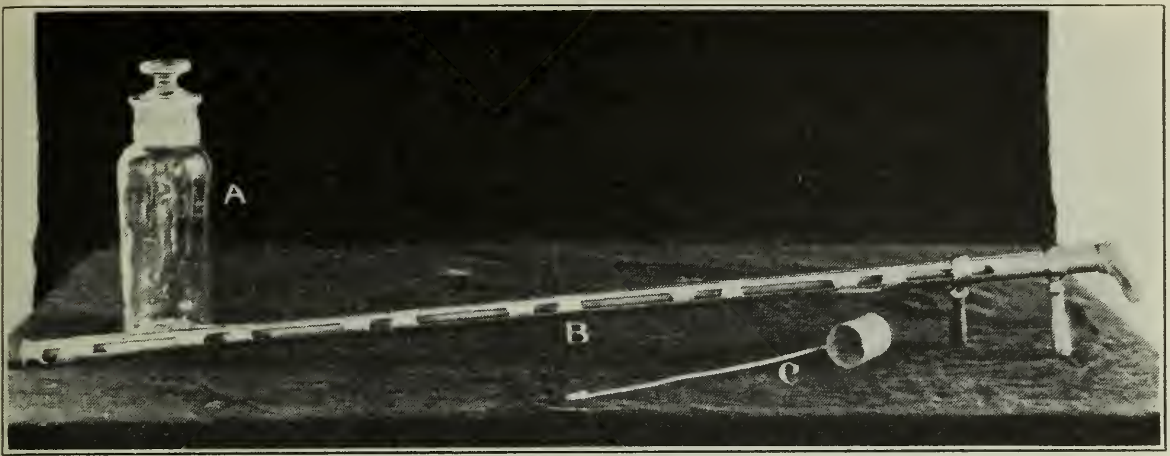


Fig. 6—(a) Composite Sample Jar. (b) McKay Sampler. (c) Sample Dipper.

Preparation of Composite Samples for Testing.—To prepare composite samples for testing, heat the samples in a water-bath to 105 deg. to 110 deg. F. to loosen the fat adhering to the sides of the jar, then mix thoroughly by pouring. The temperature of the sample should not be allowed to become high enough to melt the fat to an oil, as it is next to impossible to obtain a representative sample for testing when the milk is in that condition. When the milk has been thoroughly mixed, transfer 17.6 c.c. to the test bottle and cool to 60 deg. F. before adding the acid. Proceed with the test as given in directions above.

COW-TESTING

The true value of individual cows in the dairy herd can be determined only by regular and systematic weighing and testing of the milk for fat throughout the entire lactation periods. The most satisfactory results are obtained by weighing and recording the amount of milk produced at each milking, as well as taking a composite sample of the milk for testing night and morning for three days during the month, on the 10th, 20th and 30th. This method adds interest and enthusiasm to the work, aids in feeding and managing the herd, as well as giving an accurate record of the merits of each cow.

If weighing the milk daily involves too much labour, the following method will give very good results. Weigh the milk on three representative days of the month, the 10th, 20th and 30th, and prepare a composite sample by taking representative quantities from each of the six milkings as illustrated.

Example:

The weighings of milk on the three days are:

10th	A.M.	20.5	pounds
	P.M.	21.0	"
20th	A.M.	22.0	"
	P.M.	21.0	"
30th	A.M.	19.0	"
	P.M.	19.5	"
Total		123.0	pounds for three days.

Daily average production of milk = 123 ÷ 3 = 41 pounds.
Production for month = 41 × 30 = 1,230 pounds.
The composite sample tested 3.4 per cent fat.
Therefore, the yield of fat is 1,230 × .034 = 41.82 lbs. for month.

To obtain the approximate yield of butter from this amount of fat, increase the fat by 1/6.

1/6 of 41.82 = 6.97 pounds (estimated overrun).
6.97 + 41.82 = 48.79 pounds of butter.

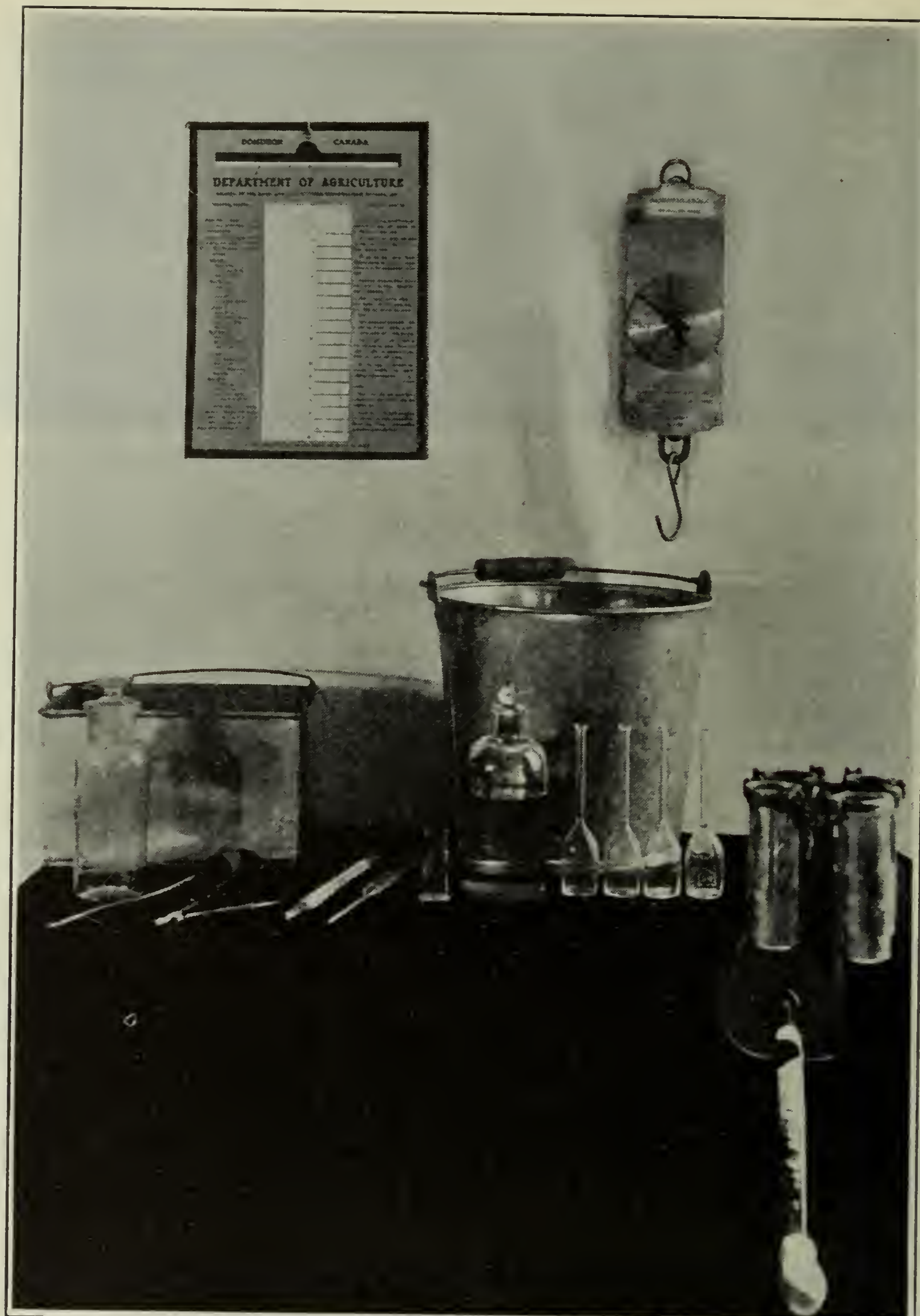


Fig. 7—Cow-Testing Outfit.

TO FIGURE THE AVERAGE TEST OF DIFFERENT WEIGHTS OF MILK OF VARYING PERCENTAGES OF FAT

230 lbs. milk testing 4.1% fat	=	9.43 pounds fat.
175 lbs. milk testing 3.2% fat	=	5.60 " "
184 lbs. milk testing 3.7% fat	=	6.808 " "
589 lbs. milk contains	....	21.838 pounds fat.

$$\text{Average test} = \frac{21.838}{589} \times 100 = 3.707 \text{ per cent.}$$

CREAM TESTING BY THE BABCOCK METHOD

Cream Test Bottles.—Cream test bottles are graduated to read from zero to 50 per cent, the smallest unit of graduation being .5 of one per cent. The standard types most commonly used are the 6 inch, 50 per cent, 9 gram bottle, and the 6 inch, 50 per cent, 18 gram bottle. The 9 gram bottle is used more extensively at the present time than the 18 gram bottle, although errors may result from the use of either type if the technique is faulty. In using the 9 gram bottle, any error made in weighing will produce twice as great an error in the test as the same error in weighing will produce in the 18 gram bottle, although the 9 gram bottle has an advantage over the 18 gram bottle in reading the test—the smaller the bore of the neck, the less error there is likely to be in reading. Which bottle one should use is largely a matter of personal preference, but, to secure uniform results, all bottles used in any plant should be uniform as to construction, graduation and weight of sample.

Why Cream is Weighed for Testing.—The Babcock test is based on weight, and it is simply for convenience that milk is measured, since the pipette delivers approximately the same weight of all milks. Measuring cream for testing is inaccurate, however, for the following reasons:

(a) Cream varies widely in fat content, hence the weight of a given volume will vary.
(b) Cream is viscous in character and will adhere to the walls of a pipette.
(c) Cream contains varying quantities of air and gas, due to the action of the cream separator and to subsequent fermentation.

"The Ontario Dairy Products Act, 1927," provides that samples of cream taken for testing shall weigh 9 or 18 grams.

The Cream Balance.—The balances used in weighing cream are specially designed and vary in capacity from one to four bottles. A four-bottle cream test balance is very satisfactory for creamery use. It should be sensitive to .03 grams. The balance should be placed on a firm level table, be properly adjusted and kept in good working order. It should also be kept dry and protected from corrosive influences, such as sulphuric acid and salt. During the period of using, the scales should not be exposed to drafts, and the weighings must be made accurately.

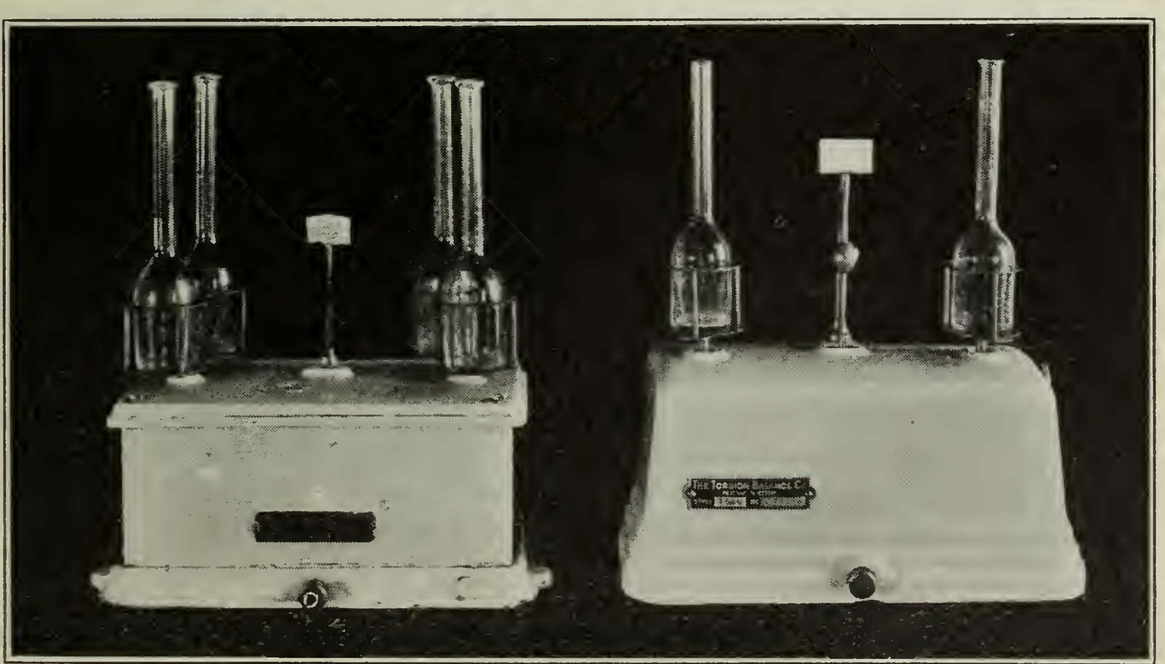


Fig. 8—Four-bottle Cream Balance. Two-bottle Cream Balance.

Taking the Cream Sample.—One of the most common causes of incorrect cream test is the inaccuracy of the cream sample as taken. Sweet cream of medium richness is easily mixed and sampled. Much of our churning cream, unfortunately, is allowed to become sour and curdled on the farm, which condition not only complicates accurate sampling, but produces butter of poorer quality. Very rich cream, e.g. 40 per cent and over, if allowed to sour, is very difficult to mix on account of its viscosity and consistency.

Cream delivered in individual cans must be sampled therefrom. Thorough mixing is necessary. The heavier the body of cream the more stirring is required if a representative sample is to be obtained. Simply giving the cream a few dips with the sample dipper is not sufficient. The stirrer must be worked to the bottom of the can several times, and the contents of the can thoroughly agitated. A small three-ounce sample may then be transferred to a suitable jar, having a tight fitting stopper, and with the patron's number attached.

TESTING CREAM

1. Preparation of the Sample.—Cream samples should be warmed sufficiently to pour freely. It is well to have them arranged in numerical order in a rack with a perforated bottom, so that the whole "run" may be warmed at once in a water-bath. Pour each sample from one container to another until the cream is uniform in consistency.

2. Weighing the Cream Sample.—Number the cream bottles to correspond with the sample bottles. Balance the test bottles carefully and place the weight, which must be Government stamped, on the opposite pan to bottle No. 1. Transfer the cream to the test bottle by means of a large-mouthed pipette, until the scale balances exactly.

3. Adding the Acid.—It must be remembered that cream contains less solids-not-fat than milk, consequently less acid is required in testing cream. The amount of acid required will decrease as the richness of the cream increases. The development of a **chocolate brown color** after mixing indicates sufficient acid. Under normal conditions, approximately 5 to 8 cubic centimeters are required for a 9 gram sample, while 8 to 12 cubic centimeters are required for an 18 gram sample of average cream.

When adding the acid to the cream, revolve the bottle once so as to allow the acid to wash the cream adhering to the neck into the bulb of the bottle. The bottle is then rotated so as to mix the cream and acid thoroughly.

Adding Water to the Test Bottles.—After mixing, add water at a temperature of 160 deg. F. or higher, to check the action of the acid. Sufficient water to bring the contents of the bottle up to the base of the neck is desirable.

Some operators follow the practice of not adding water before centrifuging the sample. Where this method is followed, it is advisable not to use acid to the point of getting a chocolate brown color as outlined, but rather to add just sufficient acid to obtain a lighter or coffee brown color.

Centrifuging the Samples.—Centrifuge the samples for five minutes at the proper speed. The fat is then raised into the graduated neck of the bottle by the addition of water at 160 deg. F. or higher, and a final centrifuging of two minutes is given.

Reading the Tests.—The bottles are now placed in a water-bath at 130 deg. to 140 deg. F. for a few minutes. Immediately before reading the tests, add a few drops of glymol (red reader) to the bottles. Glymol removes the upper meniscus, giving a clear line on the top of the fat column, thereby making possible an easier and more accurate reading. The reading is then taken with the callipers, measuring from the bottom of the fat column to the dividing line between the fat and glymol. If glymol is not available, measure the fat column from the bottom to the lower part of the curve or meniscus.

Glymol consists of white mineral oil (one quart) colored with alkanet root (one ounce).

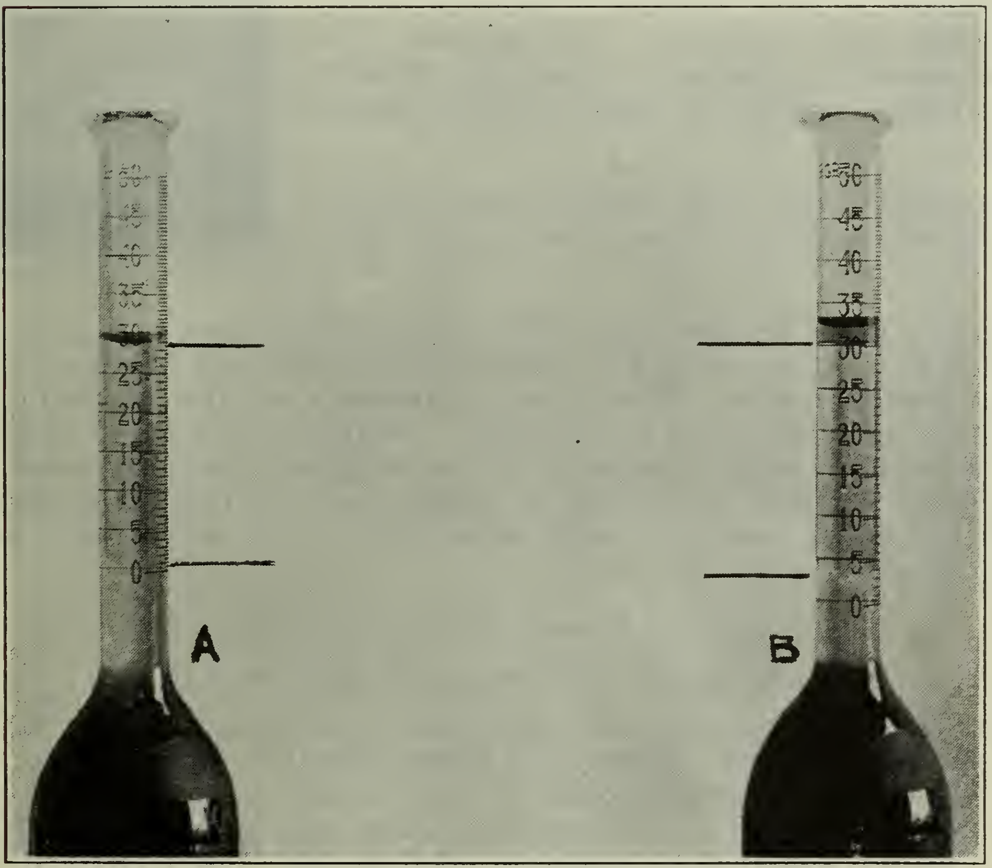


Fig. 9—The Proper Method of Reading Cream Tests.
(a) Without Glymol. (b) With Glymol.

TESTING SKIM MILK, BUTTERMILK AND WHEY

The Double Neck Bottle.—The double neck bottle (Fig. 10) is constructed especially for measuring small quantities of fat, and for this purpose gives fairly accurate results. There are two or more different types of these bottles on the market. Those having a total graduation of 0.5 per cent, with smallest sub-divisions of 0.01 per cent, are preferable. Also, from the standpoint of durability, the small graduated neck should be joined to the larger neck through which the liquid is admitted to the bottle. This larger tube should extend down close to the bottom of the bottle. It is very important that all glassware be perfectly clean, as a small amount of fat in the pipette or bottle would seriously affect the results.


Fig. 10—The Double Neck Bottle.

Taking the Sample.—A sample of skim milk from the separator is most reliable if taken after the machine has been running a few minutes. The samples should be allowed to stand for 10 to 15 minutes before testing, in order to allow the air to escape.

Buttermilk and whey samples are obtained approximately midway of the flow from the churn or vat.

Babcock Test for Whey and Skim Milk.—In testing whey and skim milk for fat, the directions, as outlined for testing whole milk, are followed, but using a double-necked bottle. Since whey contains a smaller amount of solids than whole milk, less acid is required. Ordinarily, 10 to 12 cubic centimeters of sulphuric acid is sufficient for an 18 gram sample of whey. Skim milk contains a higher percentage of solids-not-fat in the serum than whole milk, therefore the amount of acid required for an 18 gram sample will vary between 18 and 20 c.c.

Modified Babcock Test for Buttermilk.

(Acid-Alcohol or American Association Test)

(1) Place the chemicals and buttermilk or skim milk in the test bottle in the following amounts and order indicated:
2 c.c. normal butyl alcohol.
8.8 c.c. well-mixed buttermilk or skim milk at 60 deg. to 70 deg. F.
7-9 c.c. commercial sulphuric acid Sp. Gr. 1.82-1.83 at 60 deg. to 70 deg. F.

(2) Mix the liquids by a rotary motion.

(3) Centrifuge for 6 minutes at the proper speed.

(4) Add water (160 deg. to 170 deg. F.) to neck of bottle and centrifuge 2 minutes.

(5) Add water (160 deg. to 170 deg. F.) to float the fat into the graduated neck of bottle and centrifuge 2 minutes.

(6) Read the fat column at 130 deg. to 140 deg. F. from the lowest to the highest point.
Double the reading to obtain the per cent of fat.

BULLETIN 371

Ontario Department of Agriculture

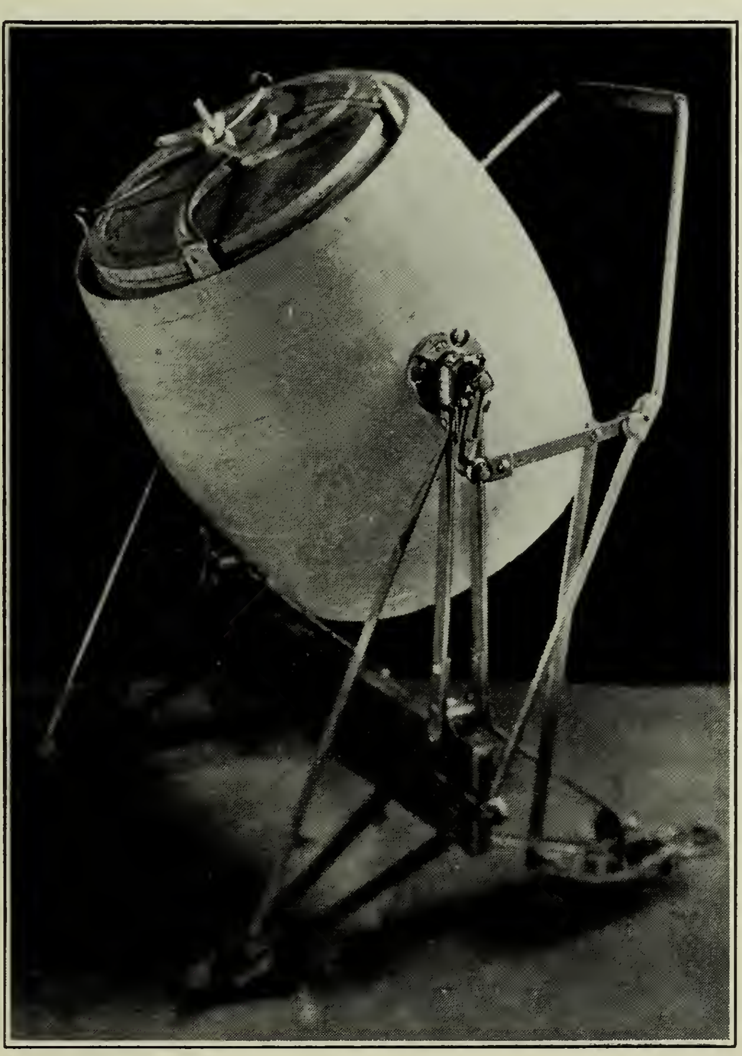
ONTARIO AGRICULTURAL COLLEGE

GUELPH, ONTARIO

Buttermaking on The Farm

By Bella Millar

Department of Dairy Husbandry



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(BULLETIN 371) (JULY, 1932)

Ontario Department of Agriculture
ONTARIO AGRICULTURAL COLLEGE

Buttermaking on The Farm

By Bella Millar

Butter is one of the foods used on our tables every day. Why not have the best?

We cannot have the best without *care* being taken in its manufacture and that begins with the production of the milk.

To produce milk of clean flavour and with a low bacterial count, *cleanliness* is essential in each step of the work.

Helps in producing milk of this kind are:—

Clean healthy cows,
Clipping the long hairs from the udders and flanks of the cows.
Wiping the udder and the flanks of the cows before milking,
Plenty of sunshine and fresh air,
Having the stable air free from dust at milking time,
Good food and pure water,
Supplying means for the milkers to keep their hands clean,
Proper washing and sterilizing of milk pails, cream separator, and all other dairy utensils.

As soon as possible after milking the milk should be strained through absorbent cotton, filter cloth, or several ply of cheesecloth.

CREAMING THE MILK

Shallow Pans—The shallow pan and deep setting methods of creaming milk are used by those who have quite small amounts of milk to handle.

Dairy Thermometer.

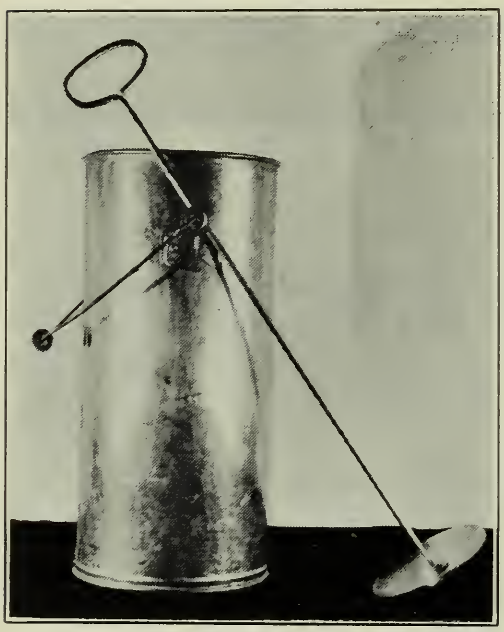
When using shallow pans the milk should be strained into the pans as soon as possible after milking and placed in a clean, well ventilated room at a temperature of 50 to 60°F for 24 to 48 hours.

When removing the cream, it should first be loosened from the pan with a thin bladed knife, then, resting the pan on the edge of the cream can, it should be tilted to allow a little skimmilk to run over first, to wet the rim of the pan and prevent the cream sticking as it is guided into the cream can.

Deep Setting System—When using the deep setting method the cans of milk are placed in cold water and kept at a temperature of 45°F., or lower for 24 to 36 hours. Ice is usually required unless the water is very cold and means are provided for changing the water in the cooling tank.

If the cans are not provided with taps at the bottom, a cone-shaped skimmer should be used for removing the cream. The cream is loosened with a knife, and the skimmer is dipped into cold water, or skimmilk, before lowering it into the can. It should be held straight to allow the cream to flow evenly into the skimmer.

Cream Separators—The general method for obtaining the cream on the farm is by the use of the centrifugal cream separator, operated either by hand or power. This should be conveniently located in a clean, well-ventilated milk house.



Cream Can and Cream Stirrer

Purchasing a separator of sufficient capacity is a "twice-a-day" time and labour saver.

To secure good results when operating, the separator must be set level; the bowl in balance; the speed of the machine, as marked on the handle; the supply uniform and the milk warm. If the milk has cooled it should be warmed to 90 to 100°F. before separating in order that efficient skimming may be done.

CARE AND RIPENING OF CREAM

The fresh separated cream should immediately be cooled to a low temperature (50° or lower). This will check the development of bacteria, thus the cream will remain sweet for a greater length of time.

With each addition of cooled cream to the cream can the contents should be thoroughly mixed.

A simple and inexpensive cream stirrer consists of a saucer-shaped piece of heavy tin about four inches in diameter with a long handle of heavy wire (tinned) fastened to the centre. With a stirrer of this kind it is easier to stir the cream from the bottom of the can.

A cream can 8 or 9 inches in diameter, and 18 to 20 inches high will be a size suitable for many. It should be provided with a well fitting cover.

Richness of Cream—Cream for farm buttermaking should contain from 25 to 30 per cent fat. This can be regulated by the screw on the separator bowl.

If it is not convenient to have the cream tested, the richness may be gauged by the churning, having a cream that will yield 3 to 3½ pounds of butter to the gallon.

By taking a rich cream there will be fewer churnings or less cream to churn, making a saving of time and labour.

A rich cream can be churned at a lower temperature, which is an advantage, especially in the summer when the butter is apt to be soft. The amount of fat lost in the buttermilk will be less than with a thin cream.

Sweet Cream Butter—Cream should be churned sweet when a butter with a mild, creamy flavour is wanted.

After separating, this cream should be quickly cooled and held at a low temperature until churning time, when the temperature should be raised to the desired degree.

Ripening Cream—As the majority of people like a butter with a little more flavour, it is necessary to allow the cream to become slightly sour before churning. A high acid souring should be avoided.

Raising the temperature to between 60 to 70°F. will favour the development of lactic acid, or in other words, the ripening or souring of the cream. Adding about a cupful of good clean flavoured sour skimmilk to the gallon of cream will hasten the souring and also help to control the flavour. Better results will be obtained if a pure lactic acid culture is secured from a bacteriological laboratory, or dairy supply house, and the directions followed. By pasteurizing the cream and adding a culture of this kind, the flavour developed should be very good. When the cream has a mild acid flavour it should immediately be cooled to a low temperature, (below 50°, if possible).

Pasteurizing Cream—In the creameries the cream is pasteurized and a butter with better keeping qualities is produced.

In the farm dairy most of the butter is going to be used within a short time, and the cream is churned in the raw state.

Although pasteurizing means extra work it would be well to resort to this method when making butter for long keeping. It is also helpful in overcoming very difficult churnings and assists in driving off bad flavours.

Cream may be pasteurized on the farm by placing the can in hot water (on the stove) and raising the temperature of the cream to 145°F., holding it at that temperature for 30 minutes, or bringing it to 170°F. and holding for 10 minutes. It should then be quickly cooled. Holding the cream at a low temperature checks the development of lactic acid and hardens the fat in the cream, thus, a better quality of butter is secured. Cream should be held at churning temperature, or lower, for at least two or three hours before churning in order to have firm butter, as the body and texture of the butter are influenced by the condition of the fat at churning time. It is a good plan to hold the cream overnight for churning the next morning. If at any time it should be necessary to churn cream that has not been held at churning temperature, or lower, for sufficient length of time, it should be cooled several degrees lower than the temperature usually used in order to get firm butter, and lessen the loss of fat in the buttermilk.

If sweet cream is added to the ripened cream at churning time, the mixture will not churn evenly, as the ripened cream tends to churn in less time, with the result that there will be a heavy loss of fat in the buttermilk.

Buttermakers who like to have "quick" churnings, that is to get butter after a few minutes churning, lose in both quality and quantity of product. The butter will be soft and greasy, and the buttermilk rich in fat.

CHURNING

Churning Temperature—Cream when ready for churning should be perfectly smooth and free from lumps. It should be churned at a temperature that will bring the butter in firm granules in from 20 to 30 minutes. It is necessary to have a dairy thermometer to take the temperature of the cream. While there is no standard temperature for churning as conditions vary, lower temperatures may be used when the cream is rich; the churn about one-third full; the cows getting succulent feed, and the cows fresh in milk.

A range of temperatures that covers most farm conditions is 52 to 58°F. in summer, and 56 to 64°F. in winter.

Farm Dairy Churn—The barrel churn is commonly used on our Ontario farms and may be operated either by hand or have power attached. A small electric motor is a wonderful labour-saver.

Cream Strainer

As a churn should not be filled more than about one-third full it is well to calculate so that one of sufficient size may be purchased.

The cream strainer is very useful in the dairy, not only for straining the cream, but for placing on the pail when drawing off the buttermilk and wash water. The size recommended is 9 inches across the top, 7 inches across the bottom, and 6 inches deep, having a strong flat handle 10 inches long. Opposite the handle there should be a loop of wire or piece of heavy tin. The perforations in the tin in the bottom of the strainer should be about 1/16 of an inch across.

A large tin dipper of about the same dimensions is very useful in the dairy.

Adding Colouring—When colouring is required it should be put in before commencing to churn. If, by chance, it should be forgotten, and the butter is too light, it may be thoroughly mixed with the salt and added to the butter in that way.

In summer the colour of the butter will be quite high enough but in winter may be rather light. Two or three drops of colouring will usually be sufficient for each pound of butter. The buttermaker will be guided by the demands of the market or the customers who are purchasing it.

The farm buttermaker who caters to the particular likes of the customers whether it be flavour, colour, salting, or style of package, should succeed in getting a price in advance of the average market. A uniform product from week to week is what people like to depend on.

When churning a ripened cream it is necessary to pull the plug two or three times during the first five minutes of churning to allow the gases to escape.

When the granules of butter are one-half the size of wheat grains, about two quarts of cold water should be added and the churning continued until the granules are the size of grains of wheat. By having the granules of this size it is easier to remove the buttermilk, to wash the butter, and to distribute the salt. If churning a thin cream this addition of water will not be required unless the butter appears to be soft.

Should a churning be stopped too soon there will be small granules of butter carried out with the first drawn buttermilk. This should be returned to the churn and a few more revolutions given.

WASHING THE BUTTER

After the buttermilk is drawn off, the butter should be rinsed by pouring over it about a gallon of cold water and then removing the plug to allow it to run off. A churn should never be revolved when there is only a small amount of liquid on the butter as it will mass the granules which should be kept apart until after the butter is salted.

The rinse water removes most of the buttermilk that was left in the churn. The rinse water and wash water are usually a few degrees lower in temperature than the cream. The condition of the butter and the temperature of the room, should be taken into consideration when preparing the wash water, so that the buttter will be of a nice firmness for working. While the water from the tap, or well, may be suitable at certain seasons of the year, in winter it may be a few degrees too cold, and require the addition of a small amount that is warmer, while in the summer, ice may be needed to get it sufficiently cold. The thermometer should be made use of.

The amount of wash water required will depend upon the amount of butter in the churn. With a thin cream, as much water as there was cream will be enough, while with a rich cream a larger amount is necessary.

The churn should be given ten or twelve quick revolutions before drawing off the wash water. If the wash water appears milky or the butter is soft, it will be necessary to use a second wash water. This is more frequently required in warm weather, and may be a few degrees colder than the first. Before running off the wash water, a small amount of butter should be pressed with the edge of a butter ladle against the inside of the churn. This will indicate to the maker the firmness of the butter, and suggest the prompt or delayed removal of the wash water.

Butter from good quality cream should not be washed more than is necessary because it takes from the fine flavour of the butter, while butter of poor flavour might be benefited by using an extra wash water.

Salting and Working—After the wash water has drained from the churn the butter is ready for salting. The amount of salt to use will depend on the market, or the people who are to be supplied. There is, at present, only a limited demand for unsalted butter.

From one-half to three-quarters of an ounce of salt to the pound of butter will be suitable in most cases. An oversalted butter is very undesirable. Some buttermakers weigh the butter before salting, while others estimate the amount of salt required from previous churnings.

Another method is to weigh the cream and test it for butterfat. For example, 20 lbs. of cream, testing 30% fat, means that the cream contains 6 pounds of butterfat. In farm dairy work it may be estimated that 1 pound of fat will make about 1 1/6 pounds of butter, therefore, 6 pounds of fat should make about 7 pounds of butter.

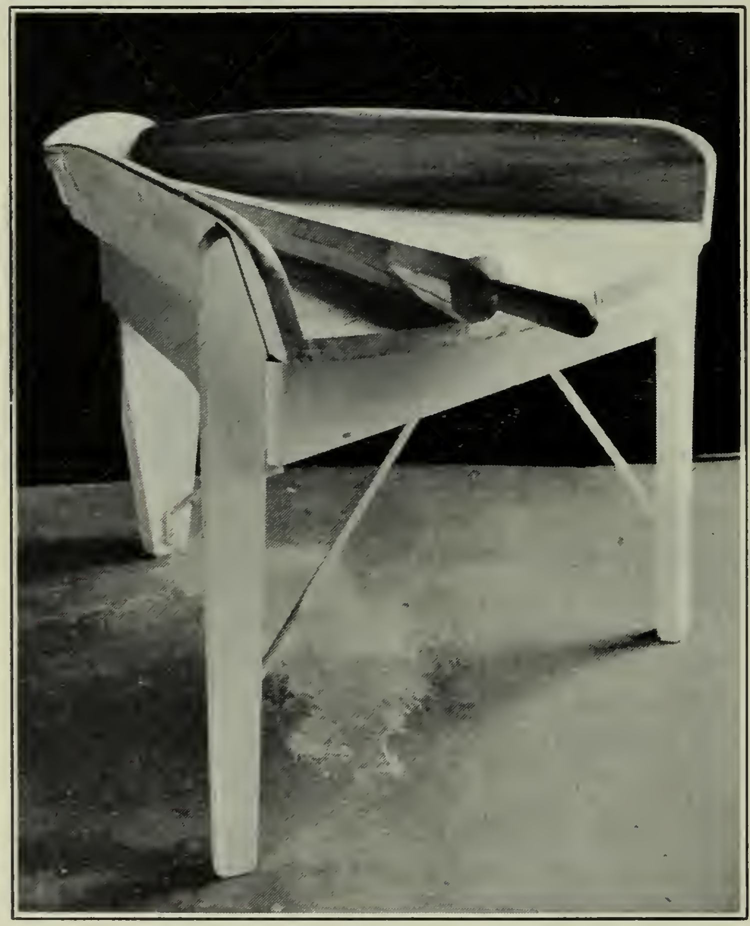
The yield of butter will depend on such factors as loss of fat in the buttermilk, and the amount of moisture and salt in the finished butter.

Butter may be salted by spreading the granules on the butter worker and sifting the salt over them, or it may be salted before it is removed from the churn. (Many prefer the latter method as it makes the work a little easier.) When salting in the churn about one-half of the salt should be sifted over the granules, which should be in an even layer on the bottom of the churn. The churn is then quickly tipped forward to cause the butter to lap over, and some more of the salt is put on. The churn is next tipped in the opposite direction when the remainder of the salt is applied. By tipping the churn back and forth a few times the salt gets better distributed.

To make the butter easier to remove from the churn it may be made more compact by massing it together with the ladles, or by putting on the lid and giving a few very slow revolutions of the churn.

Butter is worked to get rid of the surplus moisture, to make the butter close and compact, and to get the salt and moisture in the butter evenly distributed.

In earlier days butter was worked in a butter bowl, but there are butter workers that make the work easier and with less danger of destroying the body or texture of the butter.



Lever Butter Worker

The lever butter worker is inexpensive, simple in construction, and may be made, or purchased, in sizes to suit the churnings. This worker consists of a V-shaped table with sufficient slant to allow the water to drain off easily, and a pole, or lever, for working the butter.

Butter should be worked by pressing it with the lever, not by cutting into it, nor by using a sliding motion. The lever should be pressed downward turning it slightly over by a movement of the wrist. This motion is repeated until the butter is levelled across the worker. It should then be rolled up, given a quarter turn, placed in the centre of the worker, and the working continued. Care should be taken to give all parts of the butter the same amount of working. To ascertain whether the butter has had sufficient working it should be cut with a sharp ladle. The cut surface should be free from holes and when pressed by the ladle the beads of moisture should be very small.

On farms where the churnings are large, a combined churn and worker operated by power will prove to be a great labour saver. In warm weather this butter should be in better condition for printing. Having been mechanically worked in the closed churn it will not be softened by the higher temperature of the room air.

Butter Ladle

PRINTING AND PACKING—When printing the butter the brick shaped 1-pound printer is easily handled, and makes a neat package. It is filled by pressing it down on the butter, and when well filled the surplus butter is cut off with a ladle. The print of butter should weigh 16¼ ounces when made, to allow for shrinkage that may occur before it is sold.

The parchment paper, bearing the name of the maker, or dairy, should be soaked for a few minutes in cold water before wrapping it on the butter.

The 2-pound flat oblong print is well liked for table use, being marked off in eight quarter-pound blocks, each one having an attractive pattern on the upper side.

For special occasions individual patties may be made with little wooden moulds; or butter balls, and other fancy shapes may be made with a pair of corrugated ladles. These ribbed ladles are known to many by the name of "Scotch hands."

For the customers who prefer to have their regular supply of butter put up in a solid rather than prints, the small fibre containers ave very suitable. These may be secured in different sizes, they are well coated with paraffine on both sides and have close fitting covers.

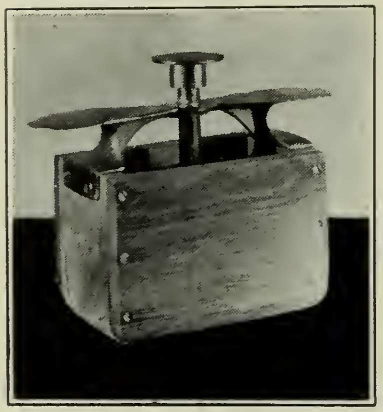
When large packages are to be filled, such as boxes and crocks, care should be taken to have these containers in good condition. The boxes should be clean and have a coating of paraffine on the inside, also a lining of heavy parchment paper. The crocks should be well glazed and free from cracks or breaks in the glazing.

On the average farm more than one churning is required to fill a large container, making it necessary for the buttermaker to make a special effort to have the butter uniform in flavour, colour and salting.

As crocks and boxes are sometimes filled in the summer and held for some months before using, only the very best quality of butter should be stored. This butter should be packed solidly to avoid holes or air spaces. A small quantity of butter should be placed in the container and packed from the centre outward and then around the edge. As each piece is added it should be firmly packed in the same way. A square packer should be used for boxes while a round one is more suitable for crocks. When the package is nearly full the surface of the butter should be levelled and then covered with parchment paper. Over this may be placed a thin layer of salt paste, made by mixing salt with cold water. As the covers of the crocks do not fit as closely as the box lids, heavy wrapping paper should be tied over the top of the crock after the cover has been put on.

Butter should be held in a clean, cool, dark place of even temperature. Better results would be obtained if the packages for long keeping could be held at a very low temperature such as may be obtained by mechanical refrigeration. Butter placed in a cold storage room will not require the salt paste.

The butter should be in good, firm condition when it leaves the farm and the packages should be protected from sun, dust, etc., so that the buyer will receive it in good condition.


Butter Printer

Not only should the housekeeper put it in a cool place when she receives it, but where the air is pure, as butter absorbs odours and flavours very readily. If it is to be kept in the household refrigerator it should be put into a tight container and placed in the coldest part.

LONG CHURNINGS

The farm buttermaker wishes to avoid long and difficult churnings as they use time and strength unnecessarily. If a churning of this kind is encountered every effort should be made to discover the reason so that the trouble may be rectified, and further churnings of this kind avoided. If, after churning for thirty minutes, there is no sign of butter coming, the churn should be stopped and measures taken to overcome the difficulty.

A very common cause for long churnings is having too much cream in the churn. This is easily remedied by taking out part of the cream. It should be understood that there must be space enough in the churn to allow the cream to drop, or to get the greatest agitation.

If the cream is too cold the churning will take a long time. The temperature should be raised by drawing all, or part of the cream, from the churn and placing the can in hot water. It should be constantly stirred and the thermometer carefully watched until it comes up a few degrees. It is then returned to the churn to complete the churning.

Cream that is too thin is another cause for trouble. Buttermakers should remember that a thin cream requires a higher churning temperature than a rich cream. With a very thin cream there will be delay in gathering the butter unless a few quarts of the buttermilk are withdrawn. To prevent the loss of small butter granules at this stage, allow the churn to rest a minute or two, then let the buttermilk run out slowly. With the granules closer together the churning may be completed without further delay.

What is sometimes called a "Clover Seed" churning is one where the granules are small, round and firm resembling clover seed. As these butter particles are a little too hard to stick together, and the amount of buttermilk too large, the temperature must be raised slightly by adding two or three quarts of water a few degrees higher than the contents of the churn. After revolving the churn a few times, some of the diluted buttermilk should be drawn off and the churning continued until the desired size of granule is attained.

Occasionally, in summer, the opposite to a "Clover Seed" churning is experienced. After a long churning, the butter appears in an oily condition, making it necessary to get the temperature lowered before the butter can be gathered. A quantity of very cold water should be added and the churn revolved a few times. This should be allowed to stand for a few minutes before reducing the amount of liquid in the churn.

Ice is necessary in a dairy unless there is a good supply of very cold water. It is quite possible that in the near future many will install an electric cooling device and thus eliminate the work of harvesting and storing ice.

A very rich cream may thicken during the process of churning and form a coating on the inside of the churn. If a cream is not dropping it is not churning. In this case enough water should be added to dilute it so that it will drop again. Churnings are sometimes made longer than necessary when the churn is revolved very rapidly, or too slowly.

Cream from cows on succulent food can be churned at a lower temperature than when dry feeds are used.

Cream from a fresh cow is easier to churn than that from a cow which has been milking for some months. This is another instance where churning temperatures must be varied.

The flavour of some butters is injured by holding the cream too long when trying to get enough to make a churning. To churn a small amount every few days would mean better butter and easier work.

Salt is necessary for the cow and it also has many uses in the dairy. Some farm churnings, where it is difficult to get a separation, are helped by the addition of some salt, or brine.

Buttermakers, by varying the temperature to suit conditions, may save much energy as well as time.

BUTTER FOR EXHIBITION

A buttermaker may learn much by exhibiting at a fall fair, or exhibition of dairy products. By comparing exhibits for appearance, and noting the points allowed each one on the score cards, some ideas may be gained that will prove useful at another time.

The scale of points on the score card that is used for butter competitions reads as follows:—

Flavour	45
Texture	15
Incorporation of Moisture	10
Colour	10
Salt	10
Package	10
Total	100

When the butter is judged a trierful of it is drawn out and the plug examined.

Especial care should be given to the cream for exhibition butter. Forty-five points out of the hundred are given for flavour which must be clean and sweet, with no objectionable flavour of any kind.

The butter should be firm and waxy, not salvy, or greasy. Proper cooling of the cream, correct temperatures for churning cream and washing butter, as well as right method of working, all have an influence upon the texture.

Butter should be made two or three days before the exhibition to have it "set", or hardened, and the flavours blended. The old practice of making it the morning of the fair has nothing to recommend it.

The moisture in the butter should be free from milkiness and well incorporated showing only in very minute droplets.

The colour of the butter should be even and bright, and the salt properly distributed and thoroughly dissolved. If the salt is not evenly distributed the colour will not be uniform.

Butter packages should present a clean, tidy appearance. The prints should have square corners, no holes showing on the surface, and the papers neatly wrapped and folded.

"Good, better, best,
Never let it rest,
'Till your good is better,
And your better, best."

CARE OF DAIRY UTENSILS

Dairy tinware should be rinsed in cold or luke-warm water, then washed in hot water, containing a little washing soda or other suitable cleanser. A brush should be used on both the inside and outside of the utensils. They should be scalded with boiling water and placed where they will drain and dry.

Simple steam fertilizers have been made for sterilizing the dairy tinware on the farm. Another efficient means is claiming attention at the present time, is the use of chemical sterilizers. By carefully following the directions sent out with these materials they prove very effective. These do not take the place of cleanliness, as a solution is weakened and will prove useless when used on equipment that is not clean.

The churn should be scalded with boiling water, then cooled with cold water before putting in the cream. After using, the churn should be rinsed with a little hot water to remove the butter particles, and washed with hot water containing some soda. It should then be scalded with boiling water. When not in use the lid should be left off. To wash a churn occasionally with lime-water will help to keep it sweet.

The butter worker, ladles and printer should be scalded with hot water, scoured with salt, and cooled by holding in cold water until required. After using, these should be rinsed with hot water, washed in hot soda water and scalded with boiling water. The woodenware should be placed where it will dry, but it should not be put in the sun as this would cause it to warp and crack.

STEPS IN BUTTERMAKING

1. Have the cream at churning temperature.
2. Prepare the churn.
3. Strain the cream into the churn.
4. Add butter colouring if necessary.
5. When churning ripened cream, remove the churn plug 2 or 3 times during the first part of the churning.
6. Churn at the speed that will give the cream a good drop or fall.
7. Stop the churn when the butter granules are half the size of wheat and add a small amount of cold water.
8. Continue churning until the granules are wheat size, then draw off the buttermilk.
9. Rinse the butter before putting on the wash water.
10. Use plenty of water and keep the granules apart until salted.
11. Salt to suit the trade, usually one-half to three-quarters ounce per pound butter.
12. Work the butter until it is compact and not showing large drops of moisture.
13. Gauge the print to allow 16¼ ozs. to the package.
14. Keep the butter in a clean, cool place until used, or sold.

BULLETIN 372 JANUARY, 1933

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

Guelph, Ontario

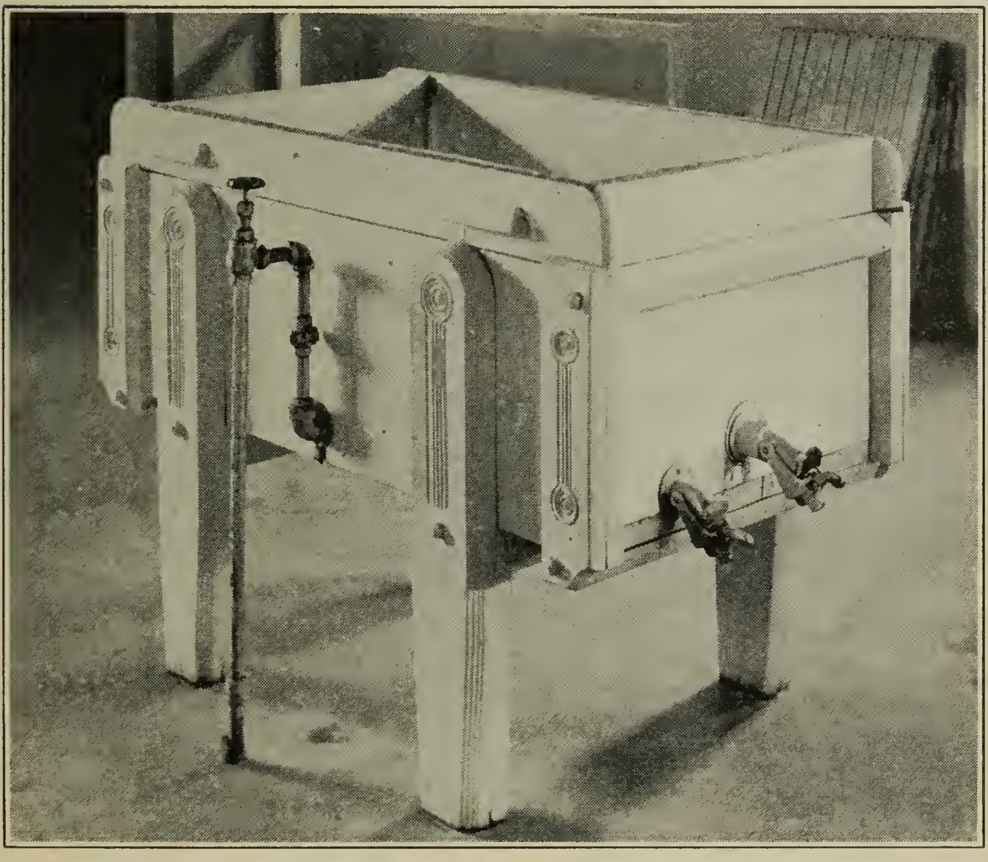
SOFT CHEESE MAKING

and

FARM DAIRY CHEDDAR CHEESE

By Bella Miller

DEPARTMENT OF DAIRY HUSBANDRY



Cheese Vat

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BULLETIN 372 JANUARY, 1933

Ontario Department of Agriculture
ONTARIO AGRICULTURAL COLLEGE

Soft Cheese Making

by BELLA MILLAR

Soft Cheese, such as Cottage Cheese, Cream Cheese, etc., are easily made in the home.

It is very necessary that the milk and cream used for this class of cheese be in the best condition and the flavour clean and sweet.

When making small amounts of soft cheese for home use, raw milk and cream are often used, but when making larger quantities it is much better to pasteurize the milk or cream. By pasteurization, the bacteria are largely destroyed, and then by adding a good culture the maker will have more control of the flavour, and the finished product will be more uniform from day to day.

Pasteurizing the Milk—To pasteurize milk for soft cheese making, it should be heated to 145°F., held for thirty minutes and then cooled to the required temperature. On the farm the milk is often heated on the stove, by placing the can of milk in a larger receptacle containing hot water. It should be gently stirred while heating and the thermometer watched until the desired temperature is attained.

COTTAGE CHEESE

Cottage Cheese is a variety of soft cheese that is made in many homes. It is often made in quite small amounts from milk that has become sour. When making it in larger amounts it is more profitable to make it from skimmilk adding cream to the drained curd at the time of salting.

Making Cottage Cheese on the Farm—After bringing the skimmilk to a temperature of 70°F., one-quarter of a teacupful of culture (see page 13) or good clean flavoured sour skimmilk should be added for each gallon of milk. The mixture should be thoroughly stirred and allowed to stand until the following morning when it should be nicely coagulated.

If the milk is in a can it should be stirred to break the curd and the can placed in warm water. During the process of heating the curd, the temperature of the surrounding water should be raised to 150°F. The curd should be stirred at intervals to maintain a uniform temperature and also to keep the curd free from lumps. When the curd is heated to about 100°F. or between 100° and 110°F., there will usually be a good separation of curd and whey. If a small amount of curd, worked between the thumb and fingers, does not appear milky the whey may be drained off. An overheated curd will be dry and grainy. Cotton bags are often used for draining the curd, but an easier method is to spread cheesecloth over a large strainer or draining rack and drain the curd on it. When the free whey has drained off, the curd may be washed by pouring some cold water over it. This is especially helpful if the curd has a high acid flavour. After washing, the curd should be well drained before applying the salt. As this cheese should be salted lightly, 1 ounce of salt will be sufficient for 5 pounds of cheese. When the salt is distributed the cream may be added using at least an ounce of rich cream for each pound of cheese. Both salt and cream may be varied to suit the tastes of the consumers.

If the cheese is to be sold it may be made into balls and wrapped in waxed paper or printed with a butter printer and wrapped in parchment paper. Small containers make neat, sanitary packages and while they add to the cost they also help to sell the cheese.

Cottage cheese should be cooled to a low temperature and held cold until it is used or sold.

COTTAGE CHEESEMAKING IN THE DAIRY PLANT

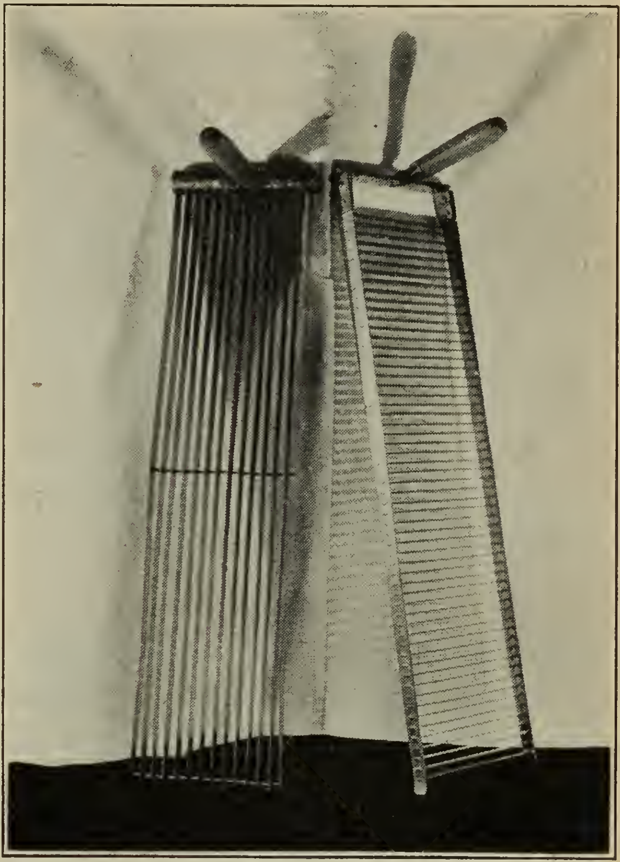
Cottage cheese is beginning to be better known in Ontario and its manufacture naturally works in with a town or city milk and cream trade and helps to prevent the wastage of surplus milk.

To make cottage cheese in a dairy plant a cheese vat and curd knives, the same as used in cheddar cheesemaking will be required. It is also necessary to have refrigeration for holding the finished product.

When pasteurizing the skimmilk for cottage cheese it should be heated to 145°F., held for thirty minutes, then cooled to the setting temperature. If the milk is pasteurized before it is required, it should be cooled to a low temperature and held until needed. The setting temperature and the percentage of culture vary, a higher temperature and a larger amount of culture being used if coagulation is required in from 4 to 6 hours. A plan commonly followed is to add 1% of culture to the milk and hold it over night at a temperature range of 70°—72°F. In many plants both culture and rennet are used, allowing 1 c.c. of rennet for each 1000 pounds of milk.

Cutting and Cooking the Curd—When the curd is ready for cutting it will be firm and the whey should contain about .55% acidity. The curd is cut into cubes 3/8 of an inch in size, or larger if there is a demand for the "popcorn" type of cottage cheese.

The horizontal knife is used first cutting lengthwise of the vat. The top of the knife is held against the end of the vat and lower end of the knife is brought through the curd making a circular cut until it rests against the end of the vat at the bottom. Holding the knife straight it is drawn through the curd to the other end of the vat. Without removing the knife it is turned in the curd and another strip is cut, repeating until all of the curd has been cut into layers. The knife is removed by reversing the method used for its insertion. The vertical knife is used next, cutting in strips across the vat first and then lengthwise, taking care to avoid overlapping.



Curd Knives

The temperature should be raised very slowly at first and the curd stirred gently as the cubes are very tender at this stage and easily broken. The curd may be heated or cooked by means of the hot water in the jacket of the vat, or it may be heated in that way with the addition of warm water added to the vat of curd. Two inches of water at 110°F. may be run into the vat and in an hour this may be repeated using water at 120°F. The time required for cooking the curd and the temperature to which it should be cooked will vary according to conditions. Some curds require 120°F. while others will need a temperature slightly higher or lower. Most curds will be in the vat 2 to 3 hours, but the makers must be guided by the condition of the curd. The curd may be tested by placing a small amount in cold water. If it is sufficiently cooked it will feel firm and solid and will be ready to have the whey drained off.

Washing the Curd—After removing the whey the curd may be washed with 2 or 3 applications of cold water. This checks the development of acid and lowers the temperature of the curd. When the curd is well drained it may be salted and creamed, or it may be placed in a cooler for 12 hours before adding the salt and cream.

Salting and Creaming—About 1 pound of salt to 100 pounds of curd will be sufficient to use, sprinkling one half over the curd and after stirring, adding the other half.

Cream is added to enrich the cheese and may be used either rich or thin—a larger amount being added when a cream low in fat is used. Some dairy plants aim to sell a cottage cheese containing a definite percentage of fat and add cream accordingly. For example, adding 25 pounds of 20% cream to 100 pounds of curd will give a finished product containing 4% fat. The amount of salt and cream may be varied to suit the requirements of the trade.

Packaging—Cottage cheese is put up in different ways but the single service container makes a neat attractive package and the name of the dairy or special trade mark may be printed thereon. As cottage cheese is one of the perishable foods it must be held at a low temperature and the customers must receive a product that is fresh and uniform. By the manufacturer, the retailer and the consumer each doing their part, the demand for a high grade of cheese will increase.

Many recipes have been printed to show the variety of ways in which cottage cheese may be used and manufacturers often make use of these when advertising their product.

CREAM CHEESE

When we use the name "Cream Cheese" we refer to a soft cheese made from cream. Sometimes the names applied to these cheeses indicate to the consumer some distinguishing point; such as, giving the name "Double Cream" to one made from a rich cream, while "Pimento Cream Cheese" means that chopped sweet red peppers have been mixed with it.

When making cream cheese for home use, the cream used may be rich or thin according to the tastes of the people. Like other soft cheeses it it better to make it in small quantities and make it frequently, rather than be overstocked and have some spoil.

Double Cream Cheese—For this rich cheese use cream testing about 22% fat. Bring it to a temperature of 70° to 80°F. using the lower temperature in warm weather. Add ½ to 1 c.c. of culture for each pound of cream. Colouring is not required. If a higher colour is wanted 1 c.c. or 20 drops of cheese colouring will be sufficient for 10 pounds of cream, stirring to get it well distributed. Rennet is added at the rate of 3½ c.c. or 1 small teaspoonful to 10 pounds of cream. It should be diluted with about 20 times its volume of cold water before mixing it with the cream.

In from 4 to 6 hours the cream will be coagulated and ready for ladling into cloths and hanging up to drain. Material such as duck or Indian head may be used cutting it into 25 inch squares and sewing a loop of tape on each corner to hang it up by.

The next morning the curd should be scraped from the cloth and this should be repeated once or twice during the day. When the curd is fairly firm it should be turned out on a muslin cloth and salted at the rate of 1 ounce of salt to 4 pounds of curd. By adding the salt in three parts it will be better distributed. The cloth should then be folded over the curd and placed between two boards with a small weight on top. When the curd has a firm pasty consistency, it is ready to mould. A tin mould 2 inches by 3½ inches and 1¼ inches deep may be used. The mould should be lined with grease-proof paper, the cheese pressed into it with a knife, the top levelled, the ends of the paper folded over and the cheese is then ready to slip out of the mould.

Gervais Cream Cheese—The cheese is made from cream testing about 10%fat. This may be obtained by adding 1 quart of cream testing 22 to 30% fat to 2 quarts of whole milk. By using 1 c.c. of rennet to 10 pounds of the thin cream the directions given for making Double Cream Cheese may be followed. The moulds for Gervais Cheese measure 2⅛ inches in diameter and 2½ inches high and may be made singly or in clusters of six.

CREAM CHEESEMAKING IN THE DAIRY PLANT

The cream used for making cheese in a dairy plant is usually homogenized. By so doing a very smooth product is made and the fat loss in the whey is lessened.

Loaf Cream Cheese—Cream testing 14 to 20 per cent fat is pasteurized to 145°F. and after holding for 30 minutes is homogenized at about 1000 pounds pressure. It is then cooled to 72°F. and culture and rennet added according to the pounds of skimmilk in the cream, using for each 1000 pounds 2½ lbs. of culture and 1 c.c. of rennet extract.

The curd will be ready in 12 to 14 hours and have an acidity of .35 to .50 per cent. It is slowly heated to 96° to 98°F. taking about an hour. When made in large amounts the cream is coagulated and the curd heated in a pasteurizer.

When the whey will separate from the curd on the coil, or by placing a small amount on a drainer cloth, it is ready for draining. It is placed on cotton clothes on draining racks allowing plenty of draining surface. In 2 or 3 hours the free whey will be drained off and the curd ready for cooling and pressing. By taking up three corners of a cloth containing curd and twisting the fourth one tightly around above the curd, a bag will be formed, which holds the curd. After placing the bags in the press they should be covered with chipped ice. Sometimes the temperature of the curd is lowered by placing it in a refrigerated room.

The curd may be salted before draining has been completed using 1 to 2 pounds of salt per 100 pounds of curd, some markets preferring the lighter salting.

When the curd is sufficiently drained it may be put up in five pound boxes. This cheese will cut in smooth slices. Very small packages may also be used containing a few ounces. This cheese is protected by a tinfoil covering as well as by the outer container.

Cream Cheese, A New Method—This method was developed by Dr. Dahlberg of the New York Agricultural Experiment Station at Geneva, and gives very satisfactory results.

Use sweet cream, testing 40 to 45 per cent fat. Add 5 per cent soluble dry skimmilk powder and either 1 per cent of high grade gelatine or .5 per cent of clean flavored powdered agar. Pasteurize at 145°F. for 30 minutes if gelatine is used or 180° F. for 10 minutes if agar is used. Cool to 110° F. and add .75 per cent salt and .5 to 1 per cent of good lactic starter. Strain and homogenize at 3500 to 4000 pounds pressure. Place the cream mixture in final container and cool by placing in refrigerator until cooled to 70°F. Hold at 70°F. for 10 to 15 hours or until a mild acid flavour has developed. Store at 32° to 40°F.

NEUFCHATEL CHEESE

Neufchatel Cheese may be made from whole milk, but a more creamy cheese will be the result if cream is added to the milk to raise the test to between 4 and 5 per cent. fat. The milk (pasteurized) is brought to 70° or 72°F. and culture added at the rate of 1 ounce to 10 pounds of milk. After mixing, the rennet is added. For 10 pounds of milk, 3 to 5 drops of rennet extract diluted with cold water is used. When well mixed it is covered and left until coagulated. As this takes 14 to 18 hours, it is usually set overnight and turned out on draining cloths the following morning. When the free whey has drained from the curd the draining cloth is raised at one side which causes the curd to roll towards the centre; the other side is then raised. By changing the position of the curd the drainage will be more rapid. When the curd becomes firmer the cloth may be folded over it and light pressure applied. The cheese while pressing may be covered with chipped ice. It is salted at the rate of 1 ounce to 4 pounds of cheese and thoroughly mixed. This, not only distributes the salt but assists in making a smooth cheese. This cheese may be used for making a fancy cheese by mixing with such flavourings as pimientos, nuts or olives.

FRESH CAMEMBERT CHEESE

Camembert Cheese is a French variety of cheese, ripened by mould. Two quarts of milk are required for each cheese.

A smaller cheese made by using a quart of milk and eaten fresh or unripened has been called by the Dairy Department, O.A.C., "Fresh Camembert Cheese" to distinguish it from the regular ripened cheese with its characteristic flavour, texture, etc.

Camembert cheese is a type of soft cheese where the curd is ladled into perforated tin moulds or hoops for draining. For the small sized cheese the mounds are 4 inches in diameter and four inches high. These are placed on boards and straw draining mats 13 or 14 inches long and 8 or 9 inches wide.

The moulds etc., are scalded and cooled before ladling the curd.

Process of Manufacture—The milk is brought to a temperature of 86°F. To each 10 pounds of milk is added 10 c.c. or about 1 tablespoonful of culture. After mixing the rennet is added at the rate of 1 c.c. to 10 pounds of milk. The rennet should be diluted with ten times the amount of cold water and then thoroughly distributed throughout the milk. The stirring should be continued for about 5 minutes followed by careful stirring of the surface for 2 minutes more to help prevent the cream coming to the top. The milk is then covered and left until coagulated, this will take about an hour. The curd may be tested for firmness by making a small cut with a knife and then drawing the knife slightly to one side. If sufficiently firm, the curd will remain rigid, but if too soft it will follow the knife. A small amount of curd should be ladled into each mould and this should be repeated every 15 or 20 minutes until all of the curd has been transferred and the moulds are full. The cheese are then turned by placing a board and mat on top and turning over. The cheese are allowed to drain until they are firm enough to turn by hand. After turning they are left about six hours longer when the moulds may be removed. After standing a few hours they are salted by rubbing the salt on the outside using ¼ oz. of salt for each small cheese. After salting the surface of the cheese will become moist and when this has dried, the cheese will be ready to use. If it is not going to be used right away it should be held in a cool place until required.

BUTTERMILK CHEESE

When making this cheese the buttermilk is heated to 130°—140°F., stirring just enough to ensure even heating. It is then allowed to stand undisturbed for an hour before placing it on a draining rack covered with cotton cloth. When sufficiently drained, salt is added at the rate of 1 ounce to 5 pounds of curd. Adding a small amount of cream at this time will give a richer cheese.

These directions are suitable for raw cream buttermilk, or for buttermilk from cream that was sweet when it was pasteurized and ripened afterwards. Buttermilk from cream that was sour when it was pasteurized has very fine curd particles, difficult to drain. The Wisconsin Agricultural Experiment Station worked out a method for treating buttermilk of this kind using a caustic soda solution to completely neutralize it and then adding a hydrochloric acid solution to acidulate it, after which the curd is heated, drained, etc., in the usual way.

CLUB CHEESE

This cheese is what might be called a Creamed Cheddar Cheese, and is made by grinding well-ripened Cheddar Cheese in a food chopper or other suitable machine. The rind is removed from the cheese which is then cut into pieces and put through the food chopper. Before putting it through the machine a second time 2 tablespoonfuls of butter are added for each pound of cheese. Afterwards cream, at the rate of ¼ cup to the pound of cheese, is added and the whole mixed thoroughly. If preferred, the cream may be omitted and the amount of butter increased.

FARM DAIRY CHEDDAR CHEESE

Cheddar Cheese is the staple cheese in Ontario. It is made in large quantities in our cheese factories, sold in all our grocery stores, and has much to commend it as an article of food.

A cheese of the Cheddar type is a suitable kind to make on the farm when a long-keeping cheese is desired.

Proper equipment for cheese making, lessens the labour, but cheese can be made in the home with the appliances on hand. It will be necessary to secure a few ounces of rennet extract and a strong cheese hoop or mould.

Milk, for cheese making should be produced under the best conditions in order that it may be as free as possible from undesirable bacteria and that the flavour may be clean, without taint of any kind.

Ten to twelve pounds of milk will be required to make a pound of cheese. The amount will vary according to the quality of the milk, the loss of milk solids in the whey and the moisture content of the finished cheese. (Although not exact, ten pounds may be considered as a gallon when making an estimate of the amount of milk to use).

The fresh morning's milk should be mixed with the cooled evening's milk in a cheese vat or some vessel suitable for holding milk. A clean wash boiler may be used.

Temperature for Setting—The milk should be heated to 86°F. by setting it on the stove or by placing a clean can of hot water into it. It should be stirred gently and the thermometer watched to avoid over-heating. A cheese vat is more convenient as it has a water jacket, making it easier to control the temperature.

Farm cheese is often made without the addition of culture or starter, but adding ½ to ¾ of a pound for each 100 pounds of milk will assist in checking undesirable fermentations and secure more uniform results.

Acidity or Ripeness of Milk—In every cheese factory there is an acidimeter for testing the milk for acidity. In the farm dairy, the acidity or ripeness of the milk may be determined by making what is called a rennet test. This is done by counting the number of seconds that are required for 1 dram of rennet to coagulate 8 ounces of milk. The milk is measured into a glass container and brought to 86°F. A small piece of match or straw is placed on the surface of the milk. The stirring of the milk should be commenced before pouring in the rennet and continued for 10 seconds after, then the stirrer is withdrawn. The exact time when the rennet was put in should be noted on the second hand of a watch or clock and again when the match or straw stops moving. When the milk has the required acidity, coagulation will take place in 20 to 24 seconds. Should it take longer than 24 seconds to coagulate there is not sufficient acidity developed and another test should be made in about 15 minutes.

Colouring Cheese—Cheese may be made without the addition of cheese colouring; but if a yellow cheese is wanted, one teaspoonful of colouring should be added for each one hundred pounds of milk. The colouring is put into a dipperful of milk and this well mixed with the milk in the vat before adding the rennet.

Adding the Rennet—One teaspoonful or 1 dram of rennet extract for each 25 pounds of milk will be required. The rennet is diluted with about ten times the amount of cold water and thoroughly mixed with the milk in the vat or boiler by stirring with a dipper or small rake for about three minutes. It should be covered to keep the surface of the milk from cooling and left undisturbed until coagulation takes place. This will usually take about twenty minutes, the time required depending upon the acidity of the milk.

Cutting the Curd—To know whether the curd is ready for cutting, the forefinger should be inserted into the curd (at an angle of 45°) until the thumb touches the surface of the curd. A slight cut is made in the curd with the thumb and the finger is then gently raised and at the same time moved forward a little. If the curd breaks clean over the finger it is ready for cutting. If there are soft flakes of curd on the finger it will be necessary to wait a few minutes longer for the curd to become firmer. The regular cheese curd knives are best for cutting the curd. The horizontal knife is used first cutting lengthwise of the vat. It is next cut with the perpendicular knife, cutting first crosswise and then lengthwise. Cutting in this way, the curd will be in small cubes, 3/8 of an inch to the side. When curd knives are not available a long-bladed knife such as a carving knife may be used. The curd is cut lengthwise and crosswise into strips about one third of an inch wide. The horizontal cutting comes last. As it will be difficult to cut the curd into uniform pieces, those that are too large may be cut smaller when the stirring is commenced.

Cooking the Curd—After cutting, the curd should be gently stirred with the hand or small wooden rake for about ten minutes before applying heat. It should be heated to 98°F. taking about 30 minutes to do so. When the curd is in a vat it may be heated by the water in the jacket of the vat. If using a boiler it will be necessary to place a clean can of hot water in it. This will be a means of raising the temperature until some whey has separated when the can may be removed and the remainder of the heating accomplished by heating some whey (free from curd particles) to about 130° and gradually adding it to the contents of the boiler. The stirring is continued until the curd is ready for dipping, which is usually 2¾ hours to 3 hours from the time the rennet was added.

When the curd is ready for the removal of the whey the cubes are about one half the original size and feel firm. When some of the cubes of curd are pressed in the hand and the pressure released, they should fall apart. What is called "the hot iron test" may be made at this stage. Some curd is gently squeezed in the hand, and when compact it is pressed against a smooth flat bar of iron which has been heated; the curd is then carefully withdrawn. It will leave fine hair-like threads on the iron the length of which will indicate the condition of the curd. At dipping these threads should be a quarter of an inch in length.

Dipping the Curd—The whey may be run off through the tap on the cheese vat using a strainer to prevent the loss of curd particles. With a boiler it is necessary to allow the curd to settle and the clear whey is dipped off. The curd and whey in the boiler is then poured on a large strainer covered with cheese cloth, or the cloth may be spread over the butter worker. When the free whey has run off the curd should be stirred over.

It is a good plan to have a small wooden rack made to fit the bottom of the boiler. The cloth containing the drained curd should be returned to the boiler to prevent rapid cooling. When a vat is used the curd, after stirring, should be piled evenly at one end of the vat and allowed to mat together. It should be covered with a heavy cotton cloth to hold the temperature.

In about 20 minutes the curd will be well matted and should be cut into blocks about 4 inches square and turned over. These blocks should be turned over every 20 minutes until the curd becomes flaky. If a piece of curd is taken in the hands and torn apart, it should tear like the meat on the breast of a chicken. A hot iron test should show threads 1 to 1¼ inches long.

Milling the Curd—On the farm a curd mill is not purchased unless cheese is made regularly. A knife may be substituted, cutting the blocks of curd into strips ½″ x 4″. The milled curd should be well stirred and covered again to keep it from cooling too much. In about fifteen minutes it may be stirred again and the salt applied using one ounce for each 25 pounds of milk used. The salt should be well mixed with the curd and when it is dissolved the curd is ready for the hoops and should be at a temperature of 80°F. to 84°F.

The cheese hoops should be made of heavy tin and have two handles. Hoops of varying sizes are used. A hoop 7 or 8 inches in diameter and 12 to 14 inches high makes a very suitable size for home use. It is necessary to have a wooden follower that fits closely around the sides of the hoops as loose followers allow the curd to squeeze out between the followers and hoops when pressing, thus causing "shoulders" on the cheese.

Before putting the curd into the hoop a piece of cotton should be placed in the bottom and the circular bandage placed inside the hoop, the end of the bandage is turned over on the curd and another piece of cotton is put over it. The wooden follower is then placed on top and the cheese is then ready for pressing. The pressure should be applied gradually.

A simple means of pressing a cheese on the farm is by the use of a scantling with a weight on the end. A piece of scantling 10 or 12 feet long is used for a lever. A small block of wood is nailed to the wall and one end of the scantling is held under it. The cheese hoop is placed on a strong box about three feet from the wall, the lever resting on a block of wood on the top of the follower. Pressure is applied by putting a weight on the lever such as some pieces of iron, a sack of sand or by hanging on it a pail of stones. By adding more weight or moving the weight outward, the pressure in increased.

When the cheese has been pressed for three-quarters of an hour it should be taken out and the wrinkles removed from the bandage. The bandage is wet with hot water, drawn up smoothly and neatly trimmed, allowing ½ inch to lap over the ends. Each end should be covered with a circle of stiffened cheesecloth over which should be placed a piece of cotton that has been dipped in hot water. The cheese are turned end for end when returned to the hoops for further pressing and are left under pressure until the following morning when they are again turned. In a few hours the cheese may be taken from the press and are ready for the final stage—the ripening of the cheese.

Ripening the Cheese—In our factories the cheese are ripened in rooms where both the temperature and humidity should be under control. When a cheese is made at home, it is usually held in a cool dry cellar. The cheese should be turned on the shelves, every day for the first month and occasionally afterwards.

The cheese should be ready for use in 6 or 8 weeks, but may be kept much longer.

Paraffining Cheese—When cheese have been on the shelves for 2 or 3 days it is a good plan to dip them in hot melted paraffine wax. This coating helps to prevent drying out and it also checks mould growth on the surface of the cheese. If a cheese is not paraffined an extra bandage should be put around it, removing it when the cheese is to be cut. By doing this it will present a better appearance. Should the cheesemaker intend to exhibit the cheese, the appearance is very important being one of the points considered by the judge.

The scale of points used for judging cheddar cheese is as follows:

Flavour	45
Texture	25
Closeness	15
Colour	10
Finish	5
TOTAL:	100

ONE POUND CHEDDAR CHEESE

The 1-lb. Cheddar Cheese are also called "Baby" Cheddar and "Tiny" Cheddar Cheese.

The moulds for these cheese are 3½ inches in diameter and 4½ inches high.

Eighteen ounces of curd are placed in each hoop and after pressing for at least half an hour they are taken from the press, a strip of bandage cotton dipped in warm water is put around the cheese also a piece on each end.

The cheese are returned to the press and left until the next morning.

The bandages are then removed and the cheese given a final pressing.

Should any of the cheese appear open in the morning they should be re-bandaged and pressed until close.

The following day the cheese are dipped in hot paraffine wax.

As it is desirable that these small cheese be ready for using within a month the cheesemaker should make a softer curd, use a little less salt and ripen the cheese at a temperature of about 60°F.

CARING FOR CHEESE IN THE HOME

Large cheese are cut by taking out wedge-shaped pieces and the cut surface should be protected to prevent drying and mould. It may be covered in one of the following ways: with butter, with a piece of cotton moistened with vinegar, with parchment paper sealed with a hot iron or by dipping in hot paraffine wax.

Small sized cheese are cut straight across varying the thickness of the slice to suit the demand. When cut in this manner the cheese may be inverted on a plate, and if necessary, a little hot paraffine may be run around the edge next to the plate. All kinds of cheese should be kept in a cool place.

Should a piece of cheese become hard and dry it may be grated and used as a flavouring for one of the many cheese dishes.

CULTURE OR STARTER FOR CHEESEMAKING

On the farm, the culture or starter is often made from milk soured naturally. The cow selected should be clean and healthy and milking but a short time. All utensils, etc., should be as clean as possible. A pint or quart of milk is put into a sterilized fruit jar and held at a temperature of 70° to 75° until coagulated, when it should appear solid, free from holes and without separation of whey. About an inch should be carefully removed from the top and the culture broken up either by stirring or by pouring from one dish to another. It should be of smooth consistency and have a pleasant acid flavour. A culture or starter of poor flavour should not be used at any time, as it will injure the finished product.

When cheese is made regularly it is better to get a culture from a bacteriological laboratory or dealer in dairy supplies. The directions sent with it should be carefully followed. When a new culture is secured it is well to propogate it two or three times before using it for cheese-making.

Skimmilk is usually used for culture making and should be pasteurized by heating to 185°F. and holding for 20 minutes. It should then be cooled to 70°F. and inoculated with the mother culture. When making culture from day to day about one ounce of culture to ten pounds of milk will usually give good results. When the culture has coagulated it should be cooled and held at a low temperature until required, care being taken not to break the coagulum. Many cheesemakers aim to have the culture ready for using when the milk arrives at the dairy, thus, dispensing with the cooling.

BULLETIN 373 FEBRUARY, 1933

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

Dairy Cattle

J. C. Steckley, Professor of Animal Husbandry, and G. E. Raithby, Associate Professor of Animal Husbandry.

THE DAIRY BARN AT THE ONTARIO AGRICULTURAL COLLEGE

Dairying is one of the largest industries in the province of Ontario. The revenue from butter, cheese, condensed milk and milk for city consumption totals many millions of dollars annually. The dairy industry may be conveniently divided into two distinct fields, that of milk production on the farm on the one hand, and dairy manufacture and distribution on the other. In the early days the manufacture of butter and cheese took place on the farm, but as cities and towns grew this end of dairying gradually developed into a distinct business, as it made it possible for men to specialize in the manufacturing end of the business. This was essential in developing a uniform product.

The dairy manufacture or distribution may be conveniently divided into four distinct fields. The fluid milk trade, while not wholly a manufacturing business, is beyond the producer of milk for most large towns and cities where pasteurization is necessary before milk can be distributed to the consumer. This is possibly one of the most important phases of the dairy industry, and usually commands a higher price than the milk used for other purposes. The manufacture of cheese is another phase of the dairy industry that is an important one in Ontario. There are a great many sections ideally situated for this business which, in other words, is Summer dairying. Most of the milk is produced on pasture and the cows are run over the winter without too much expense. The powdered or condensed milk factories have played an important part in certain sections of the province by providing a market for the milk from a great many farms. The other phase of the industry, namely, butter making, is not confined so much to the dairy districts, but is distributed throughout other parts of the province where mixed farming is generally practised.

It is the purpose of this bulletin to discuss the production end which includes breeding, feeding and management of dairy cows. There are probably two distinct types of farmers interested in dairying. One is the specialist who is dependent almost entirely on his cows for his income. The other man is just as interested in his cows, but has other live stock and crops on which he depends for part of his revenue.

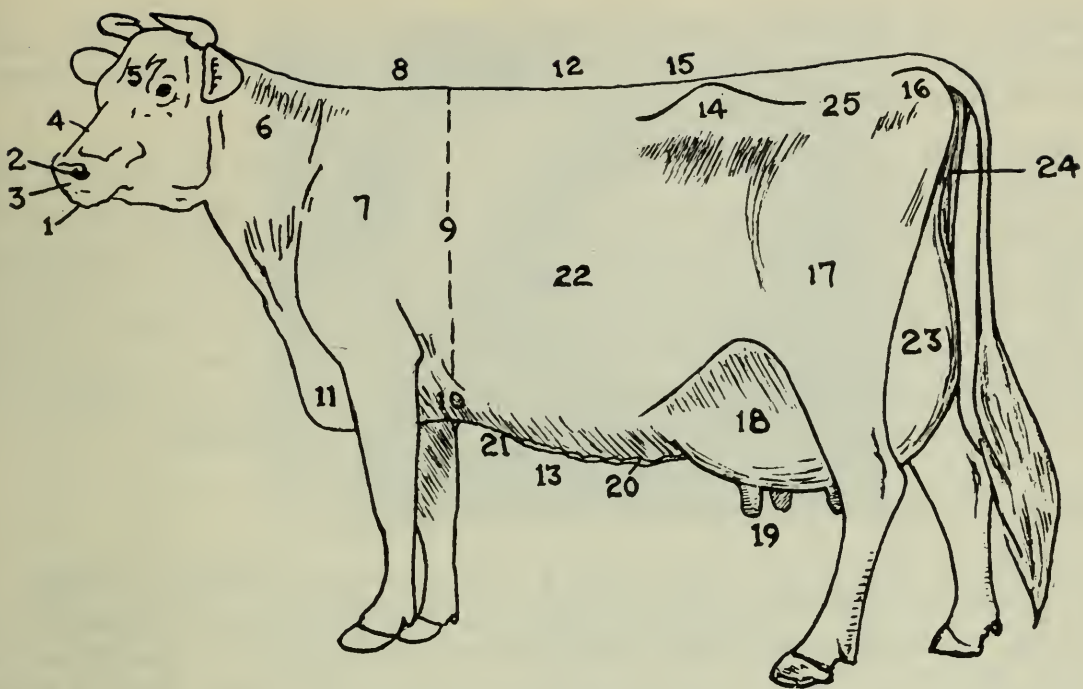
No matter which system is practised the same general principles apply. Good cows are necessary—cows that are capable of producing milk efficiently. This is not possible without systematic feeding. Systematic feeding cannot be practised without an efficient system of keeping records. Records are necessary before the farmer can breed good cows. Good cows only will respond to systematic feeding. These three items then, namely, good cows, systematic feeding, and an efficient system of records may be said to be the underlying principles of dairy production.

The successful dairy farmer should, therefore, be acquainted with dairy type. This is absolutely necessary in either buying or breeding dairy stock. He should understand breeding work. No other side of dairy farming is as interesting as trying to produce the champion cow in the ring, or in the test, or a combination of both. He must employ business methods as the dairy cattle business will not run on sentiment. The feed and milk should be weighed. The Babcock test should be applied and the non-producing cows discarded. He should know how to feed to get the most from the cows and still have an economical ration.

Dairy farming at the present time is a highly competitive business. Dairy products are rather low in price compared with other commodities and unless a man is willing to go slowly and be content with small profits, it is doubtful whether he should not go into some other line of farming. To the man who is interested in the business, who likes cows and is interested in feeding and constructive breeding work, there is probably no other line of farming that has greater possibilities.

DAIRY TYPE.

Type is defined as an ideal or standard of perfection combining all the characters which contribute to the animal's value and efficiency for the purpose specified. The specific purpose or place of dairy animals is the converting of coarse rough feed economically into milk. Dairy type provides the animal with the proper form and structure to enable it to do this work efficiently.



Points of a Dairy Cow

1. Mouth
2. Nostril.
3. Muzzle
4. Face
5. Forehead
6. Neck
7. Shoulder
8. Shoulder top or withers
9. Heart Girth
10. Chest
11. Breast
12. Topline
13. Underline
14. Hook bones
15. Loin
16. Pin bones
17. Thighs
18. Udder
19. Teats
20. Milk veins
21. Milk wells
22. Middle
23. Rear udder
24. Escutcheon
25. Thurl

The cow must be able to eat and digest an abundance of raw material; she must have the ability to thoroughly assimilate this raw material and convert it into blood constituents; she must have the necessary apparatus for secreting this material in the form of milk; and she must have the disposition to do so. Thus the cow must have:

1. A well-developed digestive system.
2. A strong constitution.
3. An active mammary system.
4. Marked dairy temperament.

Digestive System

A well-developed digestive system is indicated by a large barrel. This is obtained by length of body, width in the rear part of the barrel and depth throughout. A dairy cow must be long from the shoulders to the hips, wide across her top from hip point to hip point, and must be deep from the rear of the loin to the base of the abdomen. This width at the hooks should be carried well forward, giving a wide level loin throughout. The rear ribs should be well sprung, long, broad, flat and wide apart.

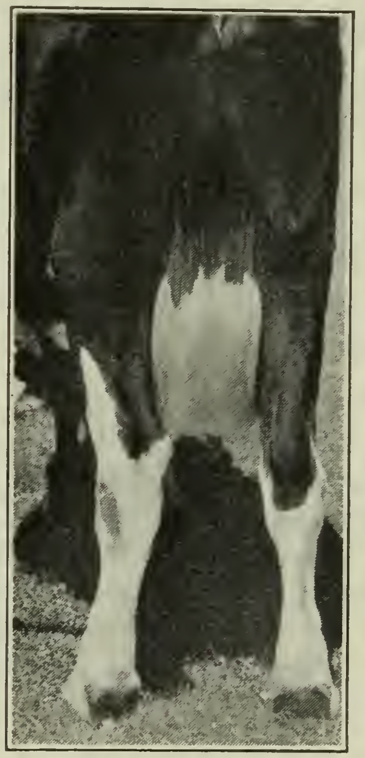
Constitution

A strong constitution is indicated by great chest capacity, which demands depth from the top to the bottom of the body just back of the forelegs, thickness through the body at this region, width on the floor of the chest and fullness in the fore-flank. The fore-ribs should be well sprung out and obtain their greatest width one-third to one-half way down the body, thus giving ample room for heart and lung development.

With width at the fore-rib, prominence or roughness of the shoulder should be avoided. The shoulder must lie smoothly into the body and the dorsal vertebrae should extend above the points of the shoulder blade. Any prominence of shoulder indicates too much flesh between the shoulder blade and the front rib, and this development of flesh is not desired. (With dry cows that are fat in preparation for their next lactation period, a breadth across the top of the shoulder develops naturally, consequently, an allowance must be made for dry cows.) A large nostril is another indication of lung development.

Mammary System

To secrete milk a cow must have a well-developed mammary system. The udder should be large and of good quality. It should be long between the rear and front attachments, extending high between the thighs. It should be broad and well filled in the rear and forequarters, with no noticeable division between the quarters. It should also be well balanced with each quarter the same size. The sole or bottom of the udder should be level and run well forward on the abdomen. In quality the udder should be soft, pliable and elastic. A coarse, firm, non-elastic udder is an indication of too much fibrous non-secreting tissue. The teats should be placed squarely in the centre of each quarter and should be large enough for comfortable hand-milking. Very short teats are objectionable, and there is no advantage in undue length and size.



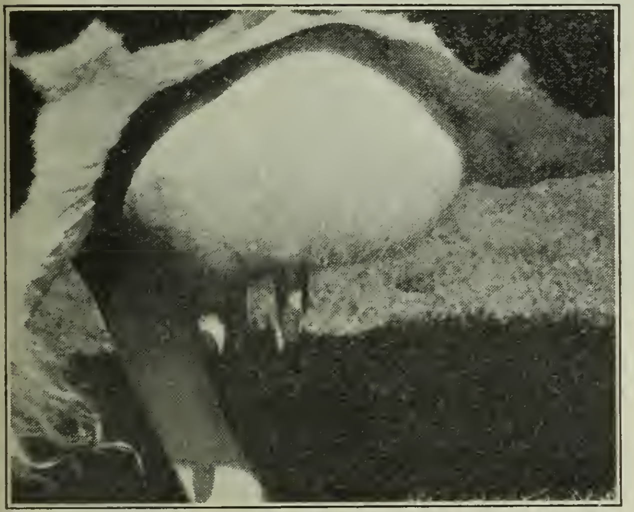
No. 3

Cut No. 3 shows an udder evenly balanced in the quarters and high and broad in the rear attachment.

No. 4

Cut No. 4 shows an udder unevenly balanced in the rear quarters and loose in the rear attachment.

No. 5
Cut No. 5 shows an udder that is pendulous, unevenly balanced, lacking development in the fore quarters and loosely attached to the body.



No. 6
Cut No. 6 shows a large capacious udder with the teats placed too closely together and a loose front attachment. Note the tortuous milk veins on the abdomen.

No. 7
Cut No. 7 shows a good quality udder unevenly balanced in the quarters.

The milk veins or the large abdominal veins running forward from the udder upon the lower surface of the abdomen carry the blood from the udder to the heart. These should be long, large, tortuous and branched and should enter the abdominal wall through large orifices called the milk wells. The size and development of these milk veins and milk wells are indications that a large flow of blood is passing through the udder and consequently there is opportunity for a large milk secretion.

Dairy Temperament

Dairy temperament is absolutely essential in a dairy cow. This is indicated in many ways, but especially by a natural leanness and angularity throughout. The head should be clean-cut and long from the eyes down to the muzzle. The forehead should be broad, the eyes prominent, full and placid, the neck long and lean. The spine should project above the shoulders at the withers and should show prominence and openness down the back. The dairy cow should show a freedom from meat and meat-carrying tendencies, indicated in a muscular loin, a thin thigh and an open twist. The rear ribs should be broad, flat and widely spread.

Quality

Quality is of utmost importance in a dairy cow. This is shown in a loose, mellow and fairly thin skin; a fine, soft, bright, oily covering of hair, and a smooth, fine, clean bone. The cow should also have trimness about the head, fine horns, freedom from coarseness about the shoulder or hooks, and a fine, slim tail. A coarse cow, lacking in quality, is almost certain to give small returns for the feed consumed.

General Appearance

The general appearance of the dairy cow also plays an important part in her make-up. All animals should have a straight, strong top line from head to tail. This adds to their appearance and helps in selling the individuals. Weak backs and drooping rumps are particularly objectionable. A cow with a weak back is less active and tires more readily and consequently is a less useful cow than one with a strong top line. A drooping rump is usually associated with an udder that lacks development in the fore-quarters. The rump should also be wide at the pins in order to give more width for attachment of udder behind. There is a direct correlation between shape and attachment of udder and the conformation of the rump of a cow. The length of attachment of udder is determined by the length of rump. A short rump indicates a short udder.

A dairy cow should be deep and fairly low set. The long legged cow is usually shallow in body and much harder to feed economically.

Further, a cow should show considerable style of carriage. She should carry her head erect and have an alert and graceful appearance. She should be well proportioned so that all parts are in harmony, and should stand squarely on her legs. Along with this active and alert carriage she should show no signs of viciousness and should not be easily alarmed.

In addition she should show considerable femininity. This term stands in opposition to that of masculinity as applied to males. Fineness in the face and in the contour of the head, lightness in the horn, fineness in the neck and lightness in the brisket and shoulder are all feminine characteristics. Femininity, besides being a guide to milk production in a cow, is a sign of a regular and reliable breeder.

THE BREEDS OF DAIRY CATTLE

The Holstein-Friesian

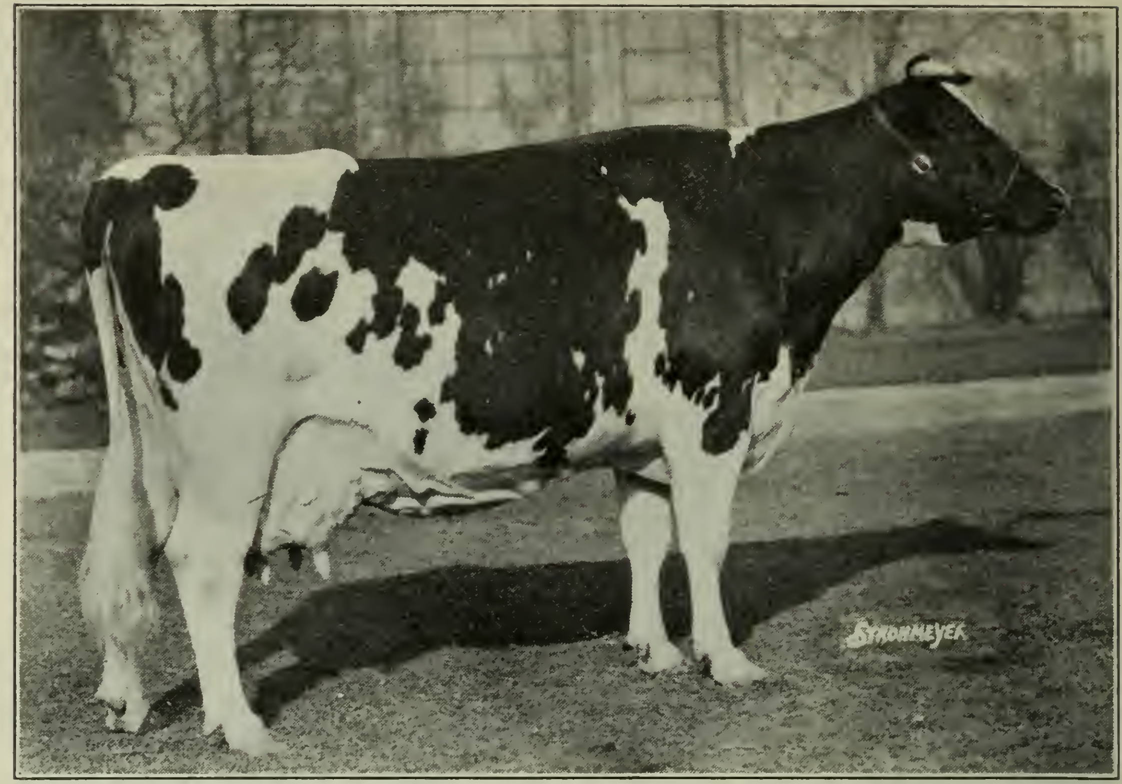
The native home of this breed is in the Province of Friesland in Holland, where they have been bred for centuries. Even back in the flourishing days of the Roman Empire, the district now known as Holland was noted for its black-and-white oxen and for its cheese. A race of cattle with many of the present characteristics of the Holstein-Friesian has doubtless remained pure for 2,000 years. These cattle have spread all over the world and have been used in the building up of many of our present-day breeds. They have been known by the names of "Holland," "Dutch-Friesian," "Dutch Holstein," "Netherland," and "Holstein-Friesian."

Sir Sylvius Posch Fayne—72598
Holstein-Friesian Herd Sire at the Ontario Agricultural College.

A little more than a half-century ago large black-and-white cattle were brought to America under two names, "Dutch-Friesian" and "Holsteins," and were advertised as separate breeds and championed by different breed associations. These two breeds were essentially the same and the associations amalgamated in 1885 and the name Holstein-Friesian was adopted in America.

In all, 7,757 animals were brought into the United States between 1852 and 1905. Since this date no cattle of the breed have been brought in from Europe on account of the danger of introducing infection of foot-and-mouth disease. From this 7,757 head imported into the United States, the breed has developed in North America. The foundation for the Holstein breed in Canada has come entirely from the United States. The breed, on this Continent, is a little more inclined to be of extreme dairy type than it is in other countries, due, no doubt, to isolation from outside blood and the extensive systems of testing adopted by the breed associations in Canada and the United States.

The colour of the Holstein is black-and-white, with no tendency for the colour to blend. Only rarely is a red-and-white calf dropped from pure-bred parents, and it is not eligible for registration. The Holstein is the largest of the dairy breeds, mature cows weighing from 1,100 to 1,600 pounds and occasionally as high as 1,900 pounds. A mature bull should weigh from 1,800 up to 2,500 pounds.



TRIUNE PAPOOSE PIEBE—184725

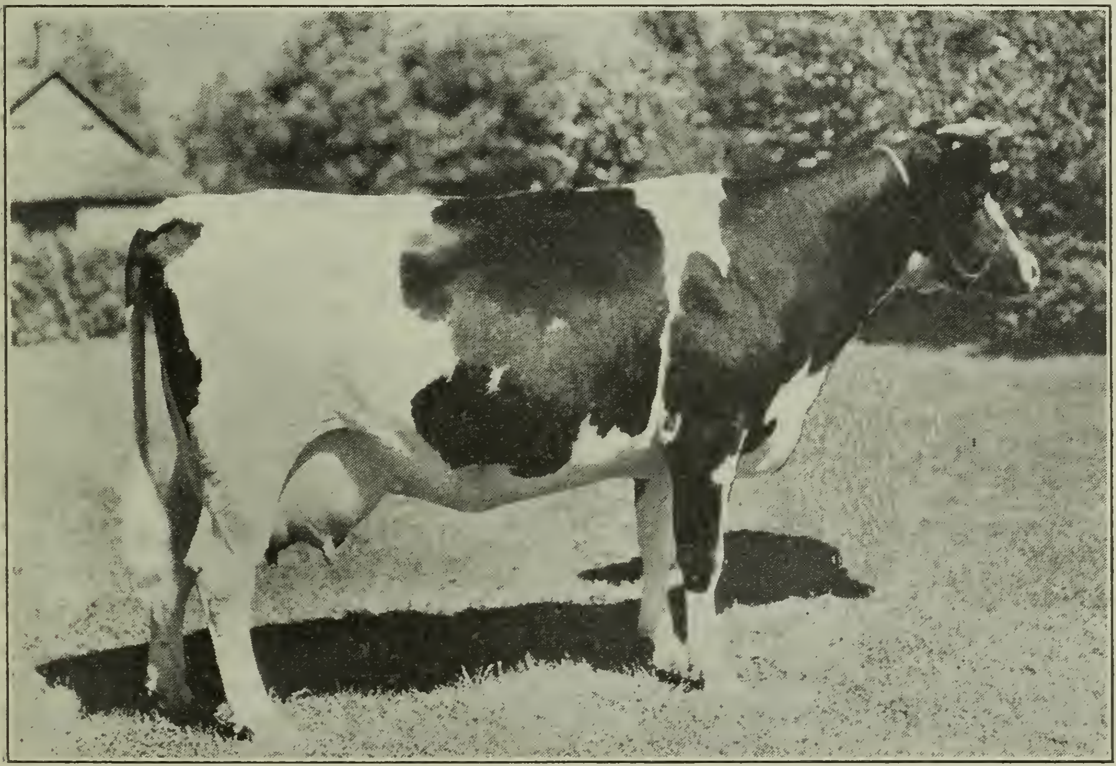
All American winner as a senior calf, a senior yearling, a two-year-old, a three-year-old, a four-year-old and as an aged cow. Mature record of 21,909.0 lbs. milk containing 1,121.25 lbs. butter, giving her an average butterfat test of 4.09%. A combination of type and production.

The Holstein-Freisian is famous for milk production but has been criticized for the low percentage of butterfat. As a breed this is probably true, but the best breeders have been guarding against this and have been successful in building up strains which are exceptionally satisfactory in this respect. Production has been the chief consideration in the developing of Holsteins in America, but unfortunately there was a tendency on the part of a number of early breeders to sacrifice type. In 1922, however, a determined effort was made by the Holstein breeders to improve and standardize the type and still retain the production characteristics of the early cattle. The results of these efforts are large roomy animals with quality, dairy temperament, constitution and capacity, swinging large, capacious, well balanced udders.

As a producer of large amounts of milk, the Holstein-Friesian leads all other breeds. Practically all the world's records, both butter and milk are held by this breed. In Canada there have been thirty cows produce more than 1,000 pounds of butterfat in a year, and thirteen that have produced over 30,000 pounds of milk in a year. The present world's record cow for milk production is Segis Pietertje Prospect, an American-bred cow, with 37,381.4 pounds of milk in a year, while the Canadian-bred cow, DeKol Plus Segis Dixie, holds the yearly butterfat record for the breed with an annual production of 1,349.31 pounds.

DeKol Plus Segis Dixie—295135

A Canadian cow holding the world's record for butterfat production. Strictly official record at nine years—33,464.7 pounds milk, and 1,349.31 pounds fat.



Toitilla Ruby Colantha—182027 (G.M.)

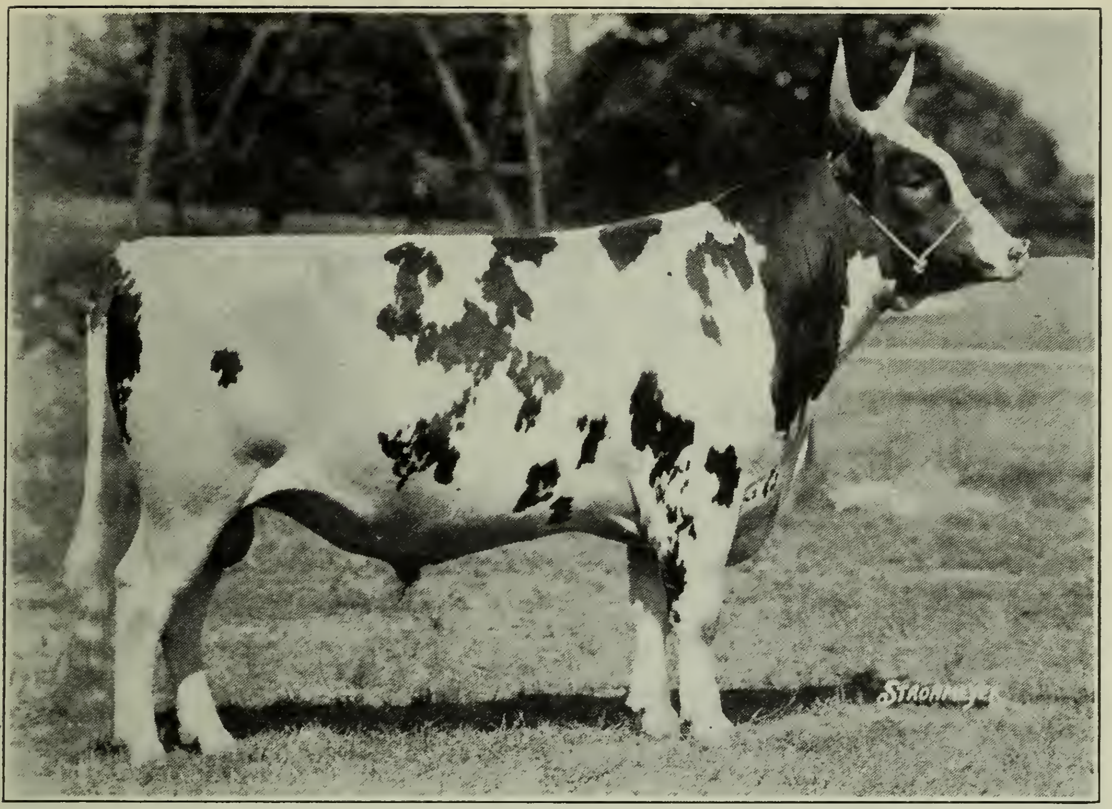
This cow shows good Holstein type as pictured when a three-year-old. She produced 13,897 pounds of milk and 519 pounds of fat (3.73%) as a two-year-old on twice-a-day milking. Bred, owned and developed by the Ontario Agricultural College.

SCALE OF POINTS FOR MATURE HOLSTEIN-FRIESIAN COW

	Score
Forehead—Broad between the eyes; dishing	2
Face—Of medium length; clean cut; feminine; the bridge of the nose straight	1
Muzzle—Broad, with strong lips; nostrils large and open; jaws strong	3
Ears—Of medium size; of fine texture; well carried	1
Eyes—Large; full; mild; bright	2
Horns—Small; tapering finely towards the tips; set moderately narrow at base; inclining forward; well curved inward	1
Neck—Long; fine and clean at junction with the head; evenly and smoothly joined to shoulders	3
Shoulders—Slightly lower than the hips; smooth and rounding over tops; moderately broad and full at sides	3
Crops—Full; level with the shoulders	5
Chine—Straight; strong; broadly developed, with open vertebrae	4
Loin and Hips—Broad; level or nearly level between the hipbones; level and strong laterally; spreading from chine broadly and nearly level; hipbones fairly prominent	6
Rump—Long; broad with roomy pelvis; nearly level laterally; full above the thurls; carried out straight to tail head	6
Pinbones—Wide between; nearly level with hips	2
Thurls—High; broad through	2
Tail Head and Tail—Strong at base without coarseness; the setting well back; tail long, tapering finely to a full switch	2
Chest—Deep; wide; well filled and smooth in the brisket; broad between the forearms; full in the foreflanks	6
Barrel—Long; deep; well rounded; strongly and trimly held up	9
Flanks—Deep; full	2
Thighs—Wide; deep; straight behind; wide and moderately full at the outsides; twist well cut out and filled with development of udder; with escutcheon well defined	2
Mammary Veins—Large; tortuous; entering large orifices or double extension; with additional developments, such as branches and connections entering numerous orifices	8
Udder—Capacious; flexible; quarters even and of uniform texture; filling the space in the rear below the twist; extending well forward; broad and well attached	14
Teats—Well forward; plumb; of convenient size; properly placed	4
Legs—Medium length; clean; nearly straight; wide apart; firmly and squarely set under the body; arms wide, strong and tapering	4
Hair and Hide—Hair healthful in appearance; fine and soft; hide of medium thickness; mellow and loose	8
Total	100

The Ayrshire

In comparison with other breeds of dairy cattle the Ayrshire may be said to be the youngest breed. The breed takes its name from the County of Ayr in southwest Scotland, where it had its origin. In 1750 the cattle in this region were described as undersized, ill-fed, irregular, and poor producers. These cattle were improved largely by crossing with the better-developed breeds. Historians differ as to the breeds used in this regard, but it is evident that the blood of Teeswater cattle, later known as Shorthorns, was among the first used. This cross produced a rather beefy animal, and later cattle from Holland and the Channel Islands were introduced to improve the milking qualities. Some early writers also mention the introduction of West Highland, Hereford and Devon into some of the herds, but how much of this blood has been handed down in the animals that formed the Ayrshire is not known.



BURNSIDE LUCKY BOY—128230—
First prize 2-year-old Ayrshire bull at the Royal Winter Fair, 1931, and 1st prize 3-year-old, Royal Winter Fair, 1932. A son of Burnside Blossom Andrietta —74206—

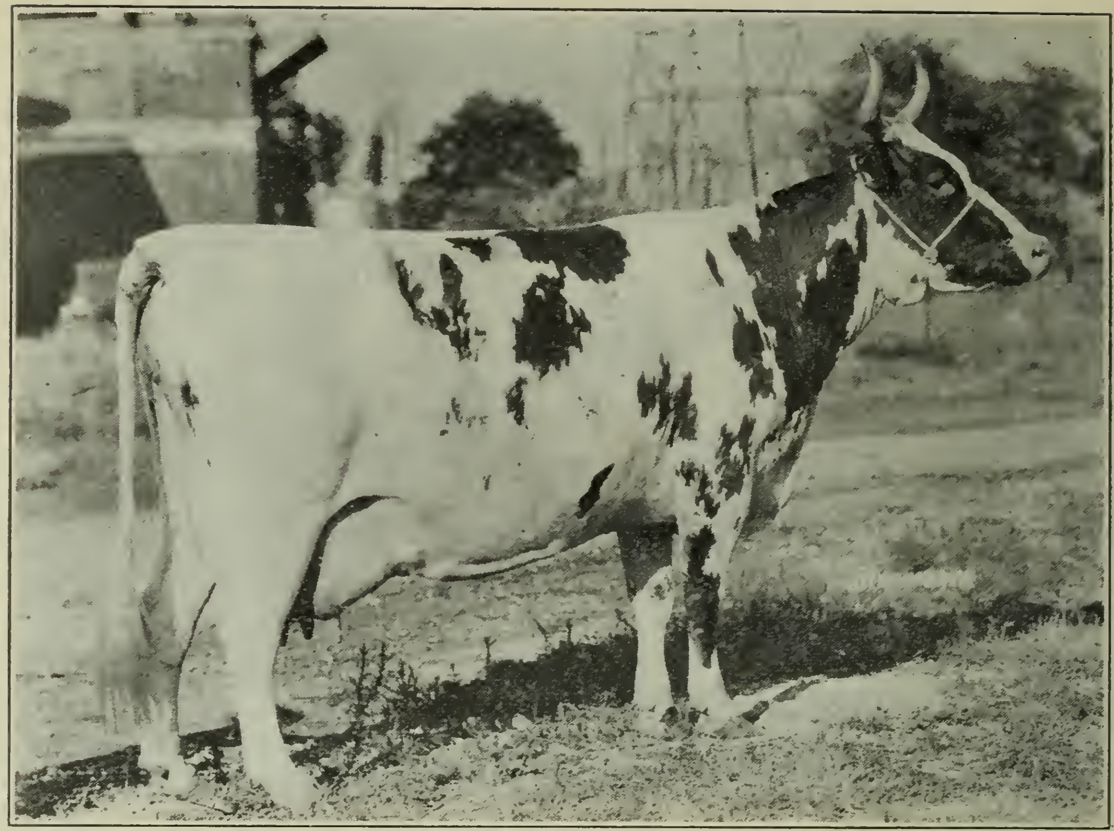
The County of Ayr is rather rough with a cool climate. There is a heavy rainfall which makes pasture abundant. Thus the Ayrshire was developed under adverse conditions of soil and climate where grazing ability was essential.

The Ayrshire ranks as a middle weight dairy breed. Mature cows weigh from 1,100 to 1,400 pounds, and bulls from 1,500 to 1,800 pounds. The colour of the Ayrshire is brown and white, the brown ranging from very light brown to almost black. The predominating colour at the present time is white with brown spots or patches. The colours are distinct and do not blend to form a roan.

For a number of years the plump form was maintained in an endeavour to retain the beefing qualities along with the dairy, but the present type is larger and more angular. The straight back, level rump, long rear-quarters and symmetrical udder are being retained in the modern Ayrshire. Short teats, a characteristic of the early Ayrshires, are being eliminated. A striking characteristic of the Ayrshire is the head. While rather short for dairy type, it is clean-cut with good width between the eyes and at the poll. The horn is rather large and usually curves outward and upward and in most cases slightly backward.

Cows of this breed are not noted for exceptional milk records, but, as a breed, are uniform producers of milk of good quality and, at the same time, produce very economically. As a breed, the Ayrshire will rank second to the Holstein in quantity of milk produced, and has a higher percentage of butterfat.

Early in the nineteenth century Ayrshires were brought to Canada, and later herds were established in the New England States. Large numbers have been brought over since that time and they are now fairly well distributed in Canada and the United States. In Canada, the Ayrshire stands second in numbers; in the United States, fourth. This breed is very popular in Eastern Ontario and Quebec.



Burnside Blossom Andrietta—74206—

A noted breeder and show ring winner. Note the type and the Ayrshire style.

Nellie Osborne of Elmshade 16th—71910—

World Champion milk and fat producer with a mature record of 27,198 pounds of milk and 1,257 pounds of fat, giving her an average test of 4.62% butterfat.

The three highest records for yearly butterfat production in the Ayrshire breed are held by Canadian cows. Pinecrest Violet has a record of 1,001 pounds; Betsy Wylie, 1,103 pounds; and Nellie Osborne of Elmshade 16th, 1,257 pounds of butterfat in one year. Nellie Osborne of Elmshade 16th also holds the butterfat record for the 305-day division of the R.O.P. as well as the world's milk record for Ayrshires with 27,198 pounds of milk in a year.

SCALE OF POINTS FOR AYRSHIRE COW

		Score
Head		9
Or individual parts of head may be scored as follows:		
Forehead—Reasonably broad between the eyes, and slightly dished	1	
Face—Of medium length, clean cut, feminine; the bridge of the nose straight to nostrils	1	
Muzzle—Broad and strong, with large open nostrils	2	
Jaws—Wide at the base, well muscled and strong	2	
Eyes—Moderately large, placid, full and bright	1	
Ears—Medium size, fine and carried alertly	1	
Horns—Small at base, not coarse nor too long; inclining upwards	1	
(An animal that has been cleanly and neatly dehorned, and whose head shows true Ayrshire character shall not be penalized.)		
Neck—Medium length, smoothly blending with shoulders and throat, showing feminine refinement		2
Shoulders—Long, sloping and tapering from the base to the top of the shoulder blades; neatly and firmly attached to the body wall. Tops of the blades not extending to the top of the chine		5
Chest—Full, and wide between and back of fore-arms. Brisket light and refined		6
Chine—Straight, strong, open jointed, narrow at the top, nicely blending into shoulders and a well sprung rib		3
Crops—Full, level with shoulders		3
Barrel—Medium length, deep, but strongly held up; rib, well sprung; bones long, flat and wide apart		10
Loin—Broad, strong and level with hips		4
Rump or Pelvic Area—Long, broad, level and roomy. Hips wide, level with back line; pin-bones wide apart and nearly level with hips; top line level from loin and to and including tail head. Thurls broad and set slightly below line from hip bones to pins. Hip bones, tail setting and pin bones well defined, and not overlaid with fat		12
Tail—Long and fine with full switch		1
Flank—Deep, slightly arched and refined		1
Thighs—Deep, straight and trim when viewed from the side. Flat and broad on side when viewed from the rear; twist well cut out for udder development, with escutcheon well defined		2
Legs and Feet—Widely and squarely set under body; clean flat bone; front legs straight; hind legs nearly straight when viewed from rear. Hocks and pasterns neatly and firmly molded. Feet round with plenty of depth at heels		8
Hide and Hair—Mellow, elastic hide of medium thickness. Hair fine and soft		4
Mammary System—Total value 30 points allotted as follows:		
Size and Shape of Udder—Broad, level, capacious, extending well forward and high behind, quarters even and of uniform size. Floor of udder should be reasonably level, and not deeply cut up between the quarters		10
Attachment of Udder—Attached well forward with a neat and firm junction at body wall; carried wide and high behind, no evidence of breaking of tissues supporting front quarters nor of dropping of floor of udder		6
Texture of Udder—Fine, soft and pliable, with light skin		4
Size, Shape and Placement of Teats—Convenient size, symmetrical and uniform, each hanging perpendicularly under the quarter. Funnel-shaped teats objectionable		5
Veining and Milk Wells—Mammary veins large, long, tortuous, branching, and entering large or numerous milk wells. Small veins clearly defined on udder		5
Perfect Anatomy Score		100
Actual Anatomy Score		

Supplementary Schedule for Breed Characteristics

In addition to the foreging scale of 100 points, the following schedule of 20 points has been made to cover certain distinguishing breed characteristics which cannot be covered in the Anatomy Score Card proper.

Score the following breed characteristics, and deduct from the foregoing actual score the total number of points in which the animal is deficient.

	Score
Style and Quality—Alert but docile; having an impressive carriage, graceful walk, and, above all, displaying evidence of feminine refinement and outstanding dairy character	7
Symmetry and Balance—A symmetrical balancing of all the parts and the proper proportioning of the various parts to each other	7
Size and Weight—Mature cows should weight from 1,100 to 1,400 pounds, depending on period of lactation	4
Colour—Red of any shade, mahogany, brown, or these with white, or white, each colour clearly defined. Distinctive red and white markings preferable. Markings of solid black or brindle strongly objectionable	2
Perfect Breed Character Score	20
Actual Breed Character Score	
Deduct from Anatomy Score Above	
Net Score	

In the case of animals, of any age, that present unmistakable evidence of over-fitting, to the point of impairing their future usefulness or preventing reasonable discernment of natural conformation, or which appear in such a poor condition as shall be injurious to their proper development—the judge shall deduct, from the total score, such points as he may consider their condition warrants.

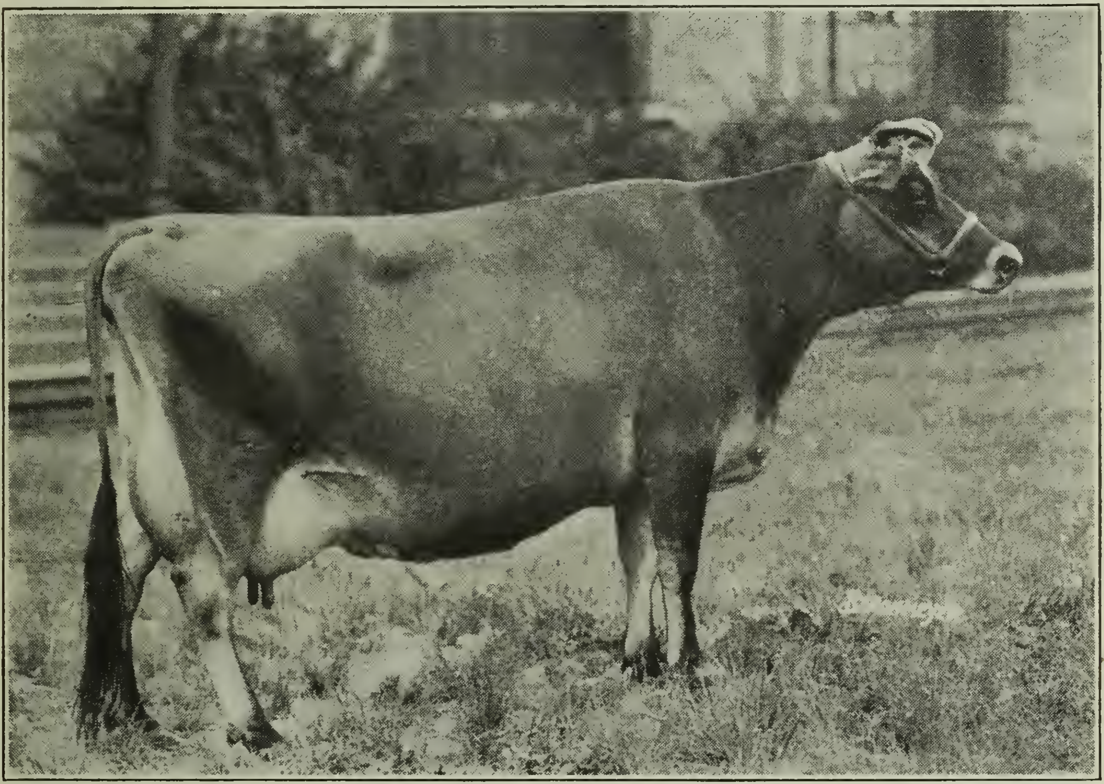
The Jersey

The native home of the Jersey is the Island of Jersey, which is the largest of the Channel Islands, situated off the north coast of France. These islands belong to Great Britain, but are populated by people of French origin. Jersey Island has an area of 31,000 square miles, of which 25,000 are tillable. While its population of 60,000 is engaged largely in truck-gardening, considerable attention is paid to the breeding of Jersey cattle. There are about 10,000 cows on the Island, or one for every two and a half acres of cultivated land.

Brampton Raleigh Volunteer—19166—
Jersey Herd Sire at the Ontario Agricultural College.

In 1763 a law was passed on the Island prohibiting the importation of cattle except for immediate slaughter. This law continues in force to-day even more rigidly than it was at the time of enactment. While this was done to safeguard the health of the cattle, it has proved to be of even greater value in preserving the purity of blood and permitting the development of one of the most noted breeds of cattle in the world.

Jersey cattle were brought to America at the beginning of the nineteenth century. At that time they were known as Alderney cattle. The first importation of importance was brought to Canada about 1870 and since that time numerous importations have been made.



Oxford Day Dream—46049—
Senior and Grand Champion female, Canadian National Exhibition, 1932.

The colour of the Jersey varies from a light silver grey to seal brown, almost black. Most of the Jerseys in this country are of varying shades of fawn. White markings are sometimes seen and are not objected to. The Jersey is one of the smallest of the dairy breeds, mature cows weighing from 900 to 1,100 pounds, while bulls range from 1,300 to 1,700 pounds. The Jersey matures at an early age and is often bred early. She is a more refined and a more highly specialized dairy cow than is found in any other breed. While not noted for giving large quantities, the milk is very rich in fat, averaging over five per cent. The fat globules are large, and the dairy products are rich in colour and of particularly firm texture.

In Canada the Jersey stands third in point of numbers, and is very popular as the family cow and for a specialized milk or cream trade. Four cows in Canada have given over 1,000 pounds of fat in a year—Eminent's Martha of St. Omer, Brampton Dark Kate, Beatrice of Newington, and Rosebay's Jolly Rose. The record Jersey cow of the world is an American-bred cow, Abigail of Hillside, with 1,197.51 pounds of butterfat in a year.

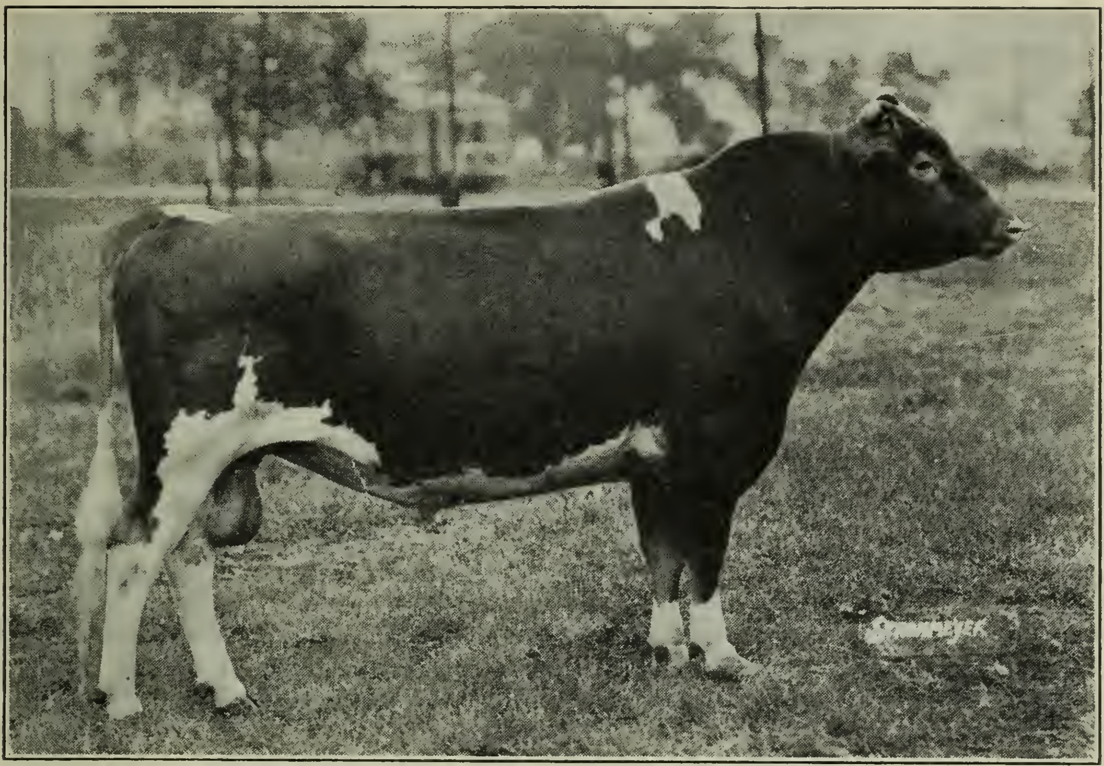
SCALE OF POINTS FOR JERSEY COW

	Score
Head, 7	
A—Medium Size, lean; face dished; broad between eyes; horns medium size, incurving	3
B—Eyes full and placid; ears medium size, fine, carried alert; muzzle broad, with wide open nostrils and muscular lips; jaws strong	4
Neck, 4	
Thin, rather long, with clean throat, neatly joined to head and shoulders	4
Body, 37	
A—Shoulders light, good distance through from point to point, but thin at withers; chest deep and full between and just back of fore-legs	5
B—Ribs amply sprung and wide apart, giving wedge shape, with deep, large abdomen, firmly held up, with strong muscular development	10
C—Back straight and strong, with prominent spinal processes; loins broad and strong	5
D—Rump long to tail-setting, and level from hip-bones to rump-bones	6
E—Hip-bones high and wide apart	3
F—Thighs flat and wide apart, giving ample room for udder	3
G—Legs proportionate to size and of fine quality, well apart, with good feet, and not to weave or cross in walking	2
H—Hide loose and mellow	2
I—Tail thin, long, with good switch, not coarse at setting on	1
Udder, 26	
A—Large size, flexible and not fleshy	6
B—Broad, level or spherical, not deeply cut between teats	4
C—Fore udder full and well rounded, running well forward of front teats	10
D—Rear udder well rounded, and well out and up behind	6
Teats, 8	
Of good uniform length and size, regularly and squarely placed	8
Milk Veins, 4	
Large, long, tortuous and elastic, entering large numerous orifices	4
Size, 4	
Mature cows, 900 to 1,100 pounds	4
General Appearance, 10	
A symmetrical balancing of all the parts, and a proportion of parts to each other, depending on size of animal, with the general appearance of a high-class animal, with capacity for food and productiveness at pail	10
Total Score	100

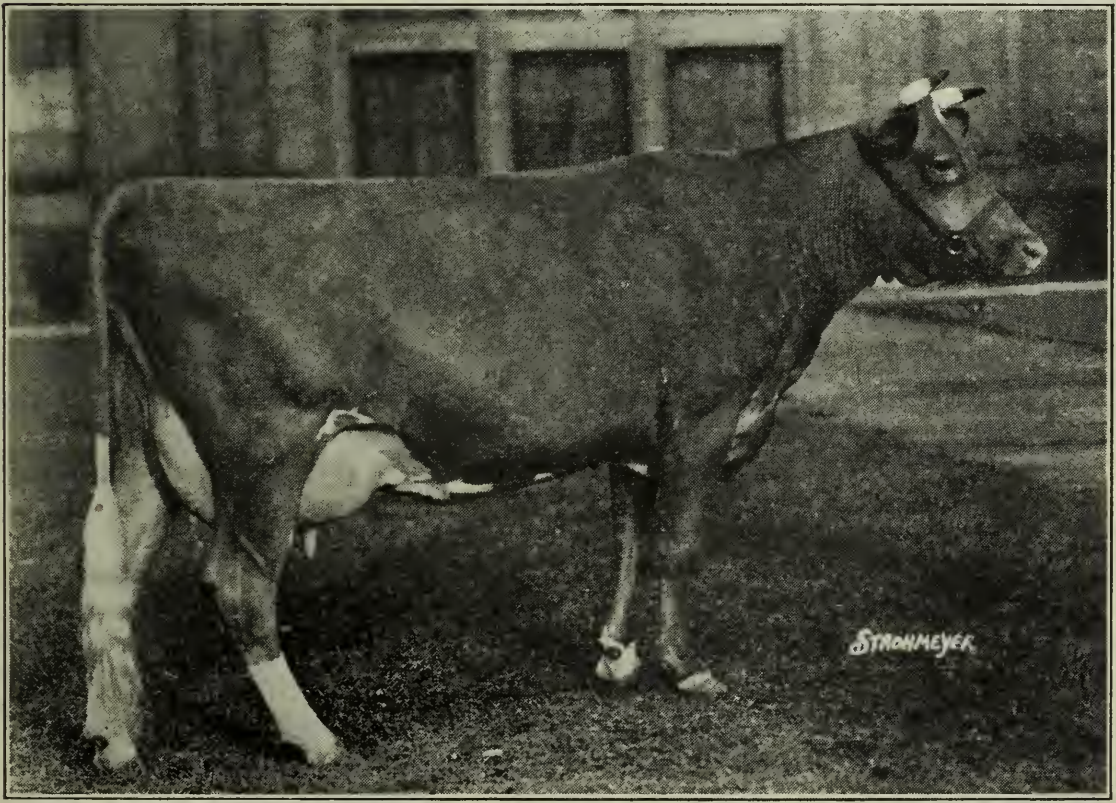
The Guernsey

The Guernsey, like the Jersey, originated on the Channel Islands, and takes its name from the second largest island of the group. In earlier history there seemed to be no distinction outside of the Channel Islands between the Jersey and the Guernsey breeds, as they were known as Alderney cattle, but for the past hundred years they have been known as separate and distinct breeds. Guernseys have become quite popular in the United States and are third in importance in respect to population. In Canada they are comparatively few in number, although during the past few years they have rapidly increased.

Guernseys are larger than Jerseys, cows weighing around 1,100 pounds, and the bulls around 1,600 pounds. In colour the Guernsey is orange yellow, which may be spotted with white. The muzzle is buff or flesh-coloured and is surrounded by light-coloured hair, as are also the eyes. The horns and hoofs are usually amber-coloured, though the horns may be nearly white. The colour of the skin is a rich yellow and is a point much emphasized by breeders as indicating a yellow colour in the product. The udder is large and is noted for its fine texture and qualities. The skin is very mellow, thin and elastic and covered with moderately fine hair.



Bonnie Brae Trojan—7370—
Grand Champion Guernsey bull at the Canadian National Exhibition, 1929, 1930, 1931, and 1932, and Royal Winter Fair, 1931 and 1932.



Martindale Faithful—6329—
Senior and Grand Champion Guernsey female, Royal Winter Fair, 1931.

Guernseys are noted for the quality of their milk. While it is not so rich in fat as that of the Jersey, they give a greater quantity of more highly coloured milk. The world's record for this breed is held by Anesthesia Faith of Hill Stead with 19,741 pounds of milk and 1,112.5 pounds of butterfat.

SCALE OF POINTS FOR GUERNSEY COW

	Score
Style and Symmetry—Attractive individuality revealing vigor, femininity and breed character; a harmonious blending and correlation of parts, an active well-balanced walk	5
Head—Moderately long, clean-cut, showing femininity and breed character; a lean face; wide mouth and broad muzzle with open nostrils; strong jaw; full bright eyes with gentle expression; forehead broad between the eyes and moderately dishing; bridge of nose straight	5
Horns—Yellow, small at base; medium length; inclining forward; not too spreading	1
Neck—Long and thin; clean throat, smoothly blending into shoulders	2
Withers—Chine rising above shoulder blades, with open vertebrae	2
Shoulders—Shoulder blades set smoothly against chine and chest wall, forming neat junction with the body	2
Chest—Wide, and deep at heart with least possible depression back of shoulders	4
Back—Appearing straight from withers to hips	5
Loin—Strong, broad, and nearly level laterally; width carried forward to junction with the ribs	3
Hips—Wide, approximately level with the back; free from excess tissue	2
Rump—Long, continuing with level of the back; approximately level between hip bones and pins. Pins well apart	4
Thurls—Wide apart and high	2
Barrel—Deep and long with well-sprung ribs. Individual ribs: Long, flat, wide apart, and free from excess tissue	10
Thighs—In-curving when viewed from side, thin and wide apart when viewed from rear; well cut up between the thighs	2
Legs—Flat flinty bone, tendons clearly defined; front legs straight; hind legs nearly upright from hock to pastern, set wide apart and nearly straight when viewed from behind. Pastern: Strong and springy	2
Skin—Loose and pliable, and not thick, with oily feeling; hair, fine and silky	3
Tail—Long, tapering with neat, strong, level attachment, neatly set between pin bones; fine bone and hair; nicely balanced switch	2
Udder—Uniformly fine in texture; free from meatiness; covered with pliable velvety skin	3
Veins prominent	1
Attachment to body: strong, long, and wide	4
Extending well forward; extending well up behind	4
Sole: level between teats	2
Teats: of even convenient size; cylindrical in shape; well apart and squarely placed, plumb	3
Mammary Veins—Long, tortuous, prominent and branching with large numerous wells	3
Secretions indicating Color of Product—Indicated by the pigment secretion of skin which should be a deep yellow inclining toward orange in color; especially discernable at the ear, at the end of bone of tail, around the eyes and nose, on the udder and teats, and at the base of horns; hoofs and horns amber colour	20
Colour Markings—A shade of fawn with white markings	2
Size—Mature cows; about 1,100 pounds in milking condition	2
Total Points	100

The Canadian

The Canadian can, more than any other breed, claim Canada as its home. Just when the first stock of this blood reached Canada is not definitely known, though it is thought to be around 1620. The stock unquestionably came from Northern France with the early settlers in the Province of Quebec. While there was no attempt made for many years to keep the blood pure, it remains essentially so on account of the limited intercourse of the early pioneers with the none too friendly English-speaking people.

While sharing the pioneer life of the people who owned them, they developed wonderful hardiness and retained a good measure of dairy qualities. They are rather small in size, being about the same size as the Jersey, the cows weighing 700 to 900 pounds, while the bulls weigh 1,200 pounds and up. They are somewhat coarser than the Jersey and do not show such refined dairy type. In colour they are ordinarily termed black, but in reality it is a brownish black. They give a moderate amount of milk, which is about the same quality as that of the Guernsey.

The Dutch Belted

Dutch Belted cattle are natives of Holland and are thought to have had the same origin in remote times as the Holstein-Friesian. They are invariably black in colour with a pure white band encircling the body in front of the hips. This belt varies in width from twelve inches to thirty inches and sometimes takes in the fore part of the udder. They are much smaller than the Holstein. The cows weigh from 900 to 1,200 pounds, while the bulls average about 1,500 pounds. There are very few representatives of this breed in Canada.

The Kerry

The Kerry is the smallest breed of dairy cattle. Mature cows do not weigh over 500 pounds. This breed is a native of Ireland, and is generally supposed to have descended from a small type of aboriginal cattle on that island, but nothing definite is known of its earlier history.

There are two types of the breed: the true Kerry, which is solid black in colour, and the Dexter Kerry, which is a blockier lower-set type, and may be black, red or roan. They are very good producers with records as high as 10,000 pounds of milk in a year. They are rather slow maturing but are good grazers and yield a fair flow of milk on very scanty rations.

DUAL-PURPOSE BREEDS

There are a number of breeds of cattle that are known as dual-purpose cattle; that is, they show a certain tendency toward beefing qualities as well as an indication of fair milk production. The breeds recognized as dual-purpose are the Red Polled, the Devon, and the Brown Swiss. Some strains of Shorthorns have been developed along dairy lines, and as most of them retain to a certain extent their beef qualities, they can rightly be called dual-purpose cattle.

The Shorthorn

The dual-purpose Shorthorn is the most popular breed of this type in Ontario. The development of the dairy Shorthorn took place largely in England and dates to the beginning of the nineteenth century. The most prominent breeder in this connection was Thomas Bates, who not only sought to improve the beef qualities of the breed, but the milking qualities as well. In Canada and the United States, considerable work has been done to improve the milking qualities of the breed. These cattle do not all trace to the Bates foundation, as a large number have been developed from the beef strains. Considerable variation is noticeable in these strains, some being very close to dairy type and showing little tendency to beef, while others adhere more closely to beef type and are not such good milkers. Up to the present time there does not appear to be a definite standard and considerable difficulty has been experienced in getting the strains to breed true. Shorthorn cattle with the combination, however, are very popular in many districts where dairying as well as beef-raising is carried on. It seems quite possible to get a fair combination of both milk and beef in this breed when hand-milking is practised and dairy characters are not overlooked in the selection of a sire.

The Devon

The Devon breed of cattle originated in the Counties of Devon and Somerset in England. It is one of the oldest breeds in England. The cows weigh from 1,300 to 1,500 pounds, while the bulls range from 1,500 to 2,000 pounds. They are bright red in colour, white only being permissible on the udder or underline, back of the navel. Very few of these cattle are to be found in Canada or the United States.

The Brown Swiss

The Brown Swiss is one of the oldest breeds of cattle known. They had their origin in the valleys and on the mountain sides of Switzerland, and is by far the best known breed of that country.

The Brown Swiss is fairly large, the cows weighing from 1,200 to 1,400 pounds, while the bulls frequently weigh a ton. They are rather heavy of bone and a trifle coarse in make-up. In colour they vary from a silvery grey to almost black and usually have a light-coloured strip down the back. They are very hardy and fairly prolific and are considered fair producers of milk. They are fairly well distributed through parts of Europe and are becoming popular in some parts of the United States, but are not found to any extent in Canada.

The Red Polled

The Red Polled cattle are of ancient English origin, having been developed in the counties of Norfolk and Suffolk in eastern England. They are fairly large, early-maturing animals, the cows weighing from 1,100 to 1,500 pounds, while the bulls range from 1,700 to 2,000 pounds. The most popular colour is a solid deep red with an occasional white patch on the udder. As their name implies, the breed is without horns. Red Polled cattle are fairly good milkers and produce a good quality of beef as well. They are hardy and are quite popular in parts of England and Ireland. They have made some headway in the United States and Western Canada but are little known in Ontario.

FEEDS AND FEEDING FOR DAIRY CATTLE

Feed Requirements

In order to properly appreciate the feed requirements of the producing cow it is well to keep in mind the composition of cow's milk which is as follows: Water —87.2%; Mineral Matter—.7%; Protein—3.5%; Sugar—4.9%; Fat—3.7%. A good average cow should produce at least 8,000 pounds of milk in a year and in so doing would yield 272 pounds of protein, 296 pounds of fat, 392 pounds of milk sugar and 56 pounds of mineral matter. The carcass of a two-year-old steer finished for market and weighing 1,200 pounds would contain 192 pounds of protein, 44.4 pounds of mineral matter and 387.6 pounds of fat. Thus the cow yields more protein and mineral matter each year than has been built up in the body of the steer during his entire life. Further, the pregnant cow is storing considerable protein and mineral matter in developing the unborn calf. To yield large quantities of milk the cow requires large quantities of feed, particularly those rich in protein and mineral matter. About half of a liberal ration fed a cow is used up in body maintenance (digestion, respiration and circulation) while the remaining half is used for milk production. If insufficient rations are fed the milk supply will go down, which may in many cases be responsible for farmers not getting a good yield of milk from their cows.

Feeds are divided into various nutrients, a nutrient being defined as any feed substance or substances of similar chemical composition that aid in maintaining animal life. The main groups of nutrients are the proteins, the carbohydrates and fats, the minerals or ash materials, and the vitamins. Proteins are complex substances found in feeds which promote growth, develop muscle, hoof, horn and hair, and are vital to milk production. The carbohydrates and fats constitute the energy and heat forming substances in the feeds. After being assimilated they maintain body temperature, provide energy to do work, and when given in excess are stored in the body as reserve sources of energy in the form of fat. Fats produce two and a quarter times as much heat and energy as carbohydrates. Mineral substances are necessary to build the skeleton of the animal and supply the large amount of ash found in the milk. Vitamins are necessary in the rations for all classes of stock. Fortunately for the dairy man they are very wide spread in the ordinary feeds, and as far as is known in well balanced rations, the various kinds and amounts of vitamins required by the animals are always present.

The term Nutritive Ratio is frequently used in discussing feeding problems. The nutritive ratio of a feed or a ration is the ratio of the digestible crude protein to the digestible carbohydrates plus the digestible fat when the fat is multiplied by 2¼. Stated as a formula it is:

$$\frac{\text{Digestible Carbohydrates} + \text{Digestible Fat} \times 2\tfrac{1}{4}}{\text{Digestible Crude Protein}} = 1:$$

Feeds with a narrow nutritive ratio are feeds rich in protein. Such products as alfalfa or clover hay, peas, wheat bran, oilcake meal and cottonseed meal would fall in this class. Feeds with a wide nutritive ratio are rich in carbohydrates or fats or both. Illustrations of products in this class are found in corn silage, oats, barley, wheat, corn and hominy feed.

The following Table will show the Digestible Nutrients found in common feeds with the Nutritive Ratio for the same:

TABLE NO. 1

DIGESTIBLE NUTRIENTS IN 100 POUNDS OF FEEDING STUFFS

From "Feeds & Feeding" by Henry and Morrison

NAME OF FEED	Total Dry Matter	Digestible Crude Protein	Digestible Carbohydrates	Digestible Fat	Total Digestible Nutrients	Nutritive Ratio
Home Grown Grains—						
Barley	90.7	9.0	66.8	1.6	79.4	1: 7.8
Buckwheat	87.9	8.1	49.7	2.5	63.4	1: 6.8
Corn	89.5	7.5	67.8	4.6	85.7	1:10.4
Oats	90.8	9.7	52.1	3.8	70.4	1: 6.3
Peas	90.8	19.0	55.8	0.6	76.2	1: 3.0
Wheat	89.8	9.2	67.5	1.5	80.1	1: 7.7
Concentrate By-Products—						
Beet Pulp (Dry)	91.8	4.6	65.2	0.8	71.6	1:14.6
Buckwheat Middlings	88.0	24.6	38.3	6.1	76.6	1: 2.1
Cottonseed Meal (Choice)	92.5	37.0	21.8	8.6	78.2	1: 1.1
Dried Brewers' Grains	92.5	21.5	30.5	6.1	65.7	1: 2.1
Dried Distillers' Grains (corn)	93.4	22.4	40.4	11.6	88.9	1: 3.0
Gluten Feed	91.3	21.6	51.9	3.2	80.7	1: 2.7
Malt Sprouts	92.4	20.3	47.4	1.3	70.6	1: 2.5
Oilcake Meal—Old Process	90.9	30.2	32.6	6.7	77.9	1: 1.6
Oilcake Meal—New Process	90.4	31.7	37.9	2.8	75.9	1: 1.4
Wheat Bran	89.9	12.5	41.6	3.0	60.9	1: 3.9
Wheat Middlings (Shorts)	89.5	13.4	46.2	4.3	69.3	1: 4.2
Succulent and Green Feeds—						
Alfalfa (Green)	25.3	3.3	10.4	0.4	14.6	1: 3.4
Blue Grass, Kentucky (Green)	31.6	2.3	14.8	0.6	18.5	1: 7.0
Clover & Mixed Grasses, green	27.3	2.2	14.1	0.6	17.7	1: 7.0
Corn Fodder (Green)	21.9	1.0	12.8	0.4	14.7	1:13.7
Corn Stover (Green)	22.7	0.5	12.0	0.2	12.9	1:24.8
Corn Silage (Well Matured)	26.3	1.1	15.0	0.7	17.7	1:15.1
Corn Silage (Immature)	21.0	1.0	11.4	0.4	13.3	1:12.3
Mangels	9.4	0.8	6.4	0.1	7.4	1: 8.2
Millet (Green)	27.6	1.9	14.8	0.6	18.1	1: 8.5
Oat Fodder (Green)	26.1	2.3	11.8	0.8	15.9	1: 5.9
Red Clover (Green)	26.2	2.7	13.0	0.6	17.1	1: 5.3
Sorghum (Green)	24.9	0.7	14.8	0.7	17.1	1:23.4
Timothy (Green)	37.5	1.5	19.3	0.6	22.2	1:13.8
Turnips	9.5	1.0	6.0	0.2	7.4	1: 6.4
Wet Beet Pulp	9.3	0.5	6.5	0.2	7.4	1:13.8
Wet Brewers' Grains	24.1	4.6	8.7	1.5	16.7	1: 2.6
Dairy Products—						
Buttermilk	9.4	3.4	4.9	0.1	8.4	1: 1.5
Skimmilk	9.9	3.6	5.1	0.2	9.1	1: 1.5
Whole Milk	13.6	3.3	4.8	3.6	16.2	1: 3.9
Whey	6.6	0.8	4.7	0.3	6.2	1: 6.8
Hays and Straws—						
Alfalfa Hay	91.4	10.6	39.0	0.9	51.6	1: 3.9
Barley Straw	85.8	0.9	40.2	0.6	42.5	1:46.2
Common Millet Hay	85.7	5.0	46.0	1.8	55.0	1:10.0
Mixed Hay	89.9	4.7	39.9	1.3	47.5	1: 9.1
Oat Hay	88.0	4.5	38.1	1.7	46.4	1: 9.3
Oat Straw	88.5	1.0	42.6	0.9	45.6	1:44.6
Oat Chaff	91.8	2.2	34.3	1.2	39.2	1:16.8
Red Clover Hay	87.1	7.6	39.3	1.8	50.9	1: 5.7
Rye Straw	92.9	0.7	39.6	0.4	41.2	1:57.9
Timothy Hay	88.4	3.0	42.8	1.2	48.5	1:15.2
Wheat Straw	91.6	0.7	35.1	0.5	36.9	1:51.7

FEEDING STANDARDS FOR DAIRY CATTLE

"Feeding Standards are tables showing the amount of each class of nutrients which, it is believed, should be provided for best results in rations for farm animals of various ages and classes."—(Henry and Morrison.)

Many attempts have been made by scientific investigators to state numerically how much of each kind of feed should be given an animal of a certain weight producing a definite amount of product or doing work. This can never be stated absolutely in figures because animals vary greatly in their individual characteristics and requirements. Furthermore, feeding standards cannot take into consideration such important factors as palatability, succulence, variety or cost.

Feeding standards have a definite place in feeding, however, in that they provide a guide or basis on which to build rations for stock. Many feeders are following the rules laid down in feeding standards with great exactitude. On the other hand many successful feeders claim they know nothing about feeding standards, yet in studying the rations fed they come very close in many cases to the standards set down by scientific investigators. The art of feeding is as important as the science of feeding.

The feeding standard that is widely used in this country is known as the Morrison Standard. This is a simple standard, easy to calculate, and because of the wide range of figures, is particularly suited to a country with a great variety of feeds and a wide spread in the price of feeds and products. The Morrison Standard is stated in terms of Dry Matter, Digestible Crude Protein, and Total Digestible Nutrients. The Dry Matter is given in the standard in an attempt to control the bulk of the ration. This varies greatly with producing cows and depends upon the amount of milk produced. The digestible crude protein is that portion of the ration which contains nitrogen and is used, when assimilated, for the promotion of growth, and the production of milk, lean meat, hoof, horn and hair. The total digestible nutrients is the sum of the digestible crude protein, the digestible carbohydrates and the digestible fat in the feed after the fat has been multiplied by 2¼. This part of the feed is used for the production of heat and energy and the surplus stored as reserve energy in the form of body fat. The quantities of these various substances in common feeds will be found in Table No. 1.

TABLE NO. 2

MORRISON FEEDING STANDARDS FOR DAIRY COWS

	Digestible crude protein lbs.	Total digestible nutrients lbs.
For maintenance of 1000-lb. cow	0.700	7.925
To allowance for maintenance add:		
For each lb. of 2.5 per ct. milk	0.045-0.053	0.230-0.256
For each lb. of 3.0 per ct. milk	0.047-0.057	0.257-0.286
For each lb. of 3.5 per ct. milk	0.049-0.061	0.284-0.316
For each lb. of 4.0 per ct. milk	0.054-0.065	0.311-0.346
For each lb. of 4.5 per ct. milk	0.057-0.069	0.338-0.376
For each lb. of 5.0 per ct. milk	0.060-0.073	0.362-0.402
For each lb. of 5.5 per ct. milk	0.064-0.077	0.385-0.428
For each lb. of 6.0 per ct. milk	0.067-0.081	0.409-0.454
For each lb. of 6.5 per ct. milk	0.072-0.085	0.434-0.482
For each lb. of 7.0 per ct. milk	0.074-0.089	0.454-0.505

Notes on Standards for Dairy Cows: The amount of dry matter to be fed daily per 1,000 lbs. live weight to dairy cows may range from 15.0 lbs., or even less with dry cows, to 30.0 lbs. with cows yielding 2.0 lbs. of butterfat per head daily. Cows producing 1.0 lbs. of fat per head daily should receive about 21.0 to 25.0 lbs. of dry matter daily per 1,000 lbs. live weight. The nutritive ratio may readily be found by computation; for example, a 1,200-lb. cow yielding daily 30.0 lbs. of 3.5 per cent. milk will require for maintenance and production 2.31 to 2.67 lbs. digestible crude protein and 18.03 to 18.99 lbs. total digestible nutrients. The nutritive ratio should therefore not be wider than 1 :6.1 to 1 :7.2.

Feeding the higher amounts of protein recommended will usually increase the production slightly, but may not be economical if protein-rich feeds are higher in price than those rich in carbohydrates. Also, the production will be slightly larger if sufficient concentrates are fed to bring the amount of total digestible nutrients to the higher figures recommended. However, with feeds at high prices, it may be economical to feed no more concentrates than necessary to meet the lower figures for total digestible nutrients.

Illustrating the Working of a Feeding Standard: For purpose of illustration, a man owns a 1,200-lb. cow producing 30 pounds of 3.5% milk per day. He has on hand the following feeds: Alfalfa hay, corn silage, oats, barley, bran and oilcake.

TABLE NO. 3

NUTRIENTS IN THE FEEDS AVAILABLE

In 100 lbs.	Dry Matter	Digestible Crude Protein	Total digestible Nutrients
Alfalfa hay	91.4	10.6	51.6
Corn silage	26.3	1.1	17.7
Oats	90.8	9.7	70.4
Barley	90.7	9.0	79.4
Bran	89.9	12.5	60.9
Oilcake	90.9	30.2	77.9

Amounts of Nutrients required according to the Morrison Standard:

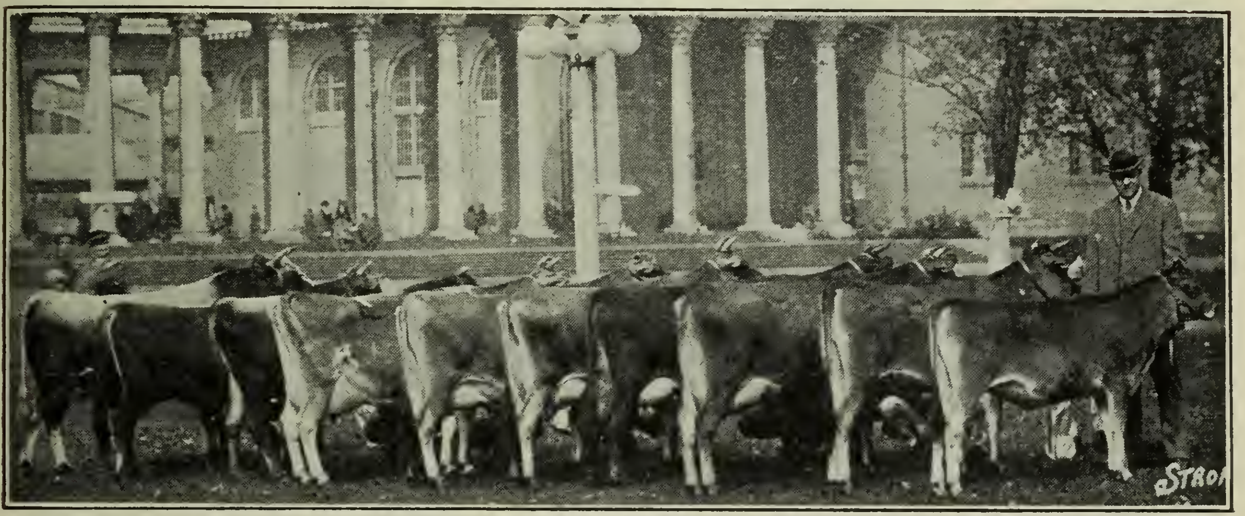
	Digestible Crude Protein	Total digestible nutrients
For maintenance of 1000-lb. cow	0.700 lbs.	7.925 lbs.
For maintenance of 1200-lb. cow		
1000 lbs.	0.700 lbs.	7.925 lbs.
200 lbs.	.14 lbs.	1.585 lbs.
1200 lbs.	0.840 lbs.	9.510 lbs.
For each pound of 3.5% milk add	0.049 to 0.061 lbs.	0.284 to 0.316 lbs.
For 30 pounds of 3.5% milk add	1.470 to 1.830 lbs.	8.520 to 9.480 lbs.
Amount required for maintenance	0.840 lbs.	9.510 lbs.
Amount required for milk production	1.470 to 1.830 lbs.	8.520 to 9.480 lbs.
Total	2.310 to 2.670 lbs.	18.030 to 18.990 lbs.

As a basis to use in building a trial ration the following simple rules will be followed:

For each 100 pounds live weight feed 3 to 3½ pounds of silage.

For each 100 pounds live weight feed ¾ to 1 pound of hay.

Feed grain at the rate of 1 pound of grain for each 3 to 5 pounds of milk produced.



ONTARIO JERSEY HERD
First prize Herd at the National Dairy Show, Syracuse, 1923.

FIRST TRIAL RATION FOR 1,200-lb. COW PRODUCING 30 POUNDS OF 3.5% MILK PER DAY.

Feed	Quantity	Lbs. Dry Matter	Lbs. Digestible Protein	Total lbs. Digestible Nutrients
Alfalfa Hay	10 lbs.	9.14	1.06	5.16
Corn Silage	40 lbs.	10.52	.44	7.08
Bran	2 lbs.	1.79	.25	1.22
Oats	3 lbs.	2.72	.29	2.11
Barley	3 lbs.	2.72	.27	2.38
Total		26.89	2.31	17.95
Standard		25 - 30	2.31 - 2.67	18.03 - 18.99

In comparing this trial ration with the recommendations of the standard the following facts are shown:

1. The dry matter is within the range recommended. This indicates that the bulk or the roughage feed in the ration is high enough and any further additions to the ration should be of a concentrate nature.
2. The digestible crude protein is up to the minimum figure of the standard. For high producing cows this probably should be increased.
3. The total digestible nutrients are only slightly lower than the standard and by adding a protein-rich feed to increase the protein this point will be rectified.

The first trial ration comes very close to the standard and would probably give good results when fed to cows with only fair ability to produce. For high records or exceptionally high yielding cows the protein content of the ration should be increased. For a second trial one pound of oilcake meal will be added to the ration.

SECOND TRIAL RATION

Feed	Quantity	Lbs. Dry Matter	Lbs. Digestible Protein	Total lbs. Digestible Nutrients
Alfalfa Hay	10 lbs.	9.14	1.06	5.16
Corn Silage	40 lbs.	10.52	.44	7.08
Bran	2 lbs.	1.79	.25	1.22
Oats	3 lbs.	2.72	.29	2.11
Barley	3 lbs.	2.72	.27	2.38
Oilcake	1 lb.	.91	.30	.78
Total		27.80	2.61	18.73
Standard		25 - 30	2.31 - 2.67	18.03 - 18.99

This ration meets the requirements of the standard in all respects. Hay is fed a little heavier than ¾ of a pound per hundredweight; silage at the rate of 3⅓ lbs. per hundredweight, and grain at the rate of 1 pound for 3⅓ pounds of milk. However, if concentrates were to be fed at the rate of 1 pound to 5 pounds of milk produced a higher protein content would be required in the mixture.

The nutritive ratio of the second trial ration is 1:6.2. It is obtained by subtracting the digestible protein from the total nutrients and dividing the product by the digestible protein. Stated as a formula it would be:

$$\frac{\text{Total Digestible Nutrients} - \text{Digestible Crude Protein}}{\text{Digestible Crude Protein}}$$

or

$$\frac{(18.73 - 2.61)}{2.61} = \frac{16.12}{2.61} = 6.2$$

There are important factors in feeding that are not taken into consideration in a feeding standard. Palatability in a ration is of prime importance and must always be given careful attention. Cows differ in their likes and dislikes and their individual tastes must be catered to. Variety of feeds in a ration is of very great importance, in fact is an absolute necessity, yet there is nothing in a feeding standard that calls for such. The mineral content of the ration is not mentioned in any standard, yet very serious results will follow the feeding of rations deficient in minerals, particularly calcium and phosphorus. Feeding standards are valuable guides in live stock feeding but must always be considered as such.

CHARACTERISTICS OF FEEDS

Oats.—The oat is the most extensively grown cereal crop in Ontario. In composition this grain varies greatly with seasons, varieties and types. The percentage of hull should not be too high as the feeding value of this is little better than straw. The oat grain is mid-way between the protein-rich feeds and the carbohydrate fattening feeds, being lower in protein than peas, oilcake and gluten feed, and higher in protein but lower in carbohydrates than barley, corn, wheat or rye. When ground, oats make a course bulky meal that is a safe feed for all classes of stock and quite palatable. To increase the bulk of a concentrate ration, rolled oats is one of the best feeds to use in making the mixture.

Oats form the basis for most of the concentrate mixtures fed to producing cows in Ontario. For best results they should be mixed with cottonseed, oilcake or gluten feed to increase the protein content, which in oats alone is rather too low for milking cows. For calf feeding good quality whole oats can be fed until the calf is six months old. Ground or rolled oats are more satisfactory for older calves and yearling heifers.

Barley.—Barley is essentially a fattening feed being much higher in digestible nutrients than oats and coming very close to corn in this respect. When ground, it forms a heavy meal that must be lightened up when fed to the producing cow. Barley may constitute one-third of the concentrate ration if it is mixed with oats, bran, or protein-rich bulky feeds. Because of its heating, constipating nature it should not be fed before freshening and not given after freshening until all inflammation, congestion and swelling have gone from the udder.

Wheat.—Wheat is a feed rich in carbohydrates and fat, low in protein, palatable and fairly uniform and constant in composition. In the ration it can be used in the same way as barley or may replace a portion of the oats or bran. When ground, wheat makes a heavy pasty meal which detracts from its value as a cattle feed, and to overcome this trouble many feeders are rolling the softer varieties of wheat. This makes a very bulky feed and certainly is much more suitable for cattle feeding than the finely ground product, but it is not advised for the very hard varieties of wheat.

A ration containing wheat that has given good results in the College herd is made up of: 2 parts rolled oats; 1 part ground barley; 1 part rolled wheat and ½ part each of oilcake and cottonseed meal. Wheat is also useful in feeding calves, heifers and dry cows.

Corn.—Although rather low in protein, corn is high in digestible nutrients. It is extremely palatable, is easily masticated and readily assimilated, but should not form more than half the ration of a dairy cow. It should always be ground and fed along with concentrates rich in protein and bulky in character. Because of the high percentage of easily digestible carbohydrates and fat, corn is a valuable supplement to skim-milk in calf feeding.

Field Peas.—While not grown extensively to-day, field peas are nevertheless a feed high in protein that can be grown on the farm. Many feeders are using small quantities of peas in mixed grains to improve the feeding value of the grain mixture. A short strong stemmed variety of peas such as the Golden Vine or O. A. C. 181 are best suited for mixtures. These varieties ripen early and uniformly and do not cause as severe lodging in the grain as the long stemmed varieties. From a gallon to a peck per acre can be sown in mixtures. Pea straw has a much higher feeding value than straw from the cereal grains.

Rye.—Rye is not much used for cattle feed in Ontario. It is not palatable and tends to produce a hard, dry butter. If available at low prices, it could be fed in small quantities mixed with other grains.

Buckwheat.—Buckwheat is sometimes used for dairy cattle in Ontario. It is a carbohydrate fattening feed and can be used to replace corn or barley in a ration. It should not be fed in large quantities as it is rather sticky in nature and lacks palatability.

Soybeans.—Soybeans as a concentrate are rich in protein, fat or oil and mineral matter. They can be ground and used in the ration to replace a portion of the oilcake, but they are not as palatable as oilcake and the change should be made gradually. Soybean hay is similar in composition to alfalfa hay and can be used to replace alfalfa in the ration.

By-Products—Concentrates

Bran.—Bran as a concentrate feed for dairy cattle is the best known and most widely used of all by-products. In addition to supplying in large quantities the two most important feed ingredients for dairy cattle, namely, protein and ash, it has a mild laxative action on the digestive system and hence may be used for animals that are sick and at calving time. It is bulky and palatable and is useful in mixing with heavier grains to lighten up the ration. Although comparatively high in price, bran will continue to hold an important place in the rations for dairy cattle.

Shorts or Middlings.—Although a little richer than bran in most of the nutrients, shorts are heavier and more sticky in texture, which detracts considerably from their value as a feed for dairy cattle. When obtainable at about the same price as bran they will yield good returns as part of the meal ration. Good shorts are fine and flour-like in texture and lighter-coloured than bran.

Dried Brewers' Grains.—This feed is the residue from barley after the removal of the soluble sugars and starch for the manufacture of malt liquors. It is rich in protein but has very little carbohydrates. According to experiments at the Ontario Agricultural College, dried brewers' grains are worth slightly more than bran, pound for pound, for milk production. On account of the high fibre content they should be mixed with other concentrates to get best results. They are quite palatable and, owing to their bulky nature, are valuable in lightening a heavy meal mixture.

They are sometimes sold in the wet condition, and as such can only be used in districts close to the breweries, as it is impossible to store them.

Cottonseed Meal.—Cottonseed meal is one of the richest of all dairy feeds in protein. Compared with other concentrates it is usually the cheapest source of protein and consequently is widely used to increase the protein content in the concentrate mixtures fed milking cows. Cottonseed meal is constipating in nature and should be fed only in small quantities and eliminated entirely from the ration at freshening time. For young stock it is not as satisfactory as bran or oilcake.

Gluten Feed.—Gluten feed contains about twice as much protein as bran and furnishes considerably more total digestible nutrients. It is quite palatable when fed in a suitable concentrate mixture. It is slightly higher in total nutrients than oilcake or cottonseed meal, but contains only about two-thirds as much digestible crude protein, and therefore when it is fed to increase the protein content of a feed mixture, more pounds are needed.

Oilcake Meal or Oil Cake.—The old process oilcake meal is one of the most valuable feeds for dairy cattle. Not only does this by-product of flaxseed contain a large quantity of crude protein, but it has a laxative and conditioning effect on the animal. It is a most valuable feed when no succulence is available or when hay from the grasses must be fed. It is highly palatable to cattle and is used extensively by feeders when fitting for show or sale. It is also used in feeding test cows and in the ration at freshening time. Frequently it is not as cheap a source of protein as cottonseed meal, but owing to its other beneficial qualities it is more generally used.

Soybean Oil Meal.—Soybean oil meal is the residue after the oil has been removed from the soybeans. This feed is rich in protein and mineral matter and very palatable. It can be used in dairy cattle rations in the same way as cottonseed or oilcake meal.

Hominy Feed.—Hominy feed is a by-product from the manufacture of hominy flour or grits from corn. It contains the corn bran and a portion of the kernel. In composition and feeding value it is somewhat similar to corn and can be used in the same way and for the same purpose. Hominy will keep indefinitely in storage.

Mixed Feeds.—Many manufactured mixed feeds are now on the market for dairy cattle. They are made up of a variety of concentrates to which minerals are often added. These feeds fall into two classes: (1) Complete rations which can be fed directly to the cattle, which usually run from 16% to 18% of protein. (2) Supplemental mixtures which can be mixed with a portion of home grown grains, and which contain from 24% to 34% of protein. These mixed feeds are sometimes more expensive than home made rations, but they insure a variety of grains in the mixture and a uniform ration throughout the feeding period.

Roughages

Alfalfa.—Alfalfa is one of the best of roughage feeds, and while it does not stand pasturing well, it makes splendid hay. It is richer in protein than red clover hay but contains less fat and carbohydrates. Alfalfa, if cut just when the new shoots are starting at the base of the old plants, yields the maximum amount of feed with a large percentage of leaf. By feeding good alfalfa hay, the dairyman is able to reduce his grain ration considerably. It makes an excellent feed for young and growing stock as well as for milk cows. It also makes a valuable feed for soiling purposes as it grows rapidly in the spring and comes up quickly after cutting.

Red Clover.—Red Clover is another good legume roughage for all classes of dairy stock when used as a hay, pasture or soiling crop. It does not yield as much per acre as alfalfa but works well into the crop rotation and stands pasturing better. To make the best quality hay it should be cut soon after it is in full bloom and cured to preserve as much leaf as possible. In feeding value it resembles alfalfa.

Alsike.—Alsike clover is about the same in composition as red clover but is not so generally grown for hay in this country. It is not as palatable and is not as well liked by dairy cattle. It does well on damp soil where red clover will not grow. If threshed, both alsike and red clover straw have slightly higher feeding value than the cereal straws.

Sweet Clover.—Sweet clover gives best results as a pasture crop, a silage crop and as a soil builder. When used for pasture it should be used early in the season to prevent the crop becoming coarse, bitter and unpalatable. It gives best results as pasture when used along with some other pasture crop. As a substitute for corn for ensiling purposes it is one of the most satisfactory crops. It yields a silage that is higher in protein than corn, but lacks the palatability of good quality corn silage. In feeding sweet clover silage to milk cows a smaller quantity will be required than when corn silage is used. It should be cut when the bloom is appearing and put in the silo as soon after cutting as possible. Care should be exercised to see that the silage is well tramped in the silo to prevent air pockets in which moulds will develop. In experiments at the Ontario Agricultural College sweet clover silage has given very satisfactory results as a feed for milk production. When cut for hay, sweet clover produces a coarse, woody product, is often difficult to cure, and is not held in high favour as a hay crop.

Pea and Oat Hay.—When clover kills out and a substitute is needed to provide the necessary hay for winter, a mixture of ½ to 1 bushel of peas and 2 to 3 bushels of oats per acre is about the best that can be grown. This hay is rich in protein, is quite palatable and yields well. It should be cut when the peas are in full bloom and the oats in the milk stage.

Timothy.—While timothy hay is the standard and most satisfactory roughage for horses, it is not so for dairy cattle. It is lower in protein than clover hay and is usually not as palatable. If it is to be used for dairy cattle it is best cut when quite young. Milk cows require more concentrates with timothy than they do with the legume hays. A mixture of red clover and timothy is often fed, and where the mixture contains considerable clover it is a very satisfactory feed.

Blue Grass.—This is very seldom used for hay but is one of the best pasture crops known. As a hay, it does not yield well, but makes an excellent feed if properly cured. It is inferior to good clover hay but is better than timothy for dairy cattle.

Orchard Grass.—Orchard grass is grown to a slight extent in Ontario. It is coarser, less palatable and, as a hay crop, is harder to cure than timothy. As a pasture crop it withstands the hot weather well and will do well in the shade, but is not relished greatly by stock. It is satisfactory to mix with grasses and clovers in a permanent pasture mixture.

Straw.—All classes of straws are high in fibre and consequently are of little value as a feed for dairy cows. When fed, more concentrates are necessary to properly balance the ration. For dry cows straw may be used as a part of the roughage. Taking everything into consideration, oat straw is about the best, barley straw coming next, with wheat and rye straw lower in feeding value. Buckwheat straw contains a little more protein but is so high in fibre that it is unsatisfactory as a feed. The straw from the legumes has a higher feeding value than that from the cereals.

Millet.—Millet is grown chiefly as a catch crop and is usually fed as hay but may be used for soiling purposes. Where it is sown thickly and cut before it becomes too ripe it has a feeding value for dairy stock similar to that of timothy.

Corn Fodder.—By corn fodder is meant the corn plant with the ear attached. It is a valuable roughage on account of the amount that can be grown per acre. It is low in protein but fairly rich in carbohydrates. Cut green in the late summer and early fall it is valuable as a soiling crop. When dried it is used for fall and early winter feeding. Later it becomes dry and woody and should be run through the cutting box to get best results. Corn for this purpose should be thickly sown to get a high percentage of leaf and stem.

Corn Stover.—Corn stover is the cornstalk after the ear has been removed. The crop is more matured than in the case of corn fodder, which detracts from its feeding value. It is of more value than straw and should be run through the cutting box before feeding.

Succulent Feeds

Corn Silage.—Corn silage is one of the best roughages for dairy cattle. There is less waste than if the corn is handled in any other way, and, instead of a dry forage, silage supplies a large bulk of succulent feed which is particularly valuable during the winter. Not only does it supply the necessary bulk in the ration, but it keeps the animal's system in tone and acts as an appetizer. Corn, for the best quality silage, should be put in the silo when in the glazed stage. Silage is also useful for feeding in the summer months when pasture is scarce. In the winter feeding of dairy cattle silage should be supplemented with a protein-rich feed.

Roots.—Roots are of value as a feed for dairy cattle in that they are palatable, succulent, laxative and easily digested. For all ages of dairy cattle roots form an excellent feed, particularly for young calves just commencing to eat and for test cows where high milk records are desired. Corn silage has replaced roots very largely, as it furnishes the succulent feed necessary for winter feeding at a lower cost than do roots. A few roots fed with the silage improves a ration considerably.

Mangels and sugar beets are the most satisfactory for the dairy farm as turnips taint the milk. Mangels will also yield more tonnage per acre than turnips.

Potatoes.—When potatoes are cheap they are sometimes fed to live stock. As a feed for dairy cattle they should be given in very small quantities as they are liable to cause an undesirable flavour in the milk.

Dried Beet Pulp—Dried beet pulp, a by-product of sugar refineries, is often fed as a substitute for silage or roots. It should be moistened with three times its weight of water before feeding and mixed with some molasses to take the place of part of the sugar taken out of the beets and to improve its palatability. It is a bulky feed and has a laxative effect on the animal. It is low in protein and should be fed with a protein-rich ration.

During the winters of 1922 and 1923 at the Ontario Agricultural College, a feeding test was made with dried beet pulp against mangels for dairy cattle. The milk yield was about the same but the cost of the beet pulp was a little higher. Judging from the results, when mangels are fifteen cents per bushel, beet pulp is worth $20.00 per ton.

Concentrate Mixtures

Home grown grains are generally too low in protein to meet the requirements of the high producing cow. It is therefore necessary in preparing rations to add protein-rich feeds which are made up largely of by-products from various manufacturing processes. To insure variety in the ration it is wise to select feeds from a number of sources. The cost of these various by-products also governs to a considerable degree the amount that can be used with economy. When hay from the legumes is fed the amount of protein in the grain mixture can be materially reduced as the protein is supplied in the hay. This is one of the

Ontario Holstein Herd

First prize State Herd at the National Dairy Show, Syracuse, 1923. The bull, Count Rauwerd Rattler, 36584, at the head of the herd was owned by Kemptville Agricultural School and bred by the Ontario Agricultural College.

strongest arguments for the use of hay from the legume crops. Where timothy or grass hay is fed a high protein grain mixture must be used to meet the requirements of the ration.

Bulk is another factor to keep in mind in preparing a concentrate mixture. A pound per quart is a good rule to follow in measuring the bulk of a grain ration. Mixtures weighing more than this are usually too heavy and pasty for satisfactory results, and mixtures weighing less are satisfactory providing this bulk has not been obtained by using coarse fibrous concentrates in excess, thus lowering the nutritive value of the mixture.

All grain should be crushed or rolled before feeding. This prevents waste, aids mastication and facilitates mixing. Too fine grinding tends to make the grains pasty and may reduce the palatability. Soaking, steaming or cooking feeds for dairy cattle is not advised except with such feeds as dried beet pulp or malt sprouts.

The following rules will serve as guides to the amount of concentrates that should be fed:

1. Feed one pound of grain for each three to five pounds of milk produced per day. This is a simple rule, easily applied and one that works out very satisfactorily in practice. It does not however, take into consideration the quality of the milk. Cows yielding high testing milk should receive more nutrients than cows yielding low testing milk.

2. Feed one pound of grain per day for each pound of butterfat produced per week. This rule takes into consideration the yield and the quality of the milk but is not as easily applied as Rule No. 1.

3. Feed as much as the cow will pay for at the ruling prices of feeds and products, increasing the allowance gradually until she fails to respond by an increase in production which will cover the increase in cost.

Suggested Rations Recommended by the Ontario Feed Committee for the Producing Cow.

Feed 1 lb. of concentrates to 4 lbs. of milk produced per day.

Where Roots and Silage are available:—

Alfalfa or Clover Hay—1 lb. every 100 lbs. live weight of cow per day
Silage —2 lbs. every 100 lbs. live weight of cow per day
Roots —2 lbs. every 100 lbs. live weight of cow per day

Concentrates: (1)

Oats	200 lbs.	
Bran	200 "	Crude Protein 18%
Barley	100 "	Crude Fibre 9%
Oil Cake	50 "	
Cottonseed	50 "	

(2)

Oats	200 lbs.	
Bran	100 "	Crude Protein 17½%
Gluten Feed	100 "	Crude Fibre 9½%
Oil Cake	25 "	

Lower Grades of Hay —1 lb. every 100 lbs. live weight of cow per day
Silage —2 lbs. every 100 lbs. live weight of cow per day
Roots —2 lbs. every 100 lbs. live weight of cow per day

Concentrates: (3)

Oats	200 lbs.	
Bran	200 "	Crude Protein 20½%
Barley	100 "	Crude Fibre 9%
Oil Cake	100 "	
Cottonseed	100 "	

(4)

Oats	200 lbs.	
Bran	100 "	
Gluten Feed	100 "	Crude Protein 21%
Oil Cake	50 "	Crude Fibre 9½%
Cottonseed	50 "	

(5)

Oats	100 lbs.	
Barley	100 "	
Bran	100 "	Crude Protein 20½%
Oil Cake	100 "	Crube Fibre 8½%
Cottonseed	50 "	

(6)

Oats	200 lbs.	
Bran	100 "	Crude Protein 19½%
Barley	100 "	Crude Fibre 9%
Oil Cake	200 "	

Where Roots are not available:—

Increase the silage to 3 lbs. per 100 lbs. live weight and use the same grain rations as above.

Where Silage is not available:—

Increase the roots to 4 lbs. per 100 lbs. live weight and use the same grain rations as above.

Where no Roots or Silage are available:—

Alfalfa or Clover Hay—1½ to 2 lbs. every 100 lbs. live weight of cow per day.

Concentrates: (7)

Oats	200 lbs.	
Bran	200 "	Crude Protein 18%
Barley	100 "	Crude Fibre 9%
Oil Cake	150 "	

(8)

Oats	150 lbs.	
Bran	100 "	Crude Protein 19%
Gluten Feed	100 "	Crude Fibre 9%
Oil Cake	50 "	

Lower Grades of Hay—1½ to 2 lbs. every 100 lbs. live weight of cow per day.

Concentrates: (9)	Oats	200 lbs.	
	Bran	200 "	Crude Protein 21½%
	Gluten Feed	100 "	Crude Fibre 9%
	Oil Cake	250 "	
(10)	Oats	100 lbs.	
	Bran	100 "	Crude Protein 21½%
	Gluten Feed	100 "	Crude Fibre 9%
	Oil Cake	100 "	
(11)	Oats	100 lbs.	Crude Protein 20%
	Bran	100 "	Crude Fibre 9½%
	Oil Cake	100 "	
(12)	Oats	200 lbs.	Crude Protein 19%
	Oil Cake	100 "	Crude Fibre 10%

Substitutes:—

Corn or wheat may be used as a substitute for barley in any of the above concentrate mixtures.

Cost Important:—

Prices and availability of grains must be considered in determining the concentrate mixture.

RATIONS FOR HEIFERS

Heifers six to twelve months

Ration No. 1

6–10 pounds of Corn Silage.
5 " Alfalfa or Clover hay.
2–3 " Grain.

Ration No. 2

10 pounds Alfalfa or Clover hay.
2–3 " Grain.

Heifers twelve to twenty-four months

Ration No. 1

12–20 pounds of Corn Silage.
8 " of Alfalfa or Clover hay.
2–5 " of Grain.

Ration No. 2

15 pounds of Alfalfa or Clover hay.
2–5 " of Grain.

A safe rule to follow in grain feeding is to feed one pound of grain for the first hundredweight of the heifer and one-half pound for each additional hundredweight.

The following grain mixtures will be satisfactory for calf and heifer feeding:

100 lbs. Oats		225 lbs. Oats
100 lbs. Wheat Bran	or	100 lbs. Bran
40 lbs. Oilcake		50 lbs. Oilcake

Many feeders use good quality oats, whole, rolled or crushed, for calves and heifers.

When legume hay is not available more protein should be fed in the grain mixture.

Mineral Feeding

In many parts of Ontario feeds are apparently low in mineral constituents and it is impossible for the cow to secure sufficient minerals from the rations supplied to meet the demands of the body. This condition is first indicated by signs of depraved appetite; cows chewing bones, sticks, leather etc. If a shortage of mineral matter continues the animal will later become stiff, thin and emaciated, often lack appetite and become drawn up in appearance. The claws or toes will grow abnormally long and production will be severely interfered with. Calcium and Phosphorus are the mineral elements usually lacking and to prevent or correct this trouble these minerals should be added to the ration.

Feeds rich in Calcium are all legume crops, milk, limestone, chalk and wood ashes. Feeds low in Calcium are the cereal grains and most concentrate by-products, straw, and root crops. Feeds rich in Phosphorus are bran, cereal grain by-products, and ground rock phosphate. Feeds low in Phosphorus are the straws, potatoes, beet pulp and molasses. Feeds containing both Calcium and Phosphorus in large quantities are steamed bone meal, bone char and bone flour.

As a lack of either Calcium or Phosphorus will produce the same condition in the animal, it is well to insure a liberal supply of each. Properly balanced rations will do much to prevent the trouble. Steamed bone meal is probably the best feed to use in providing mineral matter as it contains both Calcium and Phosphorus. To each 100 pounds of concentrate mixture add 2 pounds of steamed bone meal. This should be done summer and winter and is considered just as important in the ration as protein, hay or silage. Mineral deficiency diseases develop very slowly and when established take a long time to correct or cure. Prevention is much better than cure; therefore, minerals should be provided throughout the year. By mixing a small quantity of bone meal in the grain mixture the difficulty of getting stock to eat it is overcome. Bone meal can be fed with the salt, and in the summer may be placed in a box in the pasture field if the cows are not being grain fed.

Salt should always be provided. It may be fed in the grain by mixing one pound of Salt to each 100 pounds of grain, or it can be fed daily, or put in boxes in the pasture, or salt blocks supplied. Cows require 1 to 2 ounces of salt per day.

In areas where there is a known iodine deficiency this mineral should be supplied to guard against goitre. Iodine salt is a very convenient method of feeding, or it may be supplied by feeding potassium iodide. Dissolve one ounce of potassium iodide in one gallon of water and feed daily per animal one tablespoonful of this solution on the feed. This will supply two grains of potassium iodide per head per day, which is the recommended dose.

Sunlight greatly assists in the assimilation of minerals. Cows should be turned out, therefore, on bright days during the winter and should have mineral supplied in the summer that they may store up a reserve supply to carry them through the long stable feeding period.

Feeding Test Cows

Where high records are desired extra care in handling and feeding the cow is necessary. Cows going on official record work should have a long dry period before calving, and during this time should be liberally fed on concentrates that they may be in high condition at calving time. It is a well established fact that when a cow freshens while in high condition she will have a higher butterfat test over a longer period of time than if she commences her lactation period in a thin condition. Suitable fattening or fitting mixtures are as follows:

(1) 100 lbs. ground or rolled oats.
100 lbs. ground barley or corn.
100 lbs. wheat bran.
100 lbs. oilcake meal.

(2) 100 lbs. ground or rolled oats.
100 lbs. ground corn.
100 lbs. oilcake meal.
100 lbs. wheat bran.
50 lbs. cottonseed meal.
50 lbs. gluten feed.

Feed these concentrate mixtures liberally—about one pound of grain per hundred pounds live weight. Corn silage, roots and alfalfa or clover hay can be used as roughage feeds. Feed these as recommended under the heading of "Rations for the Producing Cow."

About ten days or two weeks before calving discontinue the feeding of the fattening ration and give a cooling ration. A mixture of two parts of oats, two parts of bran and one part of oilcake would be satisfactory. Continue feeding this until all inflammation and congestion have disappeared from the udder after freshening. Do not feed barley, cottonseed meal or corn near calving time; reduce the amount of silage, and feed liberally on mangels. Above all things, guard against any feeding practice which will cause constipation at calving time. Do not milk the cow dry for a few days after freshening to discourage the development of milk fever.

Rations fed cows on test work have four things in common. They supply a liberal amount of feed, they are made up of a variety of feeds, the concentrate mixtures are high in protein, and they supply mineral materials in some form. In other points there is a wide variation in the rations used by men feeding for high records, indicating that the personal factor is an important item in this work. Concentrate mixtures should be bulky, as heavy feeding on pasty meals tends to cause digestive troubles. Suggested mixtures are outlined below:

Mixtures for Test Cows

(1) 150 lbs. ground or rolled oats.
150 lbs. ground barley or corn.
100 lbs. wheat bran.
100 lbs. oilcake meal.
100 lbs. cottonseed meal.
200 lbs. corn gluten feed.

(2) 100 lbs. ground or rolled oats.
100 lbs. ground corn.
100 lbs. oilcake meal.
100 lbs. dried distillers' grains.
100 lbs. gluten feed.
100 lbs. wheat bran.
50 lbs. cottonseed meal.

(3) 200 lbs. ground or rolled oats.
200 lbs. ground barley.
200 lbs. ground corn or hominy.
200 lbs. oilcake meal.
200 lbs. wheat bran.
150 lbs. cottonseed meal.
100 lbs. gluten feed.
100 lbs. dried beet pulp.

The cow should be started gradually on these mixtures and some weeks taken to get her on full feed. The following is a suggested grain feeding schedule for the first ten days after calving:

1st day—3 pounds of warm bran mash.
2nd day—4 pounds of warm bran mash.
3rd day—2 pounds bran, 2 pounds of regular ration.
4th day—4 pounds regular ration.

5th day—5 pounds regular ration.
6th day—6 pounds regular ration.
7th day—7 pounds regular ration.
8th day—8 pounds regular ration.
9th day—9 pounds regular ration.
10th day—15th day—10 pounds of regular ration.

If the cow does not respond in milk flow with an increased amount of meal mixture, a reduction in the ration is necessary until a slight drop in production is detected. The grain may then again be slowly and gradually increased. Alfalfa and clover hay of good quality, corn silage, mangels and soaked beet pulp are all used as roughage feeds.

During the summer it is wise to keep the cows that are on official tests near the barn so that they can be given extra feed and attention. On hot days and when flies are bad test cows are better indoors. The windows are often darkened with sacks to add to the comfort of the cattle. Green feed can be cut and fed in the stable.

Cows giving over sixty pounds of milk per day are probably better milked three times a day. Authorities figure about a fifteen percent increase in production in three-times-a-day milking over twice-a-day milking.

The Record of Performance is the official test for all breeds of pure bred dairy cattle in Canada. Information on the R.O.P. can be obtained from the Supervisor, Mr. C. S. Wood, Department of Agriculture, Ottawa, Canada. Information on the Short-time Record of Merit test for Holstein cattle only, can be procured from Mr. G. M. Clemons, Holstein-Friesian Association, Brantford, Ontario. Information on cow testing associations can be obtained from the local Agricultural Representative.

Terms Used in Discussing Production Records

R.O.P.: Record of Performance—a semi-official long time test for pure bred cattle of the following breeds in Canada: Ayrshire, Brown Swiss, French Canadian, Guernsey, Holstein-Friesian, Jersey, Red Polled and Shorthorn.

365-day Record: A record made in 365 days after freshening. It may or may not run for the full 365-day period. There is no calving limit rule to this type of record.

305-day Record: A record that runs for 305 days after calving or a portion thereof. To qualify in this class a cow must freshen within 400 days of her previous calving date. In the Ayrshire breed a 305-day record is called an "Honour Roll" record.

Sub. B: A term used in describing records made by Holstein-Friesian cows only, and means that the record has been made on twice-a-day milking. It applies to both 365 and 305-day records.

R.O.M.: Record of Merit—a short time official record. This test is confined to the Holstein-Friesian breed.

Qualified Bull: A bull having four progeny qualified in the Record of Performance, each from a different dam.

A: The letter A when used after the registration number of an animal signifies that the animal is registered in the United States and that the number is American.

The letter A when used after a Record of Performance number indicates that it is a 305-day record.

Note: Holstein-Friesian records are frequently stated in pounds of butter rather than in pounds of butterfat. The rule used in making this calculation is that 80 pounds of butterfat will make 100 pounds of butter. If you know the fat record and want to change it to a butter record, multiply by 10 and divide by 8. If you know the butter record and want to change it to a fat record, multiply by 8 and divide by 10.

Boutflour System of Rationing Producing Cows

This system of feeding differs from the system used in general practice in that succulent feeds are eliminated entirely and the bulk of the ration is controlled. Dry feed is fed at the rate of 3 pounds of dry feed (hay and grain) per 100 pounds live weight. The grain is fed at the rate of 3½ pounds of grain for each 10 pounds of milk produced. To illustrate the working of this system a 1200-pound cow producing varying quantities of milk per day is used. Feeding dry feed at the rate of 3 pounds per hundredweight this cow should receive 36 pounds of feed per day.

Daily milk yield	*Concentrates*	*Hay*	*Total*
40 lbs.	14 lbs.	22 lbs.	36 lbs.
50 lbs.	17½ lbs.	18½ lbs.	36 lbs.
60 lbs.	21 lbs.	15 lbs.	36 lbs.
70 lbs.	24 lbs.	12 lbs.	36 lbs.

The following is the concentrate mixture recommended by Mr. Boutflour and used throughout the year:

Wheat Bran	100 lbs.
Oilcake Meal	100 lbs.
Cottonseed Meal	100 lbs.
Rolled Oats	150 lbs.
Rolled Corn or Barley	150 lbs.
Corn Gluten Feed	200 lbs.

To each hundredweight of concentrates was added 2½ pounds of the following mineral mixture:

2 parts Common Salt.
1 part Chalk or Whiting (Lime).
1 part Steamed Bone Meal.

The cow should be in good condition for calving and some time taken to get her on full feed after freshening. Twenty pounds of hay per day seems to be about the maximum amount that should be fed to a cow.

The Ontario Agricultural College conducted an experiment with a number of cows using this system of feeding. The observations indicate that it works very well for high yielding cows and compares favourably with the regular system of feeding in cost of production. The cattle maintained good health and held up in body weight throughout the test. Straw could not be used for bedding as the cattle would eat it and thus upset the effort to control the bulk. In Ontario with protein-rich feeds very expensive and a large amount of coarse roughage material to dispose of, this system of feeding will probably not find the place that it has found in Great Britain where it is used quite extensively, but under quite different circumstances.

SUMMER MANAGEMENT OF THE MILKING HERD

Dairying in Ontario naturally divides itself into two distinct periods—the pasturing of the cattle in summer and stable feeding in the winter. As a general rule the milking herd can live outside for five months, but requires shelter and indoor feeding during the remaining seven. Every dairy farmer knows that in the late spring and early summer the herd usually reaches its maximum production for the year. This is due to the abundance of suitable feed, the moderate temperature, comfortable surroundings and reasonable exercise. Obviously, progressive dairymen should attempt to imitate these conditions throughout the year.

Cows are usually pastured during the summer months. Feeding the herd indoors during the summer is much more expensive than pasturing, requires more labour, and the feed cost is greater. An experiment conducted at the Ontario Agricultural College showed a feed cost about 100 per cent higher for indoor feeding than outdoor feeding. In addition, cows on pasture get the much needed health giving properties of sunlight and fresh air.

Pasture management is a serious problem in Ontario. Little difficulty is experienced in getting abundant pasture during the month of June and in part of July, but unfortunately, pastures often dry up and become parched and bare during the latter part of July and in the month of August. Some provision must be made for this lean period. Extra feed can be supplied by the following means:

1. Pasture management.
2. Supplying succulent feeds in the form of silage, or green feed.
3. Feeding concentrates.

Pasture Management

Under this heading the problem of supplemental pastures would be included. The using of annual pasture when other pastures are not available is followed by many successful dairymen. The oat is probably the best grain for this purpose.

O. A. C. Dairy Herd pasturing on a luxuriant growth of second crop clover during the month of August, 1932.

Three bushels of oats per acre seeded with eighteen pounds per acre of sweet clover, or seven pounds of red clover and four pounds of alfalfa per acre are combinations that have given good results as annual pasture mixtures on the College Farm. This should be sown about the middle of May and the cows turned on it before the grain is out in head. While this system requires considerable labour, in favourable seasons it supplies a large amount of satisfactory feed at a time when other pastures are often bare and scanty.

The aftermath of the hay crop gives a large amount of grass at a season when other green feed is not at hand. In districts where alfalfa can be successfully grown the second crop is often used for summer pasture. Red clover is also valuable for this purpose.

Rotational pasturing has been given much consideration in recent years. This term implies the rotating or moving of the stock from one field or paddock to another, allowing a rest period for the grass to grow. This system insures, when properly handled, young grass throughout the season, which is a distinct advantage as young grass is higher in protein and lower in fibre than older more mature grass. It does, however, necessitate considerable expense in fencing, and in some cases, in the providing of water. Fertilizer in liberal quantities is recommended for the best results. In dry seasons this system does not solve the pasture problem, as moisture is necessary to insure the growth of the grass and to utilize fully the applied fertilizing material. However, much experimental work is being done on this phase of pasture work, and it is hoped that some of the problems will be solved in the near future.

Sweet clover has given good results as an early summer pasture at the Ontario Agricultural College. It supplies a large amount of pasture early in the season, and should be kept pastured close to the ground for best results. If the crop becomes rank it gets very bitter and lacks palatability, and stock will often refuse to eat it.

On many farms are fields that are seeded to a permanent pasture mixture. The following are suggested mixtures for permanent grass seeding. The amount of seed recommended is for one acre:

(1)	Alfalfa	6	
	Common Red Clover	3	
	Alsike	2	
	Timothy	3	20 pounds of seed per acre.
	Orchard Grass	3	
	Meadow Fescue	3	
(2)	Alfalfa	6	
	Alsike	2	
	White or Dutch Clover	1	24 pounds of seed per acre.
	Timothy	3	
	Orchard Grass	6	
	Meadow Fescue	6	
(3)	Orchard Grass	4	
	Meadow Fescue	4	
	Tall Oat	3	
	Timothy	2	
	Meadow Foxtail	2	24 pounds of seed per acre.
	Alfalfa	5	
	Alsike	2	
	White or Dutch Clover	1	
	Yellow Trefoil	1	

A good combination of pasturage for a dairy farm is two-thirds of an acre of permanent pasture, two-thirds of an acre of annual pasture, plus the aftermath of the hay fields for each animal over a year old.

Succulent Feeds for Summer Feeding

Silage is by far the most important feed under this heading. Corn and sweet clover are two crops widely used in the making of silage in the Ontario dairy districts. Silage feeding should commence as soon as a shortage of pasture is noticed. Where the milk is being weighed this is quickly detected by a falling off in production. A small silo is most satisfactory for summer feeding as there is less danger of surface spoiling. Where this is not feasible one half of the surface of a large silo could be used, thus preventing excess loss and bad quality feed. Silage is a cheap form of summer feed.

Soiling crops, those cut and fed while green, would come under the heading of succulent feeds. A great variety of crops can be used for this purpose. Alfalfa is particularly satisfactory as there is a succession of crops throughout the season. Oats and peas sown at the rate of three bushels of oats and from one-half to one bushel of peas per acre, make a good soiling mixture. Late in the season corn can be used. The chief criticism of all soiling crops is that much labour is required in handling them. They must be cut each day and the handling and hauling of this green feed is not always a pleasant task. This type of feeding is used in supplying green material to calves, bulls and test cows more generally than it is used in the feeding of the commercial milking herd.

Grain Feeding on Pasture

Many successful dairymen rely on concentrate feeds for supplementing pastures. While generally considered more expensive than silage, grain feeding has the advantage of being easy to feed and control, is free from loss through mould and heating, requires a small amount of labour and supplies nutrients in a concentrated form. High yielding cows should not be expected to keep up their milk flow on scanty pasture or on such bulky roughage materials as silage and soiling crops. Some grain should be fed to keep up the condition of the cattle.

Frequently little immediate benefit can be seen from grain feeding, especially when cows are on the flush of pasture in the month of June. Experimental evidence, however, shows that even at this time limited amounts of grain are beneficial in keeping up production later in the season. Grain feeding is often discontinued when cattle are turned to pasture. Unfortunately, many do not see fit to resume grain feeding until the production has dropped rather seriously late in the season, and then it is difficult to get the production back to its previous level. This condition should be carefully watched and guarded against, as once cows drop in their milk flow it is difficult to get them back.

What concentrate mixture should be fed during the summer? Oats and barley are sometimes used and when the grass is young and high in protein these grains give good results. Certainly, using these home grown feeds is much to be preferred to no grain feeding whatsoever. Later in the season the protein content of the meal should be increased, and many use the same mixture in the summer as is used in the winter.

The quantity of grain fed will depend on the amount of pasture available. Early in the season, some authorities claim a production of thirty pounds of milk per day without supplemental feeding. As the pasture decreases, twenty pounds per day is suggested as the maximum amount of milk to expect without supplements. For quantities of milk produced above these figures feed concentrates at the rate of one pound of grain to three pounds of milk. As an illustration, a cow in June is producing 50 pounds of milk per day. Allowing 30 pounds for grass, 20 pounds of milk would be produced from grain feeding. At the suggested rate, this cow would therefore get from 6 - 7 pounds of grain per day. Later in the season 30 pounds would be produced on grain feeding, which would necessitate feeding 10 pounds per day. Eckles of Missouri recommends the following rates for grain feeding on grass:

Jersey or Guernsey cow producing:

20 lbs. of milk daily	- -	3 lbs. grain.
25 lbs. of milk daily	- -	4 lbs. grain.
30 lbs. of milk daily	- -	5½ lbs. grain.
35 lbs. of milk daily	- -	7 lbs. grain.
40 lbs. of milk daily	- -	8 lbs. grain.

Holstein or Ayrshire cow producing:

25 lbs. of milk daily	- -	3 lbs. grain.
30 lbs. of milk daily	- -	4 lbs. grain.
35 lbs. of milk daily	- -	5½ lbs. grain.
40 lbs. of milk daily	- -	7 lbs. grain.
50 lbs. of milk daily	- -	9 lbs. grain.

In very adverse seasons it is often necessary to put cows on winter rations late in the summer.

The change from winter to summer feeding should be a gradual one. Severe and sudden changes of any kind are not under the heading of good management. Do not turn the cows out too early in the spring. New grass is very high in moisture and cows have to eat large quantities to satisfy their needs. This is hard on both the pasture and the cow.

Water, Salt and Shade

A plentiful supply of clean fresh water is an absolute necessity. Where possible, stock should have free access to water, and barring this, should be watered twice a day and in hot weather three times a day. Salt should be available at all times. Many use the iodized salt blocks, thus providing salt and iodine in the one operation. Shade, where a cow can lie down and chew her cud, protected from the hot sun, is a great asset. Pastures should be arranged, if possible, with access to these three important factors—water, salt and shade.

WINTER MANAGEMENT OF THE MILKING HERD

Cattle should be stabled during the cold and wet nights of the fall and on wet days. During bright weather they are better outdoors even though there is only a limited amount of feed available. When fall pasture is scarce it is often necessary to put the herd on winter rations even though they run outside during the day.

The greatest problem in winter management is feeding. This has been discussed elsewhere in this bulletin and need not be taken up here. Cows milked twice a day need only be fed twice a day. When official records are being made, feed as often as the cows are milked. The order of feeding will depend on individual conditions. It apparently makes little difference when the feeds are given providing the same order is followed from day to day. Hay should be fed after milking so that the dust in the stable might be at a minimum during milking hours. Such feeds as turnips, rape or cabbage should be fed after milking to guard against off flavours in the milk. Even silage will sometimes cause a peculiar flavour in milk when fed just previous to milking.

Water is an important item in the rations for all dairy stock. High producing cows take amazingly large amounts of it. As high as 350 pounds per day has been reported for some cows. At the Ontario Agricultural College in the winter of 1931 the water taken by two groups of cows was carefully weighed for a period of ten days. The first group averaged 56 pounds of milk per day and drank 126 pounds of water each per day. The second group yielded 36 pounds of milk per day and drank 85 pounds of water each per day. The water consumption varies greatly from day to day, but generally speaking a cow drinks 2½ to 3 pounds of water for each pound of milk produced. The chill should be taken off the water as it takes a large amount of energy to warm cold water. Many modern barns have watering facilities in the stable.

Cows should be thoroughly groomed at least once a day. This is an important item that is too often overlooked. Good grooming insures clean milk, clean cattle and assists in maintaining the health of the herd. From the time the cattle enter the stable every effort should be made to keep down lice. Prevention is better than cure with vermin, and efforts to control them should be made before the cattle start scratching and rubbing, and the hair starts falling out.

Clipping should also be done to add to the comfort of the cattle. Trimming the head and neck greatly improves the appearance of the cows and it is much easier to keep the cows clean when the flanks, udders and bellies are clipped.

A

B

Clipping greatly improves the appearance of the head. Two views of the head of a College owned cow, K.S.A.C. Dutchland Topsy—(A) before clipping, and (B) after clipping.

On bright warm days cows should be turned outdoors for a few hours. Moderate exercise is necessary to keep up the vigour and appetite. The importance of sunlight as a factor in assimilating feeds, particularly mineral substances, cannot be overemphasized. On stormy days cows are better indoors.

CARE OF THE COW AT CALVING TIME

It is good practice to allow the cow to dry up for at least six weeks before calving time. This will allow her to lay on some fat and also to store up energy for the next lactation period. It is a well-established fact that the more fat the cow has on her body at calving time, the higher the percentage of butterfat in the milk for some time after freshening.

As calving time approaches she should be allowed plenty of exercise in a box-stall in winter or on pasture during the summer. She should receive a liberal supply of roughages with plenty of succulent feed such as roots and silage, with a limited supply of grain. The concentrate ration should contain oats, bran or oilcake, but in no case should barley, corn or cottonseed be fed. The attendant should be on hand at calving time. If the cow's udder is hard and inflamed it is good practice to leave the calf with the cow for a day or two. In any case the calf should get the first milk drawn from the cow. The cow should not be milked dry for the first three or four days. If everything is progressing normally, in three or four days the grain ration may be increased and the usual milking periods commenced. It is well not to get up to the maximum grain ration for ten or twelve days, and such an increase should be made very gradually.

If the afterbirth is retained it should be removed by a competent person within forty-eight hours after calving, and after it is removed the uterus should be flushed with an antiseptic solution. Boracic acid is preferable to any of the coal tar products. If the udder is inflamed or caked, massage, apply warm water frequently and follow by rubbing on melted lard, vaseline or camphorated oil.

THE HERD BULL

The entire care of the bull should be with a view to retaining his vigour and reproducing power. Not only must he be fed properly, but he should have sufficient exercise to keep him active and vigorous. As a calf he

Illustration showing a wire ring used along with the regular ring as an added safety device for handling a bull.

should be fed for growth. He should get new milk a little longer than is ordinarily fed to heifer calves. The change from whole milk to skim-milk should be made gradually. He should be kept inside in the daytime and allowed to run out at nights during the summer months. In winter he should be allowed out on fine days and should be handled frequently. The bull is usually quieter when kept stabled where he can see the cows. He should have a roomy box-stall where he has plenty of space to move around. He should never be teased or fooled with by any one. A ring should be put in the bull's nose when he is about a year old and he should be trained to lead and handle with a staff. Unruly bulls are often made manageable by putting a small wire through the nose, fastening the ends to form a ring and using this in addition to the ring.

Feed for a bull, like that of the cow, should be of a bulky nature, but should not be too coarse or watery, such as a heavy silage ration. This has a tendency to produce too much middle, which makes him slow and clumsy. Clover hay should form the bulk of a bull's ration, with an addition of a small amount of roots and silage. A fair rule is one pound of clover hay, one pound of roots and one pound of silage to every 100 pounds of weight of the bull. The grain feed should be composed largely of oats with a little bran or oilcake. This should be fed at the rate of two to six pounds per day, depending on the size of the bull. For the young and growing bull more liberal feeding may be done, as growth has to be provided for. In the summer it is a good practice to cut some green feed such as clover, alfalfa or a mixture of oats and peas, while later in the season corn will do very well. Dairy bulls, never allowed to get too fat and with sufficient exercise, will remain active for years.

In 1922 the average cost of feed at the Ontario Agricultural College for each of the three mature dairy bulls was from $70 to $75 a year; this, with the cost of labour added, amounted to $100 per year. If interest on investment and housing were taken into consideration, this would be still higher. The average ration fed for the winter, when these figures were secured, was from three to five pounds of grain, twelve pounds of hay, twenty-three pounds of silage and twenty-three pounds of roots. Using this information as a basis, a man maintaining a bull for service would, at this rate, require fifty cows at $2 each in order to pay for the feed and labour.

THE CALF

The best and safest way of improving the milking qualities of a herd of cows is to raise the heifer calves from the best cows in the herd. Inferior heifers and the majority of the bull calves should be vealed and marketed as early as possible. Following this system the quality of the cattle will, by careful selection, become higher and more uniform. Further, there is not the danger of introducing disease in the herd, a danger ever present when cows are bought from a number of sources.

Some dairymen take the calf away from the dam shortly after it is born while others follow the system of allowing the calf to stay with the dam for two or three days. If the cow's udder is badly swollen, leaving the calf with the cow will sometimes relieve the swelling. It is easier to get a calf to drink from a pail if it has not sucked its mother and under most circumstances it is probably better to separate the calf from its mother a few hours after birth. In all cases the calf should receive the first milk or colostrum from its mother. In teaching the calf to drink there is no better method than the old fashioned one of using the finger. Many mechanical devices have been tried but are not practical because of the difficulty experienced in keeping them clean.

The development of the heifer may be quite readily divided into four distinct periods. The milk-feeding period extends from birth until six or eight months of age. From the milk-feeding period until the heifer is bred constitutes the second period. The third period is the period of nine months pregnancy, and the fourth is the first lactation period. Each period requires different feeding and management.

To the man selling whole milk the question of suitable feeds for calf rearing presents a real problem. Whole milk is a costly feed, skim-milk is scarce and milk substitutes in many cases are not available. Milk from the low testing cows in the herd can be utilized for calf feeding, leaving a better quality product for the whole milk market. To this, with older calves, water is sometimes added, reducing somewhat the amount of milk required. Where skim-milk is available it should be fed and is one of the most satisfactory feeds used in rearing calves. Skim-milk powder has been used at the Ontario Agricultural College with good results

Illustration of a 28-acre field that is divided into seven 4-acre paddocks for experimental work on rotational pastures. Milking cows in the foreground, with dry heifers shown in distance.

but has been rather expensive as compared with other feeds. Commercial calf meals and home-made calf meals have also been tried with good results. The gains from these meals have not been as great as the gains from powdered milk products but the cost per pound gain has been lower.

For the first three weeks the calf should receive whole milk and then gradually be changed to skim-milk or some other feed. Milk should be fed warm and at a uniform temperature from day to day. It is advisable to feed milk three times a day for the first few days after birth. A safe rule in calf feeding is to keep the calf a little hungry at all times.

Regularity in calf feeding cannot be too strongly emphasized. Regularity in the times for feeding, the quantity of feed, and the quality of feed are all important items in successful feeding. Cleanliness is another important factor in successful calf rearing. The pails used in feeding should be regularly washed and the feed should be clean and of good quality.

The following tables are given as recommended guides in the feeding of dairy calves:

DAILY FEEDING SCHEDULE FOR SKIMMILK-FED CALVES

For Jerseys, Ayrshires and Guernseys

Age of Calf	Whole Milk lbs.	Skimmilk lbs.	Grain lbs.	Hay lbs.
1 to 3 days	Milk from dam			
3 to 14 "	8 to 10			
2 to 3 weeks	10 to 1	1 to 10	⅛	
3 to 4 "		10	¼	All
4 to 5 "		11	½	will
5 to 6 "		12	¾	eat
6 to 8 "		13	1	
8 to 12 "		14	2	
12 to 24 "		16	3	

For Holsteins

Age of Calf	Whole Milk lbs.	Skimmilk lbs.	Grain lbs.	Hay lbs.
1 to 3 days	Milk from dam			
3 to 14 "	10 to 12			
2 to 3 weeks	12 to 1	1 to 12	⅛	
3 to 4 "		12	¼	All
4 to 5 "		14	½	will
5 to 6 "		15	¾	eat
6 to 8 "		15	1	
8 to 12 "		16	2	
12 to 24 "		16 - 20	3	

If skim-milk is not available, calf meals may be used. Where this system is followed it is wise to continue whole milk feeding for a longer period of time than three weeks. As a general rule one pound (dry weight) of a calf meal is a fair substitute for 4½ quarts or 9 to 10 pounds of skim-milk. The meal should be made into a gruel or thick paste by adding a small quantity of cold water. All lumps should be stirred out. After this is done warm water should be added at the rate of 4½ quarts for every pound of meal used. Feed warm, substituting for milk, pound for pound.

DAILY FEEDING SCHEDULE FOR CALVES FED CALF MEAL

Age	Pounds Milk daily	Pounds Gruel daily	Pounds Grain daily	Pounds Hay daily
1 to 3 days	Milk from dam			
3 to 14 "	10			
2 to 3 weeks	9	1	⅛	
3 to 4 "	9	3	¼	All
4 to 6 "	6	6	½	will
6 to 8 "		12	¾	eat
2 to 3 months		14	1	
3 to 4 "		14	2	
4 to 5 "			4	
5 to 6 "			4½	

The following mixture used as a calf meal has given good results at the Ontario Agricultural College:

Corn Meal	50 lbs.
Low Grade Flour	50 "
Oilcake	25 "
Oatmeal	25 "
Powdered Skim-milk	25 "
Bone Meal	5 "

Whole oats may be used as grain for the first six months, or a grain mixture made up of 225 pounds of ground oats, 100 pounds of bran and 50 pounds of oilcake could be fed. Second cut alfalfa is preferred for hay, but if this feed is not available, use good quality first cut alfalfa or red clover. After three months a small amount of succulent feed such as mangels, turnips or corn silage could be fed. Do not overfeed on succulent feeds as scours will invariably follow. After six to eight months the milk feeding may be discontinued and from this time on the rearing of the heifer is comparatively simple.

Dairy calves taking exercise in the sunlight at the Ontario Agricultural College.

Minerals should be provided for the growing calf. A mixture of 30 pounds of common salt, 20 pounds of bone meal and 5 pounds of charcoal has been used with good results at the Ontario Agricultural College. A small amount of this mixture is fed each day on the grain ration.

Pasturing calves under six months of age is not advised. The calves will do better if kept in a dry pen or shed where they can be fed conveniently. This pen should be darkened throughout the day to prevent trouble from flies. It is good practice to allow the calves out at night during hot weather, thus adding to their comfort as well as giving them a chance to take exercise.

THE HEIFER

The handling of the heifer during the period of her life from six to eight months of age until she is bred is comparatively simple. There are, however, a few essentials that must be kept in mind, since the usefulness of the cow when mature is largely dependent on her proper development before the first calf is dropped.

Heifers on good pasture will not require additional feed, but caution is necessary as pastures often become parched or otherwise insufficient, and the heifer is liable to suffer more from neglect in the summer than in the winter. In winter there is no better ration than legume hay, silage and sufficient concentrates to insure thrift and growth. It is absolutely necessary for the growing heifers to have sufficient protein and mineral matter that they might develop strong frames and vigorous constitutions. Clover and alfalfa hay are rich in these ingredients as well as the necessary vitamins. A liberal supply of this hay will insure proper development. Where clover hay is not available, an increase in the grain ration will be necessary.

Heifers fed on a liberal ration will mature earlier than if fed on a scanty ration, and will make larger cows, hence the reason for small cows in our herds is usually scanty feeding when young. Many breeders believe that a heifer if allowed to become too fat will develop a tendency to use much of her feed for the formation of body fat which will persist when she is in milk. The conclusions of many experiments point to the fact that heifers that become too fat make slightly inferior cows even if they lose their fat after coming into milk. Any effect of such overfeeding while young is of little importance in determining the productiveness of a cow compared with her inherited qualities. The chief argument against such practice is the increase in the cost of growing the heifer, as it is necessary to use a larger percentage of high-priced concentrates.

The age at which to breed a heifer depends largely on the breed and the size and development of the individual. Jerseys and Guernseys, which have been well fed, should usually be bred at about fifteen or seventeen months of age, while the slower-maturing breeds, such as Holsteins and Ayrshires, from eighteen to twenty months. It is commonly believed that if the heifer calves at an early age the tendency to milk production will be intensified, but, judging from the report of available data, the indications are that the highest milk yields are usually secured from cows that are well grown before lactation begins. Gestation has very little effect on the rate of growth of the well fed heifer, but growth is materially checked as soon as lactation begins, owing to the large amount of nutrients needed for milk production. Heifers fed scanty rations and bred too early are usually stunted and are smaller in the bone than those not bred until more mature.

From the time the heifer is bred until calving she should receive considerable attention in order to assure her future success as a dairy cow. Kind treatment, frequent handling and abundant feed are necessary. The feed fed should be nutritious and at the same time bulky in nature. Some meal should be supplied during the last few months of pregnancy. The heifer should come into milk in good flesh with an udder large and full. Good, clean legume hay, corn silage and roots should make up the main portion of the ration.

At calving time the heifer should be handled in the same manner as the cow. A bran mash should be given, particularly when the heifer is weak or exhausted, and warm water supplied as a drink. For a few days the ration should be light until the danger of milk fever is over. A heifer with her first calf should be fed liberally, since she is growing and producing milk at the same time. It is probably wise not to breed the heifer for some time after calving that she may be free to devote all her energies to the production of milk. This will tend to establish the "milking habit." Long lactation periods are desirable, consequently the heifer should milk for nearly twelve months during her first lactation in order that this trait be well developed. If the heifer is uneasy and nervous when first milked, considerable time and patience should be exercised that these irksome traits may be overcome. Habits formed in the first few months of milking often persist throughout the life of the cow.

PROBLEMS IN BREEDING

Successful dairy farming depends on successful breeding as well as intelligent feeding. It is impossible to make a poor cow good by feeding, so it is necessary to first have a cow that has the ability to produce milk, and then by intelligent feeding get her to produce milk economically.

Foundation Stock—If the prospective dairy farmer is buying a herd and is free to select, it is very important that he keep in mind the importance of the dairy-type animal—one showing capacity for consuming feed, with lean angular form denoting an absence of too great a flesh-forming tendency, with

Ontario Ayrshire Herd
First prize State Herd at the National Dairy Show, Milwaukee, 1924.

the udder and the milk veins well developed and with an alert disposition and strong constitution. It should also be borne in mind that he is more likely to find this type if grades of some standard dairy breeds are selected. Haecker of the Minnesota Experimental Station, divided the state herds into four groups, depending on type and conformation. Group 1 was composed of distinctly dairy-type cows with deep bodies. These required 21.2 pounds of dry matter in the feed to produce one pound of butterfat. Group 2 was composed of dairy-type cows but lacked depth of body. These required 25.5 pounds of dry matter to produce one pound of butterfat. Group 3 was composed of cows showing some inclination toward beefiness and required 26.4 pounds dry matter; and the fourth group, which were of distinctly beef type, required 31.3 pounds of dry matter for each pound of butterfat produced. This goes to show that the beef-type cows required forty-seven per cent. more feed to produce a pound of butterfat than the deep-bodied dairy-type cows.

If the prospective dairy farmer has on hand a herd of cows of unknown ability, he should at once take steps to find the profitable cows. A very poor cow is little better than no cow at all and should be disposed of at once. The calves from the best cows should be raised and if a good pure-bred bull is used, considerable improvement should be noticed with each generation.

Breed to Keep—Considerable attention should be given to the selection of the breed, whether pure-bred or grade. Generally speaking, the breed to keep is one well-established in the neighborhood where the particular farmer is located. Community breeding has many advantages and should be practised wherever possible. A community noted for one breed of stock attracts buyers and the farmer finds it easier to dispose of his surplus stock.

Selection of the Bull—In starting a herd of dairy cows, there is no single problem of greater importance and none which offers greater difficulties than the selection of a herd bull. Too many farmers forget that the bull is half of each calf produced in the herd. With a poor cow in the herd you get one poor calf; with a poor bull you are liable to get all poor calves. Whether the herd is grade or pure-bred, nothing but a high-class pure-bred bull should be kept. He should be a good individual, having plenty of constitution, vigour and masculinity, and should be true to the type of the breed he represents. Of equal importance to the individuality of the bull is his pedigree, and he should be from stock that have demonstrated ability to produce milk and butterfat.

Pure-Bred or Grade—A question that is often asked is whether the farmer should keep pure-bred or grade stock on the dairy farm. Generally speaking, the average man should commence with grades and work into pure-breds gradually. If, on the other hand, the farmer has experience with live stock and knows how to feed and care for cattle, he may find he is able to make larger returns from a pure-bred herd. It should, however, always be borne in mind that the same care in selection is necessary with pure-breds as with grades. Not all pure-bred animals are producers and it too often occurs that the beginner will buy cheap pure-bred stock and often find that they are not profitable.

Breed Families—In buying pure-breds it should be borne in mind that certain strains or families are much better than others. The old saying, "That it is the strain rather than the breed," is very true. Breeders should buy animals from good strains or families for best results, paying particular attention to the top crosses or the immediate ancestry in the pedigree.

Certain types of breeding should be mentioned, such as grading, crossing, pure-breeding, line-breeding and inbreeding.

Grading—Grading-up means the mating of grade cows with a pure bred bull and is usually the way the average breeder starts the improvement of his herd. After the first generation the best heifers are bred to a pure-bred bull of the same breed. This method continued for a few generations works marvels on the appearance of the herd, and, if good bulls are selected, improves the milking qualities as well. The following table points out very clearly how the grade blood gradually disappears:

TABLE NO. 4.

Generations	Sire's per cent of purity	Dam's per cent of purity	Offspring's per cent of purity	Percentage of unimproved
1.	100	0	50	50
2.	100	50	75	25
3.	100	75	87.5	12.5
4.	100	87.5	93.75	6.25
5.	100	93.75	96.87	3.12
6.	100	96.87	98.44	1.56

This method is an inexpensive and efficient way of improving the herd, as the only outlay is for a pure-bred bull. A graded-up sire should not be used, and no other breeds introduced, or the work of grading-up goes back very quickly to where it was at the beginning of the work. It is possible, if careful selection is practised, to build up an excellent producing herd in a very few generations by grading.

An example of this is found in work done at the Iowa Experiment Station by Professors Kildee and McCandlish, who conducted an experiment in grading up a herd for milk production. They started with scrub cows of no particular breeding, which, with good care and feed produced an average of 3,867 pounds of milk, containing 172 pounds of fat. The daughters from these cows out of pure-bred bulls gave an average of 5,945 pounds of milk and 267 pounds of fat. The granddaughters of the original cows, carrying three-quarters of pure-bred dairy blood, averaged 8,311 pounds of milk and 371 pounds fat, an increase of 116 per cent. in yield of milk and 106 per cent. of fat in two generations.

Crossing—Cross-breeding is the mating of a pure-bred male with a pure-bred female of another breed. It is supposed to produce hardier live stock than pure-breeding and is sometimes followed in producing stock for market purposes. In dairy cattle breeding crossing has no place and should not be practised under any consideration.

Pure-breeding—Pure breeding is the term applied to the breeding of a pure-bred female to a pure-bred bull of the same breed. There are several different systems followed, the most common being the breeding of males and females not closely related. This is probably the safest for beginners and the general run of farmers.

Line-Breeding—In line-breeding the breeder selects males and females of the same blood lines or animals of the same strain or family. By this means the breeder is able to get a concentration of blood which gives a more powerful hereditary influence. Line-bred animals usually have a stronger influence on the offspring than animals that are not line-bred, and a great many of the most noted sires have been line-bred individuals. Line-breeding is the safest and best system of improvement but should only be used by experienced breeders as individual selection must be practised as well.

Inbreeding—Line-breeding is the mating of individuals remotely related (not closer than cousins), while inbreeding refers to the mating of closely related individuals such as sire and daughter, son and dam, or brother and sister combinations. Inbreeding should never be practised by the beginner and only to a very limited extent by the experienced breeder. It tends to concentrate the blood and brings out desirable qualities, but is apt to multiply the defects as well. It may also result in a loss of vigour and low fertility in the offspring.

The Good Breeder—Few farmers realize the importance of keeping the successful breeding animal on the farm. The good milker that is a regular breeder is the cow which a farmer cannot afford to sell. Fertility is a very important factor in all classes of live stock and is an inherited character. Lack of vigour and failure to breed regularly is one of the commonest defects in our live stock today. While milk production is important in the dairy herd, ability to reproduce is just as important, and where these two desirable qualities are combined in one individual, they make that individual doubly valuable and such an animal should be retained in the herd.

Cull Out Unprofitable Cows—Even in the best dairy districts, probably one quarter of the dairy cows fail to pay their way. If this is true in these districts, what percentage would be in the "boarder" class in some of the other districts? The reason that there is this high percentage in good districts is because no one can tell by appearances whether a cow is profitable or not. The only satisfactory way to ascertain this is by the milk scale and the Babcock tester. Knowing the actual production of each cow and the approximate amount of feed consumed in a given period, the farmer is able to size up his profitable cows and in a few years get rid of those that do not pay a profit over feed consumed. Care should be taken in culling, however, as good cows often have a bad year and it might often be wise to give some a second chance.

Young or Mature Bull—Breeders of live stock should pay more attention to the use of proven sires. Dairy cattle breeders will find proven sires the cheapest way of building up dairy herds. Too many good sires are sold for beef before their real value is known. The young bull can usually be bought cheaper than the old bull with tested daughters and is often easier to handle. There are, however, so many disadvantages in the young and untried sire that they more than make up for the extra cost and care in handling. The young bull is untried and the buyer must wait about three years after he is old enough for service before his merits as a sire can be known. If he proves to be an inferior sire and has been used in a herd for some time, he will have impaired the type and production very materially. Furthermore, one can never be sure how a young bull will develop. Some choice typey calves develop into ungainly animals.

COMMON DAIRY CATTLE AILMENTS

It should be the aim of every dairyman to know something about the common ailments and diseases of dairy cattle as well as the simple preventive and curative measures. No attempt will be made to take up these diseases in detail or to give a thorough veterinary treatment. However, for purpose of information, the more common diseases and preventive measures for same will be dealt with in this bulletin.

In every dairy barn there should be the following equipment for treating sick animals:

A clinical thermometer
A drenching bottle
A trocar and canula
A syringe
A funnel
Rubber hose
Graduated measuring glass
Clippers

There should be a supply of the following common medicines:

Purgatives	Epsom salts
	Raw linseed oil
	Castor oil
Disinfectants	Coal tar disinfectants
	Boracic acid
Antiseptic	Tincture of iodine

Applications for the udder and teats	Carbolized vaseline Camphorated oil Lard
Bloating	Turpentine

These medicines should be kept in a medicine chest, properly labelled, while the equipment should be kept clean and ready for use.

Diseases

Scours:—Scours in calves are usually caused by careless feeding. Pails and feeding utensils should be kept clean and only good quality feed given. Where scours have developed, succulent feeds should be removed from the ration. In treating, remove the cause by cleaning the feeding utensils and giving high quality feeds. It is usually wise to reduce the feed by half and give about two to four ounces of castor oil. Linseed tea, barley water or lime water are useful in correcting the condition.

White Scours:—White scours in calves is a contagious bacterial disease affecting calves within the first 3 weeks of life in which the chief symptoms are severe whitish diarrhoea, great dullness, loss of flesh and weakness. The disease usually develops rapidly, death frequently occurring within 3 to 10 days after the symptoms are first noticed.

White scours is one disease in which curative measures are of much less importance than preventive measures. Calving stalls should be thoroughly cleaned and disinfected and if the cow is dirty she should be washed with a mild disinfectant. As soon as the disease is recognized the calf should be isolated and the pen in which it has been housed thoroughly cleaned and disinfected to prevent the spread of the disease throughout the calf pen. Give the affected calf two to four ounces of castor oil and follow with barley water or rice water. Allow the calf outdoors if the weather is warm.

Ringworm:—Ringworm is a parasitical disease and is contagious. Pull out the hairs and paint the affected areas with iodine or an ointment made from mixing lard with flowers of sulphur.

Lice:—Thoroughly disinfect stables before turning cattle in with a two per cent. solution of a coal tar disinfectant. A good practice also is to wash the stable right after cattle are turned out in the spring. Dipping and washing of cattle with different materials is frequently practised. Clipping the head and back is also a good practice to control the pest, as well as dusting with some insecticide powder. Sabadilla powder has given good results at the Ontario Agricultural College.

Tuberculosis:—This disease is very hard to diagnose and there is no known cure. The only method of eradication is to subject the herd to the tuberculin test and dispose of the reacting animals. The Accredited Herd System is doing much to eradicate this disease in the Dominion and further details of this system can be procured from the Health of Animals Branch, Department of Agriculture, Ottawa, Canada.

Abortion:—Abortion may be due to an accident or to an infectious disease of the reproductive organs known as contagious abortion. Too many herds have contagious abortion spread through them by taking for granted that the first abortion was caused by an accident. To prevent the spread of abortion all cows should freshen in a box stall that has previously been cleaned and disinfected. All afterbirth, and in the case of abortion, the dead foetus, should be burned or buried. All surroundings should be disinfected after an abortion and the cow washed with a disinfectant solution. The cow should remain isolated from the herd until all discharge from the uterus has ceased. Do not breed a cow while she is discharging.

Retention of Afterbirth:—Healthy well fed cows seldom suffer from this trouble. Retention of the afterbirth frequently follows under feeding and is also closely associated with contagious abortion. If the afterbirth has to be removed it should be taken away by a qualified veterinarian.

Barrenness:—The inability of cows to conceive is closely associated with abortion, both being the result of diseased genital organs. Very often cysts will be found on the ovaries of barren cows. Through manipulation experienced veterinarians will break these down and conception will often follow. This requires the skill of an experienced man and anly valuable cows are worth treating.

Bloat:—Bloat is usually caused by a sudden change of feed or overeating of such feeds as frozen grass, turnip tops or wet clover. Swelling will be noticed on the left side of the abdomen. The animal is uneasy and may do considerable moaning and belching. Breathing is difficult and usually the nostrils are distended.

In mild cases give two to four ounces of turpentine in a pint of linseed oil. This may be repeated in an hour's time. In extreme cases the only cure is to puncture with the trochar and canula at a point between the hip and the last rib on the animal's left side.

Milk Fever:—Milk fever in cows is caused by a very rapid depletion of the calcium in the body. Colostrum milk contains a very high percentage of calcium, consequently milk fever occurs immediately after freshening and usually with high yielding cows. To prevent this trouble do not milk the udder dry for a few days after freshening. Milk out only small quantities of milk at frequent intervals. A cow with milk fever is drowsy, lacks appetite, is partially paralyzed and the head is usually drawn to one side. In this condition a cow should not be drenched because she is unable to swallow. The old treatment was to inflate the udder with air or oxygen. This treatment was very effective but frequently was followed by udder complications and serious retardation of the milk flow for a few weeks. The new method is to give injections of calcium preparations. This treatment is quick, effective and does not in any way injure the udder. It should be administered by a qualified veterinarian.

Garget or Mammitis:—A slight congestion of the udder is the normal condition at calving time, but exposure to cold or draughts, injury, infection or neglect may bring on an aggravated inflammation. The udder becomes very hot, is inflamed and hard. Milk secretion is impeded and often the milk shows clots or streaks of blood.

Give the cow a physic. Bathe the udder with hot water. Massage the udder and apply camphorated oil. The cow should be milked several times each day.

Foul in the Foot:—Foul in the foot is an infection in the clefts of the feet of cattle. It usually develops in the stable but sometimes occurs while on pasture. Cleanliness is the best preventive. The affected foot should be cleansed thoroughly, all diseased tissue removed, and should be dressed using tincture of iodine. In severe cases of inflammation a poultice may be necessary and a purgative should be given.

VARIATIONS IN BUTTERFAT TEST

During the years 1929, 1930 and 1931 the Animal Husbandry Department of the Ontario Agricultural College did considerable work on the variations in butterfat tests with cows kept in the College herd. One of the interesting things noted was the wide variation in tests from day to day. Some cows at one particular milking would test as low as 1.8%, and the same cows, during the same lactation period, have gone as high in one milking as 9.4%. There seems to be little regularity in the change from day to day, which indicates that a butterfat test at one particular milking is of little value in determining the ability of a cow to produce fat. A composite sample covering a number of milkings should be taken at frequent intervals throughout the lactation period to get an accurate estimate of the butterfat test of the milk.

The morning milk usually tests lower than the evening milk. The quantity of milk produced in the morning is greater than the quantity produced in the evening. Because of the larger quantity of milk produced in the morning, even though it is lower in butterfat test, there is more butterfat secreted in the morning than in the evening.

The first drawn milk from the cow is much lower in test than the last drawn. The following table illustrates this point:

TABLE NO. 5

Average of Five Morning Milkings

No. of Sample	Per Cent Butterfat
1	1.7
2	1.9
3	2.4
4	3.3
5	4.0
6	4.4
7	4.7
8	4.8
9	4.8
10	4.8
11	5.0

Feeds have little influence on the percentage of fat in the milk. A cow freshening when fat and in high condition, however, will usually show a much higher test for the first few weeks of milking, than if she had freshened in a very thin condition.

MILKING MACHINES

Milking machines are being used on many dairy farms with success and have now long passed out of the experimental stage. Cows, in most cases, show little objection to machine milking but should always be stripped by hand when machines are used.

The greatest single factor in obtaining good results from machine milking is the operator. This person should know the characteristics of the cows, be scrupulously clean and have a sufficient mechanical ability to know when a machine is operating properly and how to do minor mechanical repairs when necessary.

Great care must be exercised in keeping milking machines clean. The bacterial count of milk drawn from cows by means of a dirty milking machine is always very high. If, however, the machines are carefully washed, sterilized, and kept between milkings in a chlorine solution that is up to strength, good quality milk can be produced.

CLEAN MILK

Milk is one of the most healthy foods if handled properly, but no food is so easily contaminated if not properly handled. It costs very little more to produce clean milk and the result is a better-keeping product and a higher-priced product.

Clean milk can only be produced by appreciating the following essentials:—

Healthy Cows:—The cattle should be free from tuberculosis and other contagious diseases, skin diseases and parasites.

Clean Cattle and Stables:—The stables should be cleaned regularly. Twice a day is preferable. Calf-pens and box-stalls should be cleaned at least twice a week. The cattle should be brushed off once a day. Cobwebs and dust should not be allowed to collect on the ceilings and walls and all dusty forages should be swept up after feeding.

Good Barns:—The barn should be easy to keep cleaned out. The walls, ceiling and floors should be smooth so as not to collect dirt. Plenty of light and good ventilation are important essentials.

Clean Milking:—The cows should be bedded at least half an hour before milking and the udders and flanks brushed off with a clean damp cloth just before milking. The milkers should wear white jackets or aprons which should be kept clean. The hands should be clean, and milk should not be used to dampen the teats. The cows should be milked quickly, gently and thoroughly.

Clean Bedding:—Clean straw or shavings make excellent bedding, while dusty straw or chaff from the haymow means a dusty barn and dirty milk.

Clean Utensils:—Milk pails, cans, separators and all other utensils used for milk must be thoroughly washed and scalded twice per day and well aired in a room free from dust and flies. It is well to use a good washing powder in the wash-water and scald with pure scalding water.

Milk Handled Quickly:—It is better not to leave milk in the stable or to pour it in the stable after being drawn from the cows. It should be weighed and poured into the cans in a clean room adjoining the barn. Milk should be cooled as quickly as possible. Ice is indispensible on a dairy farm in the summer in order to keep the milk at a low temperature until delivered to the factory, milk dealer or consumer.

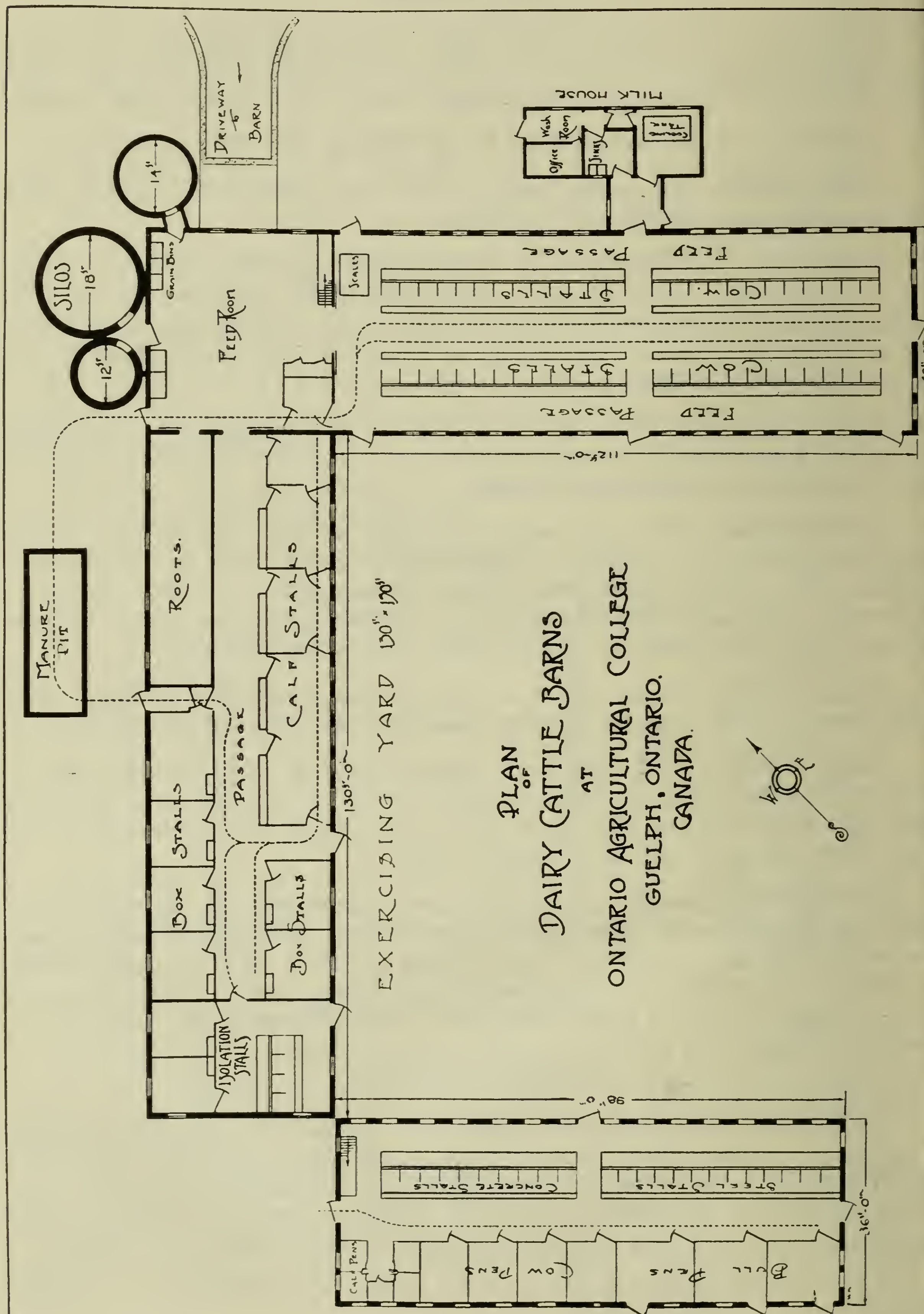
DAIRY STABLES

Good comfortable buildings are absolutely necessary to make dairy farming a success in Ontario. These should be convenient, comfortable, dry, easily ventilated and easy to keep clean. Fancy architecture is unnecessary and only adds to the overhead of the farmer. Good, plain buildings with the essentials for the proper housing of the stock and the storing of feed are all that is necessary.

The following outlines should assist the farmer who is thinking of remodelling old stables or building new:

The location should be high and dry. If possible, build in the lee of a wind-break.

Fifty to sixty feet of floor space is necessary for animals of all ages, and from 500 to 600 cubic feet of air space per cow.



Storage space for feed should be from 900 to 1,000 cubic feet per head; for silage, 150 to 175 cubic feet per head.

From four to five square feet of window space should be provided per cow, as plenty of light is essential. Windows should be hinged at the bottom so they will open at the top. This will allow fresh air to come in at the top so that there will be no direct draught on the cows.

Provide plenty of ventilation. About eight square inches of inlet area and fifteen square inches of outlet per head is necessary. The inlet should not be less than 12 inches by 6 inches in size of opening, and larger if possible; the outlets, 15 inches by 15 inches. Smaller outlets cause too much friction and interfere with the smooth flow of air.

The best material for floors is concrete. These should be at least six inches in thickness. An insulating layer in the concrete makes the floor dry and warm, and can be provided by putting a layer of tar paper or a coat of tar in between two layers of concrete. The finish of the floor should be rough and any sloping parts should be avoided to overcome the danger of cows slipping. Sprinkling ground limestone on the floors and passages once daily effectively prevents slipping. Keep the floor as nearly level as possible, but sufficient slope for drainage should be provided.

The walls of the stable are important. Concrete is very satisfactory but for best results it should be studded up on the inside and lined with boards. Hollow concrete blocks make a very satisfactory wall. Where lumber is available, nothing will serve better as it makes a particularly dry stable. A concrete foundation rising a foot to eighteen inches above the ground, a double coating of lumber with paper between outside, and boarded up with matched lumber inside makes an ideal stable wall.

While it is not absolutely necessary to board over the ceiling, yet, where expense is not too great, a tight ceiling is an advantage. It is easier to keep clean and is much drier.

Cow stalls should be 3 feet 6 inches in width. The length of the stand from manger to gutter varies with the size of cow, from 5 feet 9 inches for large cows to 4 feet 6 inches for small cows and young cattle. A good plan is to make it the maximum length at one end and narrow it down to the minimum at the other where the herd to be stabled varies in size.

Mangers may very profitably be made of concrete. They should be wider at the top than at the bottom with the corners at the bottom rounded so there is no place for dirt to accumulate. The bottom of the manger should be about two inches higher than the cow's feet.

A passage, either in front or behind a single row of cows should be five feet wide. A passage, either in front or behind two rows of cows, should be about seven feet wide.

Plenty of box-stall room is necessary. A good size is ten feet by ten feet, or larger, if there is sufficient space available. A few smaller stalls for calves may often be worked in to advantage. Partitions between box-stalls should be five feet high.

The gutter should be eighteen inches wide and six or seven inches deep. It should be square, with a gradual slope to one end of the stable, one to two inches in fifty feet.

Stanchion ties are recommended for dairy cattle as an aid to cleanliness, but possibly double-chain ties may prove more comfortable for large, heavy cows.

Dairy cattle should be housed separate from other classes of farm stock, if possible. A T- or L-shaped barn will make this possible on a farm where all classes of stock are housed in the one barn. One wing should be given over to the dairy herd.

A total width of thirty-six to thirty-eight feet is sufficient to provide plenty of room for two rows of cow stalls. When a barn is wider than this it might be advantageous to run the stables crosswise.

With a concrete manger and water in the stable the cows can be watered conveniently by running water in the manger if a drain is provided at the lower end. This necessitates keeping the manger clean at all times which is an advantage. The water used is always fresh. It is also cheaper than installing special water troughs or individual drinking bowls.

APPENDIX

TABLE NO. I.

CAPACITY OF CYLINDRICAL SILOS IN TONS

Height of silo in feet	Diameter of Silo in Feet										
	10	11	12	13	14	15	16	17	18	19	20
20	30	36	45	51	60	66	....	....	....	....	....
22	33	41	50	57	66	76	87	....	....	....	....
24	36	45	55	64	73	85	95	....	....	....	....
26	40	50	60	71	80	94	103	....	....	....	....
28	44	54	66	79	90	102	111	....	....	....	....
30	48	58	75	86	100	110	120	136	150	168	185
31	50	62	79	90	105	114	125	141	156	176	193
32	53	66	84	94	110	118	131	148	162	184	200
33	55	69	89	98	115	123	137	155	169	192	208
34	58	73	94	102	120	131	143	162	175	200	217
35	61	77	100	106	125	136	149	169	183	209	226
36	64	82	105	110	130	139	155	176	190	218	235
37	67	86	109	115	135	144	161	183	200	227	245
38	70	89	114	119	140	151	167	190	212	236	256
39	73	95	118	124	145	157	173	197	220	245	267
40	75	98	121	129	150	165	180	204	228	255	279
42	80	104	128	139	160	176	193	218	244	270	300
44	....	......	135	150	171	188	207	233	261	289	320
46	....	......	......	......	182	200	222	247	277	307	340
48	....	......	......	......	......	......	236	261	293	325	361
50	....	......	......	......	......	......	......	......	310	344	382

TABLE NO. II.

CAPACITY OF SILOS — NUMBER OF COWS — DESIRABLE DIMENSIONS

Capacity of silo	Will feed for 6 months 40 lbs. per day	Most desirable dimension of silo in feet
30 tons	8 cows	8x30
36 "	10 "	9x28
40 "	11 "	9x30
44 "	12 "	10x28
48 "	13 "	10x30
50 "	14 "	10x31
55 "	15 "	10x33
65 "	17 "	11x32
75 "	21 "	11x35
85 "	23 "	12x32
95 "	26 "	12x35
105 "	29 "	13x35
115 "	31 "	14x33
125 "	34 "	14x35
150 "	41 "	14x40

(Tables Nos. I and II from Bulletin No. 287)

TABLE NO. III.

Cost of One Pound of Crude Protein in Common Concentrate Feeds

FEED	Percentage of Crude Protein	Pounds of Crude Protein per ton	Cost per pound of Crude Protein in Cents when the cost per Ton is:							
			$15	$20	$25	$30	$35	$40	$45	$50
Oats	12.4	248.0	6.0	8.1	10.1	12.1	14.1	16.1	18.1	20.2
Barley	11.5	230.0	6.5	8.7	10.9	13.0	15.2	17.4	19.5	21.8
Wheat	12.4	248.0	6.0	8.1	10.1	12.1	14.1	16.1	18.1	20.2
Corn	10.1	202.0	7.4	9.9	12.3	14.8	17.3	19.8	22.2	24.7
Peas	22.9	458.0	3.3	4.4	5.5	6.5	7.6	8.7	9.8	10.9
Linseed Meal (Old process)	33.9	678.0	2.2	3.0	3.7	4.4	5.2	5.9	6.6	7.4
Cottonseed Meal (Choice)	44.1	882.0	1.7	2.3	2.8	3.4	4.0	4.5	5.1	5.7
Gluten Feed	25.4	508.0	3.0	3.9	4.9	5.9	6.9	7.9	8.8	9.8
Wheat Bran	16.0	320.0	4.7	6.2	7.8	9.4	10.9	12.5	14.0	15.6
Shorts	17.4	348.0	4.3	5.7	7.2	8.6	10.0	11.5	12.9	14.4
32% Ready Mixed Feed	32.0	640.0	2.3	3.1	3.9	4.7	5.5	6.2	7.0	7.8
24% Ready Mixed Feed	24.0	480.0	3.1	4.2	5.2	6.2	7.3	8.3	9.4	10.4
20% Ready Mixed Feed	20.0	400.0	3.7	5.0	6.2	7.5	8.7	10.0	11.2	12.5

TABLE NO. IV.

Cost of One Pound of Crude Protein in Common Roughage Feeds

FEED	Percentage of Crude Protein	Pounds of Crude Protein per ton	Cost per pound of Crude Protein in Cents when the cost per Ton is:			
			$5	$10	$15	$20
Alfalfa Hay, 1st cut	13.9	278.0	1.8	3.6	5.4	7.2
Alfalfa Hay, 2nd cut	14.7	294.0	1.7	3.4	5.1	6.8
Red Clover Hay	12.8	256.0	1.9	3.9	5.8	7.8
Mixed Hay	8.6	172.0	2.9	5.8	8.7	11.6
Timothy Hay	6.2	124.0	4.0	8.0	12.0	16.0
Oat Straw	3.6	72.0	6.9	13.9	20.8	27.8

TABLE NO. V.

GESTATION TABLE FOR COWS

Date bred		Date due to freshen		Date bred		Date due to freshen	
January	1	October	8	July	1	April	8
"	5	"	12	"	5	"	12
"	10	"	17	"	10	"	17
"	15	"	22	"	15	"	22
"	20	"	27	"	20	"	27
"	25	November	1	"	25	May	2
"	30	"	6	"	30	"	7
February	1	"	8	August	1	"	9
"	5	"	12	"	5	"	13
"	10	"	17	"	10	"	18
"	15	"	22	"	15	"	23
"	20	"	27	"	20	"	28
"	25	December	2	"	25	June	2
March	1	"	7	"	30	"	7
"	5	"	11	September	1	"	9
"	10	"	16	"	5	"	13
"	15	"	21	"	10	"	18
"	20	"	26	"	15	"	23
"	25	"	31	"	20	"	28
"	30	January	5	"	25	July	3
April	1	"	7	"	30	"	8
"	5	"	11	October	1	"	9
"	10	"	16	"	5	"	13
"	15	"	21	"	10	"	18
"	20	"	26	"	15	"	23
"	25	"	31	"	20	"	28
"	30	February	5	"	25	August	2
May	1	"	6	"	30	"	7
"	5	"	10	November	1	"	9
"	10	"	15	"	5	"	13
"	15	"	20	"	10	"	18
"	20	"	25	"	15	"	23
"	25	March	2	"	20	"	28
"	30	"	7	"	25	September	2
June	1	"	9	"	30	"	7
"	5	"	13	December	1	"	8
"	10	"	18	"	5	"	12
"	15	"	23	"	10	"	17
"	20	"	28	"	15	"	22
"	25	April	2	"	20	"	27
"	30	"	7	"	25	October	2
				"	30	"	7

Normal period of gestation for a cow—283 days.
Extremes—265 to 300 days.

Table from Toole—"The Book of Live Stock."

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