CONTENTS

AGRICULTURAL COLLEGE AND DEPARTMENTAL BULLETINS

257	The more Important Fruit Tree Diseases of Ontario	J. E. Howitt. Lawson Caesar.
258	The more Important Fungus and Bacterial Diseases of Vegetables in Ontario	J. E. Howitt. D. H. Jones.
259	Books on Agriculture and Household Science	O. J. Stevenson.
260	Results of Co-operative Experiments with Farm Crops	C. A. Zavitz. W. J. Squirrell. A. W. Mason.
261	Wheat and Rye	C. A. Zavitz.
262	Sugar Beets	C. A. Zavitz. A. W. Mason.
263	Mushrooms	R. E. Stone.
264	Common Diseases of the Digestive Organs of Horses and Cattle	J. Hugo Reed.
265	Bacteria—Friends and Foes	D. H. Jones.
266	Cheese and Butter Making	Staff of Dairy School.
267	Farm Water Supply and Sewage Disposal	W. H. Day. R. R. Graham. D. H. Jones. H. L. Fulmer.
268	Farm Crops	C. A. Zavitz.
269	Hay and Pasture Crops, Grasses, Clover	C. A. Zavitz. W. J. Squirrell.
270	Judging Vegetables	A. H. McLennan.
271	The Apple Maggot	L. Caesar W. A. Ross.
272	Contagious Abortion in Cattle	C. D. McGilvray.
273	Community Halls	Dept. of Agriculture
274	Sheep	Wade Toole. J. P. Sackville.

BULLETIN 257] [DECEMBER, 1917

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

The More Important Fruit Tree Diseases of Ontario

J. E. Howitt and Lawson Caesar.

INTRODUCTION.

The object of this bulletin is to furnish all who are interested in fruit growing with information which will enable them to identify the more common diseases of fruit trees and to apply successfully the treatments which experiments and observations extending over a period of eight years have shown to be the most effective in each case.

WHAT FUNGUS DISEASES ARE.

The majority of the diseases of fruit trees are what are known as fungus diseases. It is important that those having to deal with them should understand fully the causes of such diseases, in order that they may apply intelligently remedies for their control. Fungus diseases are caused by plants known as fungi. These plants, unlike ordinary flowering plants, have no green colouring matter (chlorophyll), and are unable therefore to manufacture their own food. All their nourishment must be obtained from decaying animal or vegetable remains or from living animals or plants. Those fungi which derive their nourishment from living plants in so doing injure them in various ways and thus give rise to what are known as fungus diseases.

The bodies of fungi which cause plant diseases are usually very simple, consisting of very fine, delicate, thread-like structures (hyphæ), some of which become modified and produce reproductive bodies called spores, which may be considered similar to the seeds of flowering plants. Sometimes the fungus threads live upon the surface of the plants and obtain their nourishment by sending down little suckers (haustoria) into the cells below. Most frequently, however, they live within the plants, either in or between the cells. Two kinds of spores are frequently produced—thin-walled summer spores, which spread the disease during the growing season, and thick-walled resting or winter spores, which serve to carry the disease over the winter. Spores are scattered by various agencies, chief among which are wind, water and insects. On coming in contact with a suitable host plant they send out little threads (germ-tubes), which enter the plant through the breathing pores on the leaves (stomata), through the skin or through wounds. Once within the plant the little threads grow very rapidly, drawing their nourishment from the cells of the host plant and setting up a diseased condition.

Generally speaking, in combating fungus diseases methods of prevention only are practicable. Once a fungus is within the plant nothing can be done to destroy it. Spraying with lime-sulphur, Bordeaux mixture or other fungicide is not done to cure but to prevent disease. In other words, the object of spraying is to cover the surface of the leaves, fruits or other parts of the plant with a substance poisonous to the spores of fungi, in which they cannot grow and penetrate the plant. Spraying, therefore, in order to be effective, must be timely and thorough. The spray mixture must be on the tree before the spores reach it and the surface of the leaves, fruit and other parts of the plant must be completely covered so that there is not the smallest space on which a spore can germinate.

SPRAY OUTFITS.

Those who purpose buying a spray outfit and spray materials can find the addresses of the various manufacturers by looking over the advertisements in the *Canadian Horticulturist* and the various agricultural journals.

If there are only a few trees to spray, such as one finds in a back yard in a town or village, a small hand-pump, holding about five gallons of liquid, will suffice. This should be equipped with about twenty-five feet of good hose, a leakless stop-cock, an eight or ten-foot rod and a good disc angle-nozzle. Some companies manufacture a special rod and nozzle, so that by adjusting the latter the spray may be shot to the top of even a very high tree. A machine of this character with all the necessary accessories costs about $20.

For more than about a dozen large trees this small outfit is much too slow. If the orchard consists of not more than about six acres of large apple trees or of about ten acres of trees the size of a moderately large plum, cherry or pear tree, a barrel-sprayer will suffice. This, fully equipped, will cost from $20 to $40.

A double-action or duplex type of pump gives considerably more power than a single-action or barrel pump, and so will enable a person to cover more trees each day, especially if the pump is installed in a 120 or 160-gallon tank. This type of outfit without tank will cost from $40 to $65.

For all apple orchards larger than those mentioned above, a gasoline outfit is almost essential for good work. A power outfit of this type along with tank and trucks costs between $250 and $400.

Good care with any of these outfits will more than double their period of usefulness. Any kind of machine should be washed out each evening after spraying, and when the season's work is over should be well cleaned, oiled and put away in a dry place.

SOME SUGGESTIONS ON SPRAYING.

All trees should, of course, be pruned before they are sprayed, and large apple trees should be headed back to a reasonable height, care being taken in doing so to give them a symmetrical, umbrella shape. If San José Scale is present, the rough, loose bark should be removed from apple trees.

Good spraying continued year after year should usually result in from ninety per cent. to ninety-nine per cent. of absolutely clean, sound fruit. Unfortunately, not many of our fruit growers are good sprayers. The following are some of the chief reasons for this: First, their outfits are not kept in good condition to do rapid, thorough work; often the pump needs repacking or the hose is too short, or the nozzles are worn out or are the wrong kind. Second, they do not study the nature of the disease or insect they have to combat, and so do not recognize the importance of promptly spraying at the special times indicated in the spray calendar. A spray applied a few days too early or too late will often mean complete failure. Moreover, the omission of one or more of the regular applications will often mean cull fruit. Third, in many cases not nearly sufficient material per tree is used, frequently only about one-third of the proper amount. It is absurd to expect the spray to keep all of an apple free from scab if only half of its surface is covered by the mixture, or to kill all the San José Scale on a tree unless every particle of the bark is wet with the liquid. Fourth, the spray mixtures are sometimes not used at the strength recommended. Fifth, many men foolishly experiment with new mixtures instead of waiting until these have first been thoroughly tested by unprejudiced experimenters.

Before beginning to spray the machine must be put into good condition so that it will give good pressure and not leak. If two lines of hose are used, the one for the man on the ground should be from thirty to forty feet long, the other twelve to fifteen feet. The most satisfactory nozzles at the present time are those of the angle disc type. When the plates of these become much worn they should be replaced by new ones. If two nozzles are used on a T or a V they should not be set at a wide angle of divergence, but should be made to supplement each other and thus give a dense spray that will quickly wet the part being treated. Bamboo poles with aluminum rods inside are light and satisfactory if not roughly handled. A ten foot pole is about the right length for the man on the tower, and a six or eight ·ot one for the man on the ground. To prevent the drip running down the pole, a small rubber or leather disc about three or four inches in diameter, cut out of an old shoe or rubber, is helpful. It should be placed at the top of the rod just below the nozzle. Good pressure is necessary for speed and thoroughness. It should never be less than 100 pounds. With gasoline outfits about 150 to 200 pounds is high enough. Higher than 200 is more liable to cause leaf injury. The mixture in the tank must, of course, be kept well agitated to prevent settling.

When spraying, especially in the first application, it is desirable to take advantage of the wind. A strong wind is a great help, as it carries the spray right through the tree. If the wind is weak and the trees are wide apple trees, it is necessary that the man on the ground go in underneath the tree to the far side, and shoot the spray up upon the branches and twigs or foliage and fruit, and gradually work his way back to the outside. This is the only way in the case of large trees to make sure that the inner surface of upright twigs and small branches and later of he young fruits will be thoroughly covered, for they will not be reached from the ther side when the wind changes, except where the wind is very strong. It is on this inner side of young fruits that the scab nearly always first develops, hence the need of the step just indicated. In the case of San José Scale great care must also be taken not to miss the tip of the branches. This is a very common fault with many sprayers.

In many instances there is too short a period to justify a person's waiting for a change of wind; hence under such circumstances the best method is to drive the team facing the wind and shoot the spray in at right angles to the row. This is a little slower, but if care is exercised is satisfactory. Moreover, by coming back and going up the other side, also against the wind, it enables a person to finish the trees the same day.

Thorough spraying requires great care and constant study. One should follow always some system with each tree, otherwise he will be missing parts here and there. Sometimes the best way is to take the tree branch by branch. At other times it is better to move the rod slowly up and down and work gradually from left to right or right to left, seeing that everything is covered as one goes. The angle on the nozzles permits the spray being directed first in one way then back in the opposite way, so that both sides of a branch or of fruits may be more easily covered. Often both sides of the branch may be covered by holding the nozzles against the wind and allowing it to drive the spray back. An apple tree capable of bearing five or six barrels of fruit will usually require from eight to ten gallons of spray, especially for the Codling Moth or for San José Scale.

DUSTING TREES FOR INSECTS AND DISEASES.

Dusting fruit trees for insects and diseases. (Original.)

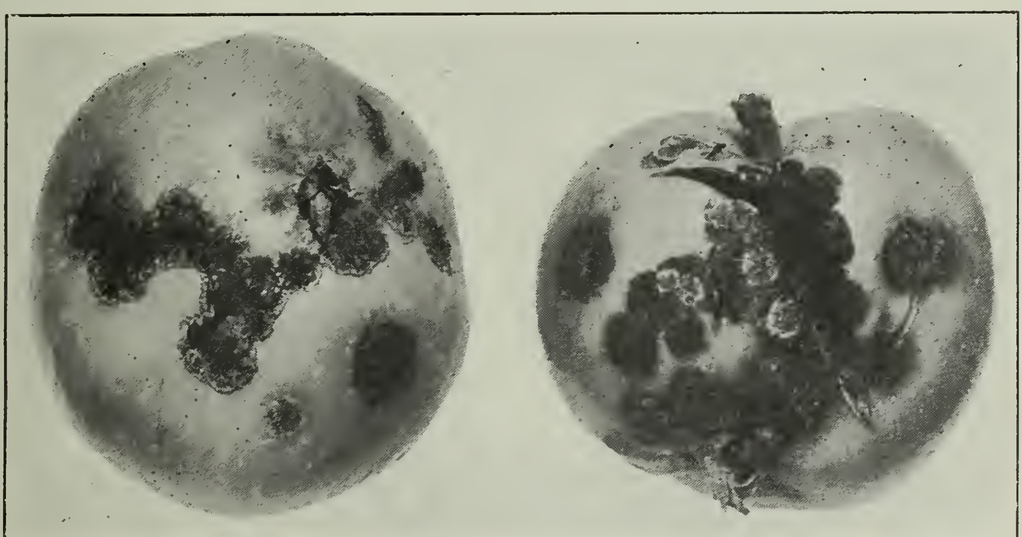
During the last few years considerable success has been obtained, especially in New York State, in treating trees with dust instead of liquid sprays. The dust used consisted of from 85 per cent. to 90 per cent. of very finely ground sulphur and 10 per cent. to 15 per cent. of the powder form of arsenate of lead. It is applied by means of a blower driven by a gasoline engine. (See figure.) This is a very rapid and clean way of treating trees. At least twenty acres of large apple trees can be done in one day. The above substances, however, are useless against San José Scale, and also against Aphids and Pear Psylla. Other dust materials to combat these are being manufactured, but their success is still uncertain. We ourselves have had only two years' trial of dusting, and are unable therefore to speak with certainty as to its merits.

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 Calendar from year to year. Hence every fruit grower should write each spring to the Fruit Branch, Toronto, and request a copy of the latest Spray Calendar, so that he may have the most up-to-date information available.

Apple Scab (*Venturia pomi, (Fr.) Wint.*)

This is the most common and most serious disease of apples in Ontario. It occurs wherever apples are grown, and the scab spots on the fruit and leaves are familiar to almost every fruit grower. In wet seasons it causes a financial loss of many thousands of dollars to the fruit growers of the Province. This is to a large extent a needless loss, for Apple Scab can almost always be prevented, no matter how wet the season may be, by thorough, timely and intelligent spraying. Such spraying, however, can only be done when the fruit growers understand the nature of the disease and how it is spread, and know the climatic conditions which favour the development of the fungus which causes it. Such knowledge is invaluable in the control of Apple Scab. It makes clear the necessity for thorough and timely spraying, and prevents the waste of time and materials which frequently occurs



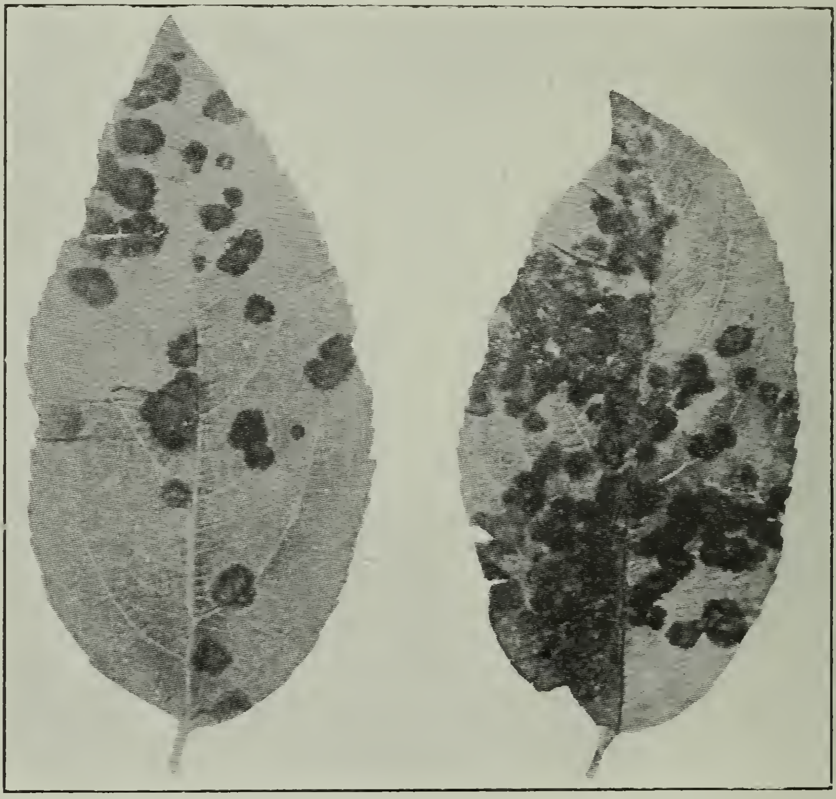
Apple Scab on fruit. (Original.)

through spraying when climatic conditions are such that there is no danger of scab developing.

Symptoms. Apple Scab affects the blossoms, fruit, leaves and sometimes the twigs. It is most conspicuous on and does most damage to the fruit and leaves. Scab may appear on the fruit during any stage of its development, provided climatic conditions are such as to render possible the spread and growth of the fungus which causes it. It may attack the stems of the very young fruits, causing them to drop and in this way very much reduce the crop. Frequently it attacks the base of the calyx of the blossom, and as this will become the fleshy part of the apple, an early infection of the blossoms causes the fruit to be scabby.

Frequently young fruits on which scab spots develop are stunted and misformed. Mature fruit is rendered unsightly and unsaleable by the conspicuous black and brown scab spots, often bordered with a greyish rim. In severe attacks there is sometimes a cracking of the fruit, such as is so often seen when Pear Scab destroys Flemish Beauty pears. Not only does the scab render the fruit unsightly, but it also makes it very subject to rot when placed in storage. If scabby apples are packed during moist, warm weather, or kept in a moist condition, a pinkish-white mould is very likely to develop around the edges of the spots. This soon causes a rotting, which markedly injures the fruit and makes it unpalatable. This is known as Pink Rot. Other rots such as the common storage rot, caused by blue moulds (Penicillium) and other fungi, also develop around scab spots on apples in storage. Such fruit is of course hard to market and can be sold only at a very much reduced price.

On the leaves Scab first appears as small, somewhat circular, olive-brown spots, on one or both surfaces. Under weather conditions favourable to the fungus, these increase in size, run into each other and become brown or black, so that a considerable portion of the leaf is destroyed. In severe attacks the leaves become crinkled and to some extent curled. Sometimes they fall, but more frequently they remain on the trees. The leaves are the food factories of the trees. The food



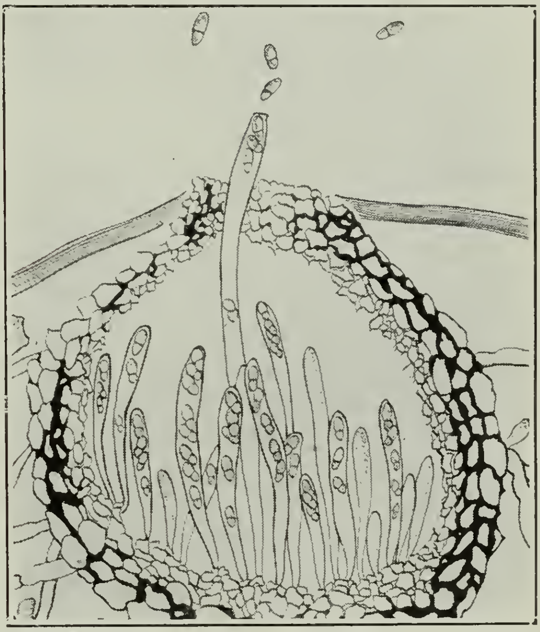
Apple Scab on leaves. (Original.)

manufactured by them is used for the growth of the fruit, stem and roots, and for the formation of fruit buds for next year. Hence severe injury to the leaves by Scab impairs the vitality of the trees and prevents the normal development of fruit buds and thus may reduce the crop below the average the following year.

On twigs the Scab is very seldom noticed in Ontario. Sometimes, however, following a severe attack of Scab on the leaves and fruit the previous year, dead and blighted twigs may be seen in spring on some of the trees. On the surface of such twigs elongated cracks or fissures filled with a brownish-black powdery substance can be observed.

Varieties of apples differ very much in regard to their freedom from Scab. It is a great help in controlling Scab to know something regarding the susceptibility of the different varieties, as the Scab is very much harder to control on varieties which are very susceptible to it than on those which are not. Common varieties of apples which are (*a*) very subject to Scab—Snow, McIntosh, Gravenstein, Early Harvest and St. Lawrence; (*b*) moderately subject to Scab—Spy, Rhode Island Greening, King, Baldwin and Ben Davis; (*c*) slightly subject to Scab—Duchess of Oldenburgh, Blenheim Pippin, Yellow Transparent, Tolman Sweet and Golden Russet.

Life History. The fungus which causes Scab passes the winter chiefly on the fallen leaves beneath the trees. If these are examined in the spring, small black dots or pimples will be seen projecting above the skin of the leaf on one or both sides. They vary in size from a mere speck to a pin head. Each is a fruiting body (perithecium) of the fungus, and contains numerous long, sac-like structures (asci), (See Illustration), each of which in turn contains eight two-celled spores (ascospores). When mature the fruiting bodies (perithecia) open by means of a minute pore, through which the spores are shot out from the sacs by a peculiar pop-gun-like arrangement. Moisture is necessary for the discharge of the spores, which takes place chiefly during the spring rains from about the time the leaf buds burst until the blossoms are opening. Some, however, are discharged much later than this. The spores which are shot up for a short distance from the leaf are extremely light, and are scattered here and there by the wind. Some of them reach the unfolding leaves or blossoms, and here, if there is rain or heavy mist for about two days, they germinate and send out a tiny thread-like structure (germ-tube), which penetrates beneath the skin of the leaf or the calyx of the blossom, which afterwards becomes the flesh of the apple. Moisture is essential not only for the germination of the spore but also for the further development and penetration of the germ-tube. It is, therefore, only when we have a period of two or three days' rain or heavy fog that the fungus can gain entrance to the leaves and fruit.



Section of Fruiting Body (Perithecium) of the Apple Scab fungus, showing the discharge of the spring spores (ascospores). (After Wallace.)

About ten days or two weeks after the spores from the fallen leaves have germinated and the germ-tube has penetrated beneath the skin of the leaf or young fruit, the first scab spots of the season are observed. These if examined with a microscope are found to be composed chiefly of spores and fungus threads. The spores are right on the surface of the scab spots, the fungus having developed under and pushed off the outer layer (cuticle) of the skin of the fruit or leaf. The spores are thus readily scattered through the orchard by wind, rain or insects. If the weather is dry and warm they can do no harm, but if a period of wet weather comes those that are on the leaves or fruits germinate and the germ-tube penetrates the leaf or fruit, and in ten days or two weeks another crop of scab spots is developed. The spores from these may in turn give rise to more scab spots containing spores, so that there may be several successive generations of spores during the season. By means of these spores the scab is spread through the orchard during wet weather. A single shower is not sufficient to cause the spores to germinate and penetrate the leaf or fruit. Observations indicate that it requires two days of wet weather—

rain, heavy fog or mist—for the spores to germinate and the germ-tube to get under the outer layer of the skin of the leaf or fruit. Frequently the fruit grower thinks that the scab spots have all developed in a day or two, not realizing that the fungus must have been living in the leaf or fruit for nearly ten days or more before the scab spots appeared on the surface.

Moisture being essential to the development and spread of the scab fungus, it can be easily understood that it is during the spring of the year that there is the greatest danger of infection. At this season wet weather is frequent, and often prolonged. The days are short, the nights long and cool, so that the leaves and fruit may remain covered with moisture for a long time after each rain. The fruits at this time are small and covered with hairs which hold moisture much more readily than the smooth skin of the more mature apples. Such conditions favor the development and spread of the fungus, and so there is great danger of scab becoming prevalent at this time. In seasons of average weather conditions for Ontario, the period when most infection occurs is from the time when the blossoms are showing pink until about two weeks after the petals fall. Sometimes, however, serious infection occurs earlier than this time, when the leaves are unfolding, or again it may be later, about the end of June. So May and June are nearly always the months when there is the greatest danger of scab becoming serious. During July and most of August the scab fungus can rarely develop, because at this time there is not sufficient moisture, as prolonged wet periods seldom occur and the days are long and the nights short and warm, so that the leaves and fruit are quickly dried even after heavy showers. In late August and in September, however, prolonged cool, wet weather may occur, and at this time there is danger of late infections.

Prevention. Apple Scab can be prevented by timely and thorough spraying in combination with the proper pruning of the trees. Spraying must be done at the right time. The spray mixture must be on the leaves and fruit before the spores reach them. We have already learned that the spores only develop during wet weather. The times of the year, therefore, when we get our wet weather are the times we have to spray if we are going to prevent Scab. One spraying with either lime-sulphur or Bordeaux mixture is not sufficient to prevent Scab, as the rain gradually washes the spray off and as the leaves and fruit by growing larger develop more surface to cover. In order to be sure of preventing the disease, we must spray from three to six times during the season, the number of sprayings depending upon whether the weather is wet or dry. The first spraying should be done just as or soon after the leaf buds burst. For this application concentrated lime-sulphur at the regular strength recommended for the dormant wood spray, namely, specific gravity 1.035 (=1 gallon commercial to 7 gallons of water) should be used unless the grower is certain that there is no San José Scale in the orchard and very little Oyster Shell Scale. If he is sure as to this, a weaker solution may be used, of the strength 1.020 specific gravity (=1 gallon commercial lime-sulphur diluted to about 15 gallons with water). There is little danger of burning the foliage with either of these strengths of lime-sulphur provided the spraying is all completed before the little leaves have reached the size of a ten-cent piece.

The second spraying should be given just before the blossoms open, that is, just when they are showing pink, using concentrated lime-sulphur, strength 1.010 or 1.009 specific gravity (=1 gallon commercial to from 30 to 35 gallons of water), or Bordeaux mixture, 4.4.40 formula.

In average seasons the third application should be given immediately after the blossoms have all or nearly all fallen, with a concentrated lime-sulphur solution, strength 1.009 or 1.008 specific gravity (=1 gallon commercial to from 33 to 40 gallons of water). This is generally the most important spray for the control of Apple Scab and always for Codling Moth, and it must be promptly applied, as a delay of a day or two may make all the difference between success and failure.

In some years there is a long period of cold wet weather between the date when the blossoms begin to burst and that when they fall. Sometimes the length of this period is three or four weeks. In such cases it is necessary to give an intermediate spraying between the second and third. Hence if the grower finds at the end of twelve days or two weeks after he has applied the second spray that the weather is still cold and wet, and development of the blossoms is very slow, another spraying should be given at once to protect the young blossoms and foliage. This should be of the same strength as for what is ordinarily the third application, but poison should be omitted because of the bees. It is very important to observe carefully the weather conditions and apply this spray when necessary. Failure to do so may result in the apples being scabby in spite of the regular sprayings being given.

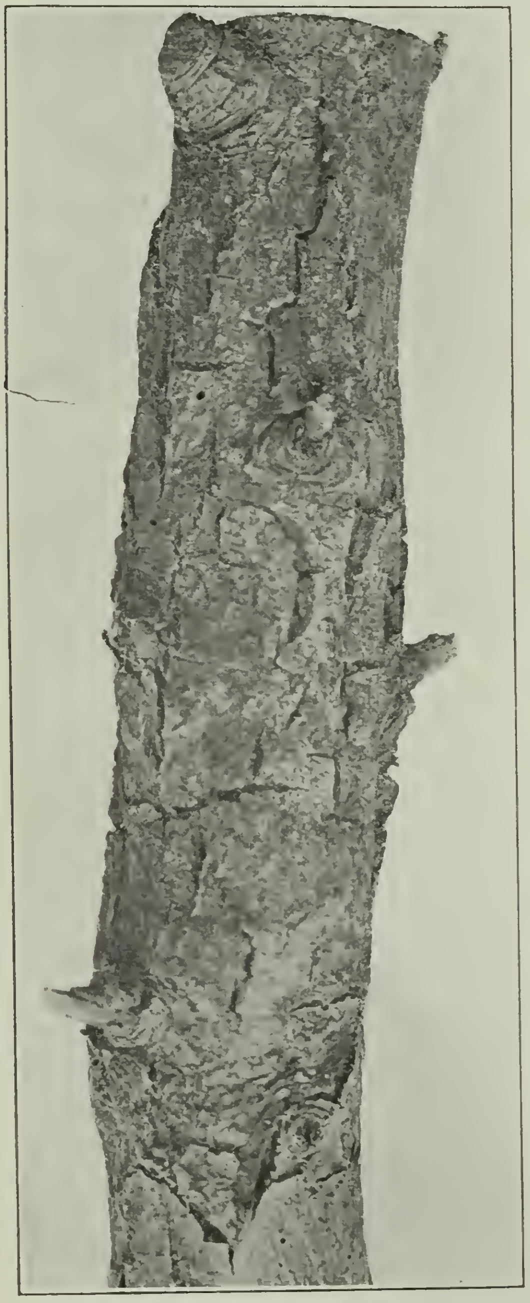
If June is cold and wet another spraying about ten days or two weeks after the third regular spraying will be necessary. The solution for this application should be of the same strength as that for the third, or slightly weaker, for example, 1 gallon of the commercial to not more than 40 gallons of water. No poison is necessary unless the Codling Moth or the Plum Curculio is specially troublesome. Bordeaux mixture is also satisfactory for this application.

Spraying in early August is an insurance against late infection of Apple Scab and Sooty Fungus. In wet autumns such spraying is necessary to prevent late attacks of Scab, especially with varieties such as McIntosh Red and Snows, which are very susceptible to Scab. For this application use a weak lime-sulphur solution, such as concentrated lime-sulphur, strength specific gravity 1.008 or 1.007, which equals commercial lime-sulphur 1 gallon to 40 or 45 gallons of water, or Bordeaux mixture. No poison should be used at this time. Often if the spraying is done later than the first or second week in August there is a chance of the fruit being discoloured at picking time. Should the dust method prove satisfactory it could be used at any time in the fall without danger of staining the fruit. If the early sprayings are thoroughly done, and the fall is not extremely wet, usually the crop will remain clean without this last application. Hence every man will have to use his own judgment in regard to it.

Thoroughness in Spraying. Very few men spray thoroughly enough to get the best results. The object of spraying is to cover the surfaces of the leaves and fruits with a good fungicide (a substance which destroys the spores of fungi), such as lime-sulphur or Bordeaux mixture, so that when a spore reaches leaf or fruit it is destroyed and cannot grow and cause Scab. We see therefore that if spraying is to accomplish its object it must be very thoroughly done; every fruit and leaf must be completely covered with the fungicide so that there is not the least space on which a spore can germinate. Thorough spraying necessitates the liberal use of the spray mixture. A large apple tree will require from six to ten gallons or more to cover it properly. Care must be taken to reach every side of the young forming fruit or (in other words) of the calyces or flower cups which develop into the fruits. If a tree is examined for Scab before the fruit is an inch in diameter, nearly all of it will be found on the more sheltered side, that is, the side facing the centre of the tree, because that is the side most protected from wind and sun, and hence the side which retains the moisture the longest. Later when the fruit grows larger it bends over and these Scab spots will thus be seen on the outer side. This fact emphasizes the necessity of being sure to spray thoroughly the centres as well as the outsides of the trees. In order to do this it is necessary, except in the case of small trees, to send the man on the ground in underneath the trees, so that he may shoot the spray up into them from beneath as well as do all the lower outer parts.

Pruning. Good pruning before spraying makes it easier in three important ways to control Apple Scab. First, it is almost impossible to spray thoroughly a large tree with numerous, thickly clustered branches, because the superfluous branches interfere with the mixture reaching all sides of the fruit and foliage; second, it costs less to spray a well pruned tree, because fewer gallons of mixture are necessary; third, well pruned trees let in the light and allow a free circulation of air much better than unpruned trees, and thus the moisture which is so favorable to the development of the Scab fungus will dry off more quickly. Scab and Sooty Blotch for this reason will almost always be worse on unpruned trees.

BLACK ROT CANKER, BLACK ROT AND LEAF SPOT (*Physolospora cydoniae, Arnaud*).



Black Rot Canker on branch. (Original.)

This disease is found in most parts of the Province, and is worst generally in poorly cared for and neglected orchards. In the apple growing districts east of Toronto it has caused serious injury to apple trees and much alarm to the growers. In that part of the Province, however, it is not by any means confined to neglected orchards. Observations and experiments show that the fungus causing Black Rot Canker is unable to penetrate healthy bark, and can gain entrance and produce cankers only through wounds due to various causes, such as winter injury, sunscald, carelessness in cultivation, pruning and picking of the fruit. Varieties of apples which are most susceptible to Black Rot Cankers are those which are too tender for the district and so suffer severely from winter injury and sunscald.

The fungus which causes Black Rot Canker is not confined to the apple. It is recorded as affecting pear, quince and other trees, but the writers have not observed it at least to any appreciable extent in Ontario on any host but the apple.

Symptoms. This disease attacks the trunk, branches, leaves, fruit and sometimes the twigs, but causes most damage by the cankers produced on the trunk and larger limbs. On the leaves circular spots from one-eighth to one-quarter of an inch in diameter are produced. These are brown in the centre, with a distinct purplish margin. Towards the centre of these spots the minute black fruiting bodies (pycnidia) of the fungus can often be seen by a careful observer. The leaves are seldom severely injured by these spots, but frequently they are plentiful enough in unsprayed orchards to attract the attention of the grower.

On the fruit a small brown spot first appears. This gradually increases in size until the whole fruit becomes rotten, brown and later black. The surface becomes covered with minute black fruiting bodies (pycnidia), which helps to give to the rotted fruit a black appearance. For some time the infected fruits remain firm and retain their normal form, but finally shrivel. These black, shrivelled fruits are frequently seen hanging on the trees or lying on the ground beneath. In Ontario, the rotten fruit in the orchard is not abundant and is seldom noticed by the grower. In storage also, so far as our observations go, the Black Rot on the fruit attracts but little attention.

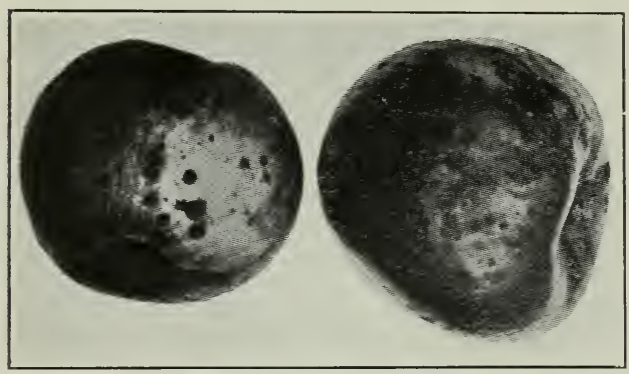
On the trunk and larger limbs discoloured areas appear on the bark. These may increase in size, forming large cankers, which with age become cracked, rough and black. These cankers may be only a few inches long, or they may be a yard or more in length. They are usually found on the south-west side of the trunk and on the upper side of the larger limbs, these being the parts of the tree that are most likely to suffer from sunscald and winter injury. In many cases the cankers gradually enlarge, extending completely around the trunk or branch, and penetrating through the bark to the wood, thus girdling the part attacked. The cankers in this way frequently destroy the larger limbs, and when they occur on the trunks, which they very often do, may cause the death of the whole tree. Sometimes the cankers remain small. Frequently even the larger ones do not penetrate deeply, and cause merely a superficial roughening of the bark, which in time may disappear. Embedded in the bark of the cankers small, black, pimple-like structures may be seen with the naked eye. These are the fruiting bodies (pycnidia) of the fungus.

Life History. The fungus causing this disease is carried over winter as fungus threads (mycelium) in the cankers, and also as numerous spores contained in the fruiting bodies (pycnidia), which are seen in abundance embedded in the skin of the rotted apples, the bark of the cankers, and to a less extent in the spots on the leaves. These spores are discharged from the fruiting bodies (pycnidia) during the spring and early summer. As has been stated before, observations and experiments show that infection can only take place through wounds, the spores being unable to infect sound and healthy tissue. Winter injury, sunscald, carelessness in cultivation, pruning and picking of the fruit, or other causes make wounds through which the fungus gains entrance to the bark and finally spreads and causes cankers. Varieties which suffer from winter injury and sunscald are very subject to Black Rot cankers, because it is chiefly through such wounds that the fungus gets a start in the healthy bark.

Treatment.—Plant only those varieties which are known to be hardly in the district where they are to be grown. Keep the trees thrifty by proper pruning and cultivation. In districts subject to extreme cold during the winter months, do not cultivate later than the middle of June, then sow a cover crop. Such treatment will check the growth of the trees and cause the wood to harden for winter. Cut out all cankers on the trunk and larger limbs, except those that are merely superficial. Use a draw-knife for this purpose and cut back to healthy bark, taking care to leave the edges of the wound smooth, even and perpendicular. Wash the wounds thoroughly with concentrated lime-sulphur or with bluestone, one pound to ten gallons of water, and paint over with coal tar or white lead mixed with linseed oil without turpentine. White lead checks and cracks, and if it is used the wounds will have to be painted over two or three times. Coal tar does not check or crack, but slightly discolours the bark around the edges of the wounds. The writers, however, have never noticed any serious injury to the bark from the use of coal tar on apple trees. Badly cankered trees, which would be dead in a year or two if neglected, can in many cases be saved by cutting and treating the cankers as described above. In pruning it is often advisable to cut out and burn large limbs which are badly cankered, if this can be done without causing too much injury to the tree. Sometimes, when it is necessary to remove a badly cankered main limb, a sucker nearby can be left to grow and take its place. Proper spraying is also of importance in controlling this disease. Spray at the regular times indicated in the Spray Calendar for the apple. The first or so-called dormant wood spray with concentrated lime-sulphur, specific gravity 1.030 to 1.035 (=1 gallon to 7 to 9 gallons of water), is especially important in the prevention of cankers, and care should be taken to see that the trunk and main limbs are all thoroughly covered at this time. This application, combined with the other sprayings when the trees are in leaf, will completely prevent the spotting of the leaves.

Sooty Blotch and Fly Speck (*Leptothyrium pomi, Mont. & Fr. Sacc.*).

This disease frequently disfigures apples, and by so doing much reduces their market value. It does not usually appear until late summer or early fall, and only becomes prevalent enough to cause serious disfigurement of the fruit when the weather is specially damp at this time of the year.



Sooty Blotch. (Original.)

Symptoms. This disease is easily recognized by the characteristic irregular sooty blotches which the fungus causes upon the fruit. These may be few and scattered or numerous, and often coalescing so as to give a sooty appearance to a considerable area of the surface of the apple. This form of the disease is known as Sooty Blotch. The other form, commonly called Fly Speck, is recognized by the small, black, shining specks on the surface of the fruit. These are frequently very numerous and clustered together in large groups so that they noticeably disfigure the skin of the apple. Both forms of the disease may be present on the same fruit. Affected apples are disfigured and rendered unattractive, but the flesh is not injured as the fungus does not penetrate below the skin.

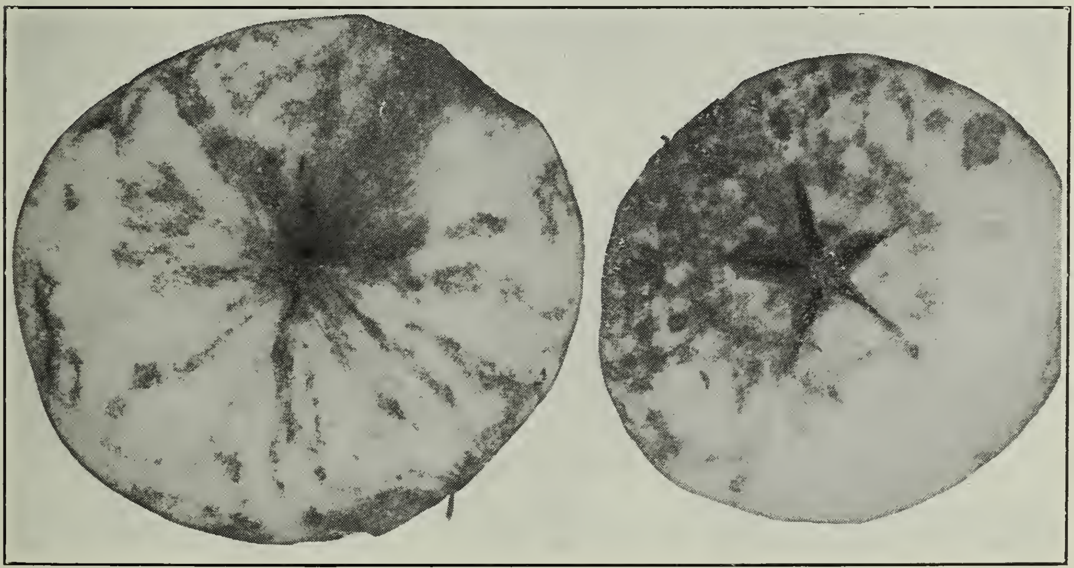
Prevention. Prune the trees to let in plenty of light and air, as the disease is always worse where too dense foliage keeps the fruit damp for a long time after every shower and heavy dew. Spray the trees in the spring as recommended for the prevention of Apple Scab and spray again the first or second week in August. For this last spraying use concentrated lime-sulphur, strength specific gravity 1.008 or 1.007 (=1 gallon of commercial lime-sulphur to 40 or 45 gallons of water). No poison should be used with this application.

Stippen, Baldwin Spot, or Bitter Pit.

This disease is frequently seen in Ontario. The Baldwin and Spy are particularly subject to it, but it is by no means confined to these varieties.

Symptoms. Small, sunken, dark spots, from one-sixth to one-quarter of an inch in diameter are seen on the surface of the fruit. The skin of the spot is usually unbroken. The flesh beneath is dead and brown, and frequently similar brown spots and streaks are scattered through the interior of the fruit. Very often apples may be badly affected in this way without showing the characteristic

Stippen or Bitter Pit. (After McAlpine.)

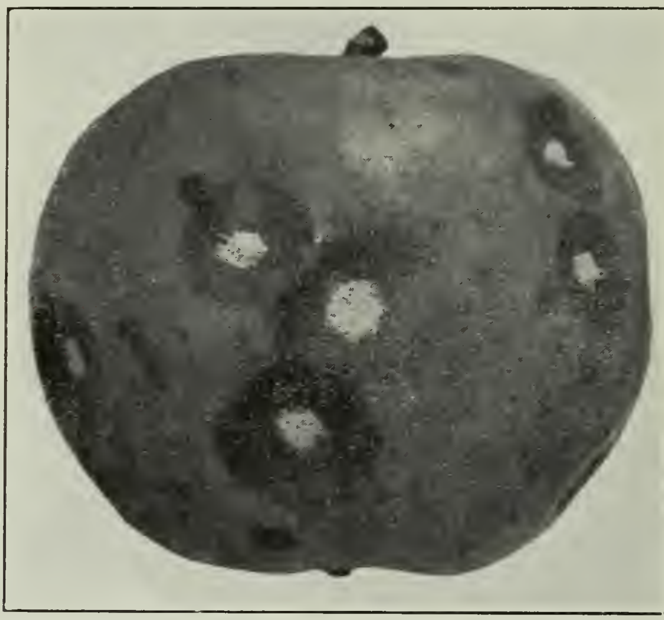


Internal Stippen. (Original.)

pits on the surface. This form of the disease may be referred to as internal stippen. So far as one can judge, it occurs early in the growing season and is mistaken frequently for the work of the Apple Maggot, which it resembles to some extent. Occasionally fruits may be deformed, due to the extreme development of internal stippen. Frequently, apples apparently sound when picked develop the external form of the disease in storage.

No fungus has been found to account for this disease. Though a great deal has been written about it there appears to be very little exact knowledge concerning its cause and prevention. It is thought to be due to extreme variations in the water supply to the trees during the growing season, which tend to check and stimulate alternately the growth of the fruit. Internal stippen appears to be worse in seasons when there is plenty of rain during the spring and early summer, followed by a sudden and severe drouth. On the other hand, the typical surface stippen appears to be worse when we have severe drouth in July and August, followed by heavy rains. Probably the water-holding capacity of the soil has an important bearing on the occurrence of the disease. Sometimes a few trees in an orchard develop stippen year after year, while others of the same variety remain free from it. It appears in certain orchards to a greater or less extent every year, while other orchards in the same district and containing the same variety of apples apparently remain free from it.

Prevention. So far as is known, very little can be done to prevent this disease beyond adopting those horticultural practices which tend to an even, normal



Pink Rot following Apple Scab. (Original.)

development of the fruit throughout the season. Such practices include the thorough under-draining of the orchard, proper fertilizers, as may be required, good cultivation during the spring and early summer, cover crop sown not later than the end of June, at least in the colder districts, thorough and timely spraying and careful pruning. Trees that are subject to stippen year after year might with advantage be mulched with barnyard manure about the first of June. This will conserve the moisture and insure an even and steady development of the fruit.

Pink Rot (*Cephalothecium roseum* (*Cda.*))

Pink Rot is chiefly a storage trouble, succeeding Apple Scab. It is found on scabby apples which have been packed during moist weather or stored in a damp place. The fungus which causes this rot cannot penetrate the sound skin of the apple, and can gain entrance to the flesh only through scab spots or other wounds. Greenings and Snows are particularly subject to Pink Rot.

Symptoms. A whitish mould sometimes with a distinct pinkish tinge develops around or upon the scab spots. This is followed by a brown rotting around the spots, which markedly disfigures the fruit and renders it unpalatable.

Prevention. Spray thoroughly to prevent Apple Scab. Pink Rot never causes serious injury except to scabby apples. In packing, discard any fruits showing signs of white mould. Store the fruit in a cool dry place as soon after picking as can be done. If possible pick and pack when the weather is cool and dry.

Pear Blight (*Bacillus amylovorus, Burrill*).

This destructive disease is usually known by the above name, but fruit growers speak of it also as Blight, Fire Blight, Twig Blight, Blossom Blight, and, when it infests the trunk, as Body Blight.

It attacks not only pears, but also apples, crab apples, quince, mountain ash, hawthorn and juneberry. The last three are rarely much affected, but pears,

Young pear orchard in early spring, showing blighted branches. The presence of the leaves indicates where the disease is. (Original.)

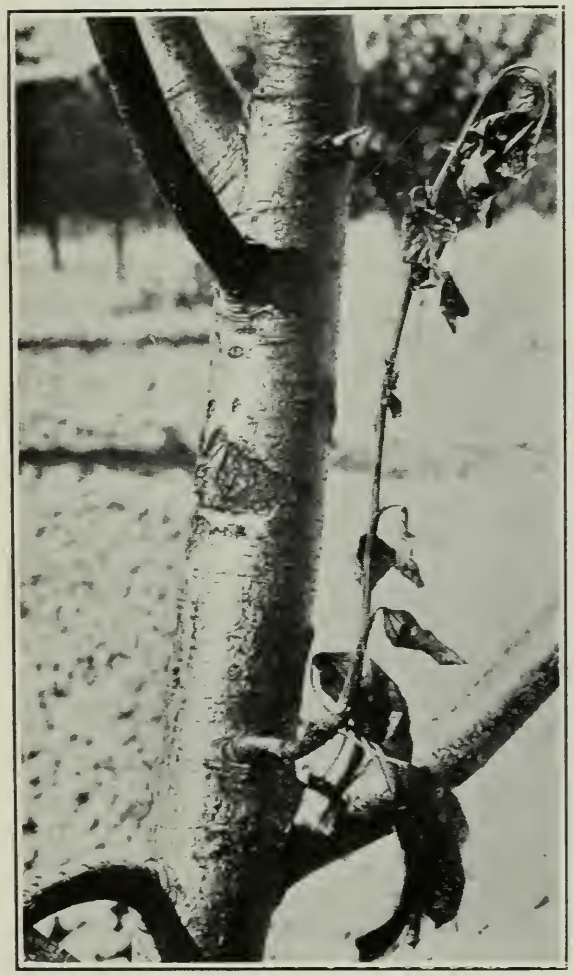
apples, crabs and quince suffer severely in seasons favourable for the development of the organism. So destructive is the Blight to pears that many good orchards have been almost totally destroyed by it; in fact so great has been the loss that in many districts fruit growers have given up pear growing in the belief that they cannot successfully cope with the disease. Apples do not suffer so severely as pears, yet some varieties, even of large, bearing trees, are much injured, and young, rapidly growing trees of very susceptible varieties are not infrequently killed. All varieties of quince are much damaged by the killing of branches and twigs, though trees themselves are not often killed.

The disease is found in nurseries as well as in orchards.

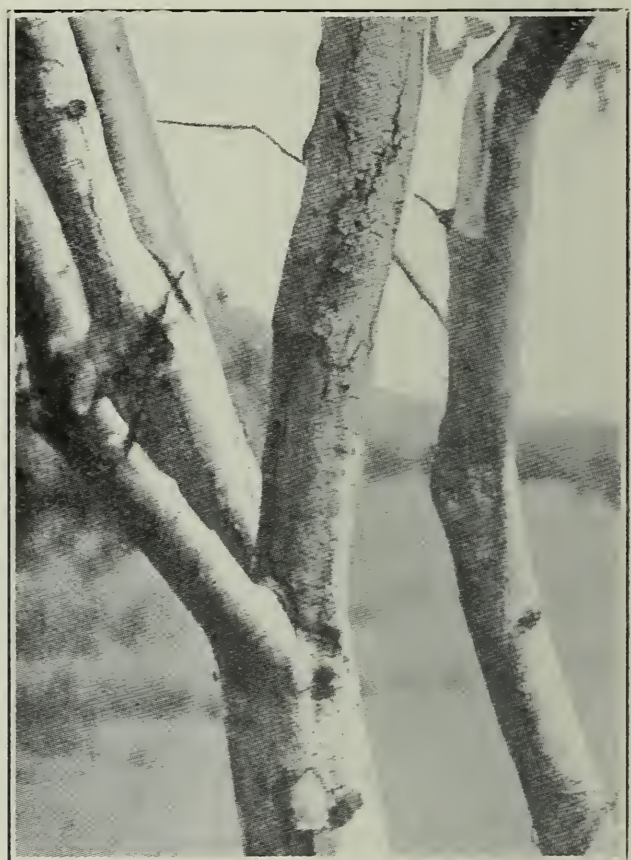
In pears and apples there is a considerable amount of difference in the susceptibility to attack of the different varieties. It is generally agreed that Clapp's Favorite is the most susceptible pear, and that Bartlett and Flemish Beauty are also very subject to attack, whereas Kieffer is least susceptible and Seckel is usually not severely injured. Of apples, Tolman, Gravenstein, Rhode Island Greening, Alexander and King are among the most susceptible, while Spy, Duchess and Ben

Davis are among those least attacked. No variety, however, either of apples or pears, is entirely immune, especially to infection through the blossoms, even Kieffer pears often being attacked in this way.

Symptoms. The disease manifests itself in many forms. (1) In June we often find numerous wilted and dying young fruits with their enveloping leaves. After a few days these leaves turn brown on apples and nearly black on pears and become very conspicuous. There may be hundreds of such dead little twigs and fruit spurs on a single apple or pear tree. In all or almost all such cases the organism was introduced by insects into the blossoms and by working back through the fruit stems into the twigs killed both fruit and twigs. This blossom inoculation is the greatest source of infection and largely accounts for later troubles.



Blighted twigs on pear trunk. The disease runs down such twigs and enters the trunks or branches. (Original.)



Main limbs of a Flemish Beauty pear tree, O.A.C. orchard, in which the blight is rapidly spreading. The limb to the right is practically dead. Notice the cracking and blistering of the bark, especially on the middle limb. All the disease above the crotch developed this season from the cankered area below the crotch. It spread throughout the bark very rapidly during June, July and August. Photo taken in September. (After Jones.)

(2) Throughout the remainder of the season the twigs, suckers, water-sprouts and branches die, their leaves remaining attached instead of dropping to the ground. The death of these parts is caused by the organism working down from the fruit spurs and twigs that had been previously infected, through the blossom or through fresh infections introduced by sucking or other insects.

(3) Not infrequently the trunks and main branches become infected as the result of the disease continuing down from smaller branches or from getting into a water-sprout and running down into the trunk or as the result of direct inoculation by some bark or wood infesting insect. Roots of trees may also become inoculated through infected suckers. On these diseased branches and trunks, especially on rapidly growing pear trees, the bark in many cases becomes swollen, spongy, and after a time shows on its surface drops or little masses of a gummy exudate which is at first nearly colourless, but soon turns brown. This liquid substance is sticky, contains millions of the disease organisms, and by being visited by various kinds of insects, to the legs, mouth parts or other structures of which it becomes attached, serves as a great source of contagion for the rest of the orchard. Exudate may occur also on twigs or any other infested part. If affected bark is cut with a knife it will usually be seen to be streaked beneath the surface with brown or reddish-brown. After a time the diseased bark dies, shrinks and cracks away from the neighbouring bark. In the case of pears, if the organism once becomes established in a large branch or in the trunk, it will usually continue to develop until it kills the tree if not treated; but in the case of apples, even though it may pass down a water-sprout or branch into the trunk or larger branches and kill areas of the bark there which may be several inches in diameter, it will in most cases ultimately die without killing the tree itself. The dead areas or "Blight Cankers" as they are called, may later be invaded by the Black Rot fungus, increase in size and result in considerable damage to the tree.

(4) Occasionally the fruit is attacked at any time throughout the growing season and killed.

Cause. The disease is caused by a very tiny organism, a bacterium, known as Bacillus amylovorus. This is so small that at least 10,000 individuals could find room on the head of a pin. These germs work chiefly in the tender tissues of the bark and have marvellous powers of multiplying. Millions may be produced from a single one in a day. They feed on the food substances found in the living bark and soon kill the part affected. Warm, moist weather, which causes rapid growth and abundance of sap, favours greatly their development, whereas drought soon checks them and may even cause their death. As the bark tissue in apple trees is harder and less succulent than in pears this seems to explain why the disease usually dies out in the larger branches and trunks of apples, so that most injury to apples is due to the blossom infection destroying the young fruits, twigs and smaller branches.

Means of Distribution. As stated above, insects serve as the chief means of distribution. During the winter the organism lives in the healthy bark that bounds the dead areas. In spring with the rise of the sap the germs multiply, clog the tissues of the bark and cause a gummy exudate on badly infested trees, though this is often not easy to find. Ants are very fond of this exudate and by feeding upon it cause their legs and mouth parts to become infested with germs. They are also very fond of the nectar of the blossoms; and hence can readily inoculate them on a diseased tree. Bees and other insects also visit the inoculated blossoms and in turn carry the organism to blossoms on other trees. Doubtless other insects besides ants may serve as the direct original inoculators of the blossoms, but none seem to be so fond of the exudate as they.

Later in the season the exudate is much more abundant on the various twigs and other affected portions, so that sucking or bark infesting insects are much more liable then to become contaminated and act as carriers to healthy trees.

Methods of Control. It requires a careful, observant man to keep Pear Blight in control, so that this work should never be entrusted to anyone else. The first step is to go carefully through the orchard after the foliage has fallen in autumn, or at least before there is any movement of sap in spring, and cut out all diseased branches, cutting always when practicable several inches below the dead portion. If there are diseased areas on the trunk, these can in many cases be removed successfully by a drawknife and stout pocket knife or chisel, care being taken to remove all bark until the healthy bark with no brown or reddish streaks in it is reached. Often dead looking areas on the trunks and larger branches are not caused by Blight, but are due either to a natural dying of the outer bark or to winter injury or some other cause. By cutting through these it will usually be seen that the inner bark and cambium are alive, and thus one can see that they are not blighted. If these doubtful areas are left until many trees have been studied the operator will soon learn in most instances to diagnose the case correctly. The orchard should again be inspected carefully about the first week in April or a little earlier to see that no diseased parts have been overlooked. Any cuts made at this time of the year or later should always be disinfected with corrosive sublimate, 1 part to 1,000 parts of water, or 1 tablet in 1 pint of water. This can be applied by means of a bottle with a little piece of sponge instead of a cork in the opening. The pruning implement must also be disinfected after each cut. (*Remember that corrosive sublimate if taken internally is very poisonous.*) All prunings should be removed promptly and burned lest they act as a source of contamination. *The great object of this early inspection is to remove all traces of Blight so that insects will not be contaminated and spread it to the blossoms in the spring.*

The next step in control is to watch for the first signs of the wilting of the young fruits and leaves on twigs and fruit spurs after the blossoms have fallen. Prompt attention here is very essential, for upon the rapid destruction either by breaking off or cutting out of these infested twigs before the disease can pass down them into the larger branches, depends the success of the later steps. Much of this work can be most readily done from a dray driven along close to the trees. The trees for a week or two at this time of the year will have to be inspected every day or two until all traces of the Blight have been removed. After this in good growing weather a weekly inspection is desirable or in very dry weather a bi-weekly inspection. In cutting out any of these twigs or branches it is very important to cut a foot or eighteen inches below where the disease shows on the bark, otherwise in many cases the germs will not all be removed. Usually it will require only a very short time if the Blossom Blight has been thoroughly removed, to make the later inspections. One man can sometimes inspect ten acres of pears in a few hours.

Young apple trees, crabs and quince should receive the same attention as pears, but on large apple trees it is often impracticable to remove Blossom Blight. On these, however, it will usually be found that the disease soon dies out without running more than a few inches down the stem. On very susceptible varieties, if the larger branches are being attacked, the disease should be cut out as on pears.

As a very succulent condition of the bark favours the Blight, it is usually not desirable to prune pear trees heavily or to cultivate more than is necessary to give fair-sized fruit.

Suckers and water-sprouts on the trunk and main branches of pears and young apples should be promptly removed to prevent the disease getting into these and passing down into the older portions or to the roots.

Though no variety is entirely immune, it is not wise to plant Clapp's Favorite, as these trees are so extremely susceptible to attack and so favourable to the rapid growth of the organism that it is very difficult to save them.

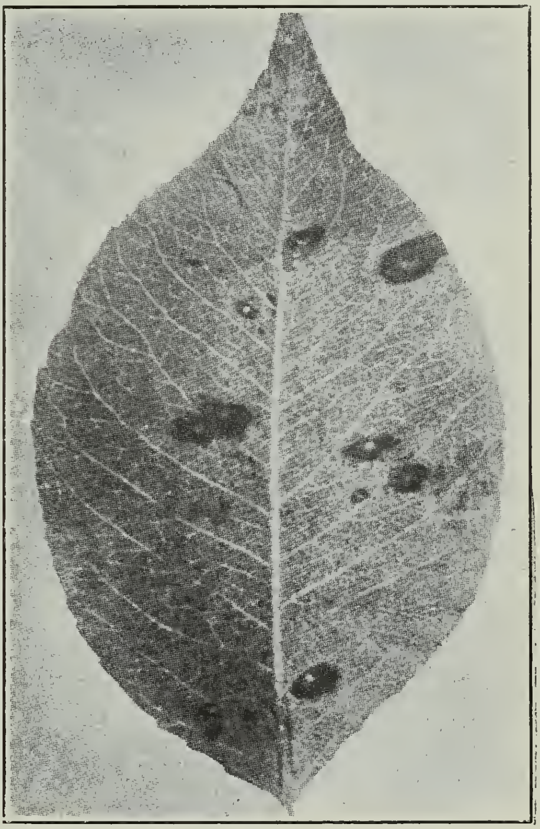
The plan of planting Kieffers and later budding or grafting Bartletts or other desirable varieties on the branches of these seems a rational one; for in such cases even if the organism attacks the twigs or branches it is not likely to kill the tree, because of the resistant nature of the Kieffer trunk and main branches.

As a rule control of blight on pears will be simplified by planting the pears at a considerable distance from other pear, apple or quince orchards.

Pear Scab (*Venturia pyrina, Aderh.*)

Pear Scab is similar in nearly every respect to Apple Scab. In Ontario only the Flemish Beauty and a few of the less valuable and often unnamed varieties of

Pear Scab on fruit. (Original.)



Leaf Spot on pear. (After V. B. Stewart.)

pears are very subject to it. Scab is a great drawback to the otherwise valuable variety, Flemish Beauty. When the fruit is badly affected it is cracked open and rendered almost valueless for commercial purposes.

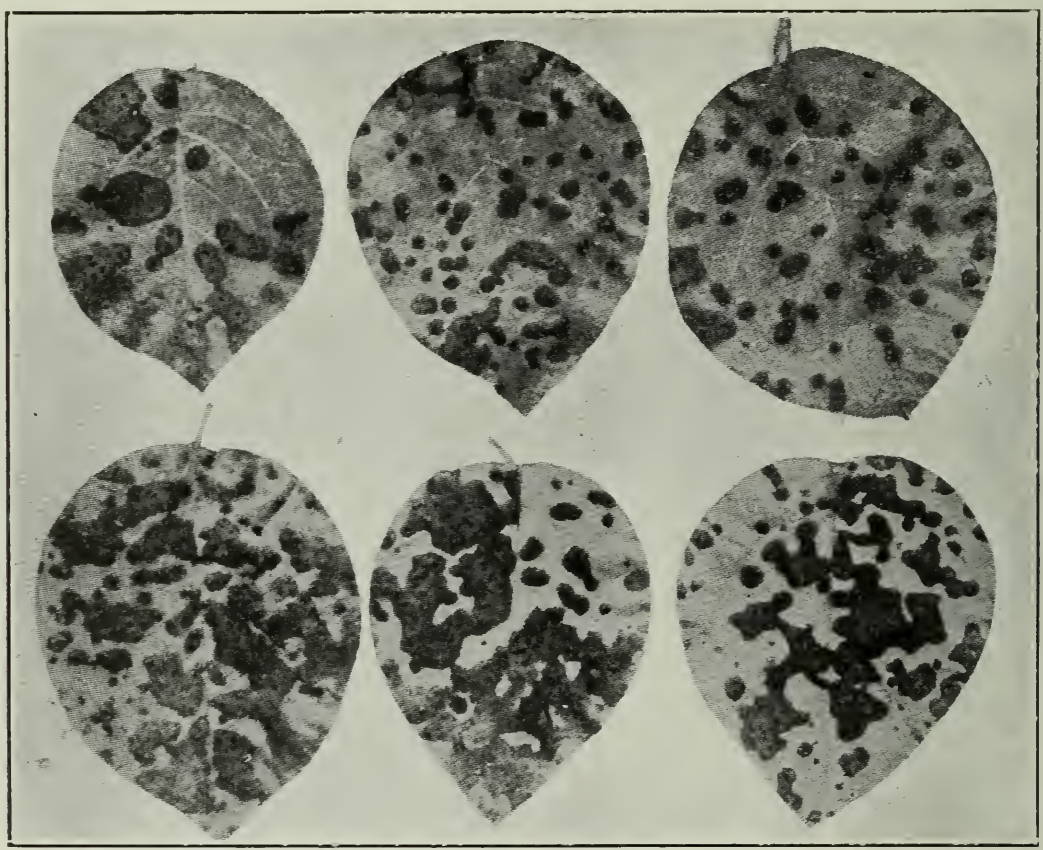
Prevention. Prune and spray as recommended for Apple Scab, taking special care with the first spray to see that the tips of the twigs are thoroughly covered, and always give a fourth application about ten days after the third.

Leaf Spot of the Pear (*Mycosphaerella sentina* (*Fckl.*))

This disease is frequently seen in Ontario, though it seldom causes any appreciable harm except in badly neglected orchards or to trees growing wild on roadsides or in fence corners. It is sometimes observed in nurseries and occasionally results in premature defoliation which checks the growth of the young trees.

Symptoms. This disease is confined to the leaves, on which are seen small, somewhat angular spots, usually with grey centres and brownish or purplish-brown borders; but sometimes the whole spot is dark in colour, with no distinct grey central area. In the centre of the spots as they mature, small black specks, the fruiting bodies (pycnidia) of the fungus, appear. The size of the spots appear to vary with the variety and the season. When the disease is severe the spots may be so numerous as to injure the leaves markedly.

Life History. The tiny black specks or fruiting bodies (pycnidia) are filled with minute, slender, thread-like spores, which are discharged from a small opening at the tip of the fruiting body (pycnidium). They are scattered through the orchard by wind and rain, and serve to spread the Leaf Spot during the summer months. Moisture is essential for the germination of these spores and for the



Leaf Blight of quince. (V. B. Stewart.)

penetration of the leaf by the germ-tube. Hence it is that the Leaf Spot is always most prevalent in a wet season. The fungus lives over the winter in the fallen leaves. In these another form of spores (ascospores) are developed in a special kind of fruiting body (perithecium). These are discharged in the spring of the year and some of them are blown by the wind to the newly developed leaves on which in a short time they produce the characteristic spots and the first generation of summer fruiting bodies (pycnidia).

Prevention. The sprayings which are given for Scab appear to control completely Leaf Spot. To control it on nursery stock spraying with Bordeaux mixture or with commercial lime-sulphur 1 gallon to 40 gallons of water is recommended. The first application should be made just as soon as the trees come into full leaf in the spring, the second about two or three weeks later. In very wet seasons one or two more sprayings at intervals of about two weeks may be necessary.

Leaf Blight of Pear and Quince (*Fabrea maculata*), (*Lev.*) *Atk.*)

This is another disease of comparatively little importance in Ontario. It is seen on both pear and quince, but is usually more noticeable on the latter. It is chiefly a leaf spot disease, but the fruit is sometimes also affected. The spots on the leaves are small and circular, dull red or brown in the centre with darker borders. One or more black pimples, fruiting bodies (pycnidia), of the fungus can be seen in the centre of each spot. In severe attacks the spots may be so numerous that the leaves turn yellow or brown and fall. Red and brown spots are sometimes also seen on the fruit. On the quince the disease is sometimes so severe as to cause a premature defoliation.

Prevention. In orchards the sprayings as ordinarily given for Scab appear to prevent completely this disease on pears. On quince it may be prevented by spraying with lime-sulphur or with Bordeaux mixture. An early dormant wood spray should be given with concentrated lime-sulphur, strength specific gravity 1.030. This should be followed by a second spraying shortly before the blossoms appear and another soon after they fall. Concentrated lime-sulphur specific gravity 1.008 or Bordeaux mixture may be used. In wet seasons a fourth spraying may be required about ten days later.

Peach Leaf-Curl (*Exoascus deformans*) (*Berk.*) (*Fckl.*)

This is the most common and most injurious fungus disease of peaches. It is familiar to every peach grower and very frequently seriously impairs the vitality of his trees.

Symptoms. Blossoms, young fruits and twigs are sometimes affected, but it is by the destruction of the leaves that the chief injury is done. The leaves are infected as they expand in the spring and become distorted, curled, thickened, and yellowish-white, pinkish or purplish in colour. A little later in the season they turn brown and fall. The disease may spread from the leaves into the shoots and destroy them. In severe attacks of Peach Leaf-Curl the trees are almost completely defoliated, the fruit is stunted or drops to the ground, and the vitality of the trees is so impaired that they are likely to be severely injured by the cold the following winter. The proper development of fruit buds is also prevented. Young trees may be killed the first year they are set out if they are defoliated before they have recovered from the shock of transplanting. Peach Leaf-Curl is always more severe in cold wet springs.

Life History. On the surface of the affected leaves numerous spores are produced and the fungus which causes Peach Leaf-Curl is thought to be carried over the winter by some of these spores adhering on or between the bud scales. In the spring, when the buds begin to swell with warmth and moisture, the spores germinate and infect the unfolding leaves. Hence the necessity for early and thorough spraying. In cold wet springs the opening of the buds is retarded, while the germination of the spores and the development of the fungus is favoured by the excessive moisture and not retarded by the cold. Thus the fungus has plenty of time to get established in the tender tissues of the developing leaf. This explains why Peach Leaf-Curl is always worse in cold wet springs.

Prevention. Spray with lime-sulphur, using the strength recommended for San José Scale, namely, concentrated lime-sulphur strength 1.035 specific gravity (=1 gallon commercial lime-sulphur to 7 gallons of water). Spraying must be done early in spring before the buds have started to swell, and care must be taken to see that every bud is thoroughly covered. Success depends upon early and thorough spraying, as can be understood from a consideration of the life history of the fungus. Somewhat weaker solutions of lime-sulphur or Bordeaux mixture will prevent the Leaf-Curl, but will not kill San José Scale, which is apt to be found wherever peaches are grown, and therefore it is advisable to use the strong solution of concentrated lime-sulphur as recommended above. Fall spraying for the prevention of Peach Leaf-Curl has been tried in New York State and satisfactory results obtained. The results of experiments in Ontario in the fall of 1915 and again in 1916 point to the same conclusion.

Peach Leaf-curl.

Peach Yellows and Little Peach.

These two diseases are so closely associated in the orchard and seem to be so nearly related that they may be discussed together. They are both very destructive and are much feared by all peach growers who have had an opportunity to see the damage they can do. From about the year 1909 to 1913 these diseases were so prevalent in the Niagara district that there was something like a panic among the growers lest the peach industry might soon be ruined. At that time the writers saw several otherwise excellent orchards varying in size from 500 to 1,000 trees, in which almost every tree was diseased and thus worthless; for there is no cure for a tree once it is diseased. Some of these orchards were not more than eight years of age, and so had not reached their prime. Fortunately, a better knowledge of the symptoms of the disease and better inspection has since brought both diseases under control.

Symptoms of Peach Yellows. On a diseased tree some of the fruit will usually ripen from a few days to two or three weeks prematurely. Such fruit is more highly coloured than normal, is blotched outside with red, streaked inside with the same colour and has the flesh around the pit abnormally red. Sometimes only one branch or even one twig will show these symptoms and all the rest of the tree bear quite normal fruit. The first year the diseased fruit is either normal in size or a little larger, but the next year it is smaller than normal. The foliage on at least some of the branches is nearly always a sickly yellow colour and is often clustered and curled as described below for Little Peach. Sometimes we find arising from the main branches little upright tufts of much-branched twigs with narrow, yellowish leaves. This symptom, however, is not common except on trees in which the disease is in an advanced stage.

Branch of tree affected with Little Peach just beginning to show the clustering and curling of the leaves near the base as indicated by the arrows. (Original.)

Symptoms of Little Peach. The fruit on a typical diseased tree or part of a tree ripens later than usual, is smaller than normal, but has no peculiar colour markings. In many cases, however, we find trees on which the fruit ripens at the usual time and is about normal in size, and yet the foliage shows clearly that the trees are diseased. The symptoms on the foliage are the curling and clustering of the leaves, *especially on the inner parts of the tree,* and the sickly yellowish or sometimes reddish-yellow colour they assume. On some varieties the leaves cluster much more than on others. Curling and clustering of leaves apart from the yellowish colour is not a symptom of disease. On young diseased trees the leaves on the outer branches will usually remain quite green for a long time after those on the inner or central portion have begun to show the disease. If the centre of the tree looks healthy but the outer branches because of a reddish-yellow colour look diseased, it will nearly always be found that such trees are not affected by Little Peach or Yellows, but are suffering from lack of nourishment. Care must of course be taken both with Yellows and Little Peach not to confuse the foliage symptoms of these diseases with those caused by winter injury or by borers at the base of the tree or by cankers on a branch or elsewhere. A little study and experience will soon enable a person to recognize injuries from these causes. It is also worth remembering that the foliage on the Crawford type of trees differs from that on the Elberta, and the latter again from that on the Smock or Triumph or St. John; so that to study Yellows and Little Peach one should first familiarize himself with the different kinds of foliage to be found on the different varieties. This is especially important as the amount of curling and clustering due to the diseases depends largely upon the sort of leaf characteristic of the particular tree affected.

Leaves from Little Peach tree, showing the characteristic flattening and curling. (Original.)

Cause. The cause of Yellows or of Little Peach has not been discovered. There are, of course, several theories, but none are satisfactory. No organism, whether bacterial or fungus, so far as the microscope or as cultures are able to reveal it is present.

It has been shown both in our own experiments and in those of several investigators in the United States, that the disease can be produced in healthy trees by budding them with buds from diseased trees. We have done this in many cases, both on large and small trees, and in the majority of instances, though not in all, the disease has developed. In all but one case in our experiments it required two years from the time the buds were inserted before the symptoms could be detected on the foliage or fruit. Hence it is clear that in the tree itself development of the disease is very slow.

It has been claimed by several writers that pits from diseased trees will not grow. In our experiments this was true only of pits from badly diseased trees, but not of those from trees which had shown symptoms of the disease only for a month or so. Of these, as high as eight per cent. of the pits germinated and grew.

It has also been claimed by certain writers that if the pit from a diseased tree grows, the tree thus produced will be diseased. We have had several hundred such pits grow and at the end of three years they showed no sign of disease. So that it would appear as if the danger from pits from diseased trees was not an important factor.

There is good reason to believe that whatever be the cause of Yellows and Little Peach, there is much danger in some mysterious way of the disease passing from one tree to another in the orchard. It is true that for several years this may not happen, and the explanation may possibly lie in the nature of the weather, some years compared with others. In any case we can see no other explanation of the great increase of the disease in the past in orchards where infected trees were not removed than that infected trees spread the disease to healthy trees.

Methods of Control. There is just one method of control, and that is to encourage the local inspector to mark every clearly diseased and suspicious tree or to mark them oneself, take them out and burn them promptly. This has resulted already in a very rapid decrease in the diseases. In 1911, 60,000 trees were marked and destroyed in the Niagara district; in 1912 this was reduced to 25,000, in 1913 to 7,000, and in 1914 to 3,000. Since that date there has been a tendency to over-confidence on the part of the growers in some localities, with the result that the figures for 1915 and 1916 are practically the same or slightly higher than for 1914.

Nurserymen also can help to keep down the disease by special precautions not to take bud sticks from a diseased tree or even from any orchard where considerable disease has appeared at any time during the preceding three years.

Brown Rot of Stone Fruits (*Sclerotinia cinerea* (*Bon.*) *Wor.*).

This, as the name implies, is a disease of peaches, cherries, plums and apricots. It is to be seen in Ontario to a greater or less extent every year, and in some seasons causes very serious damage, especially to certain susceptible varieties of peaches, to sweet cherries, and several varieties of European plums.

Symptoms. Blossoms, fruits, leaves (sweet cherries), and twigs are affected. It is by the destruction of the fruit that the chief loss is caused. On the fruit the disease first appears as a small brown spot, which gradually increases in size until the whole fruit becomes soft, brown and rotten. These rotten fruits retain their form for a time, but finally they dry out and become shrivelled, hard and wrinkled, and are known as "mummies." These are frequently seen hanging on the trees or lying on the ground underneath. On the surface of the rotten fruits greyish-brown velvety spore pustules are easily seen with the naked eye. They look like small pimples. The fruit does not usually begin to rot until about half grown, and becomes more subject to rot as it approaches ripeness. Sometimes, however, the young green fruits are destroyed by the disease. The blossoms also are sometimes attacked. They turn brown and fall. Destruction of the blossoms by this disease has not often been noted in Ontario. Sometimes the fungus which causes the rotting of the fruit grows back into the twigs and girdles them, and thus causes a twig blight. This is most frequently seen in the case of the peach, but is not uncommon on plums. On sweet cherry leaves brown, dead areas, due to this disease, are common when the rot is bad on the fruit.

Life History. The fungus which causes the disease is spread during the summer months by means of spores produced in great numbers on the surface of the rotting fruits. These are scattered by rain, wind, insects and other agencies. In warm, muggy weather the rot is spread by them very rapidly, especially when the fruits are close together and the foliage so thick as to keep out light and prevent the free circulation of the air.

The fungus which causes the disease is carried over the winter in various ways:—

1. By means of the mummied fruits hanging on the trees or lying on the ground beneath. In these the mycelium of the fungus remains alive all winter, and in the spring, when they are soaked by rains, the fungus threads may grow again and produce fresh crops of spores (conidia) on the surface. From some of the mummied fruits lying on the ground underneath the trees partly covered by

Mummified plums and peach, due to Brown Rot. About one-half natural size. (Original.)

the earth, about blossoming time little trumpet-shaped growths (apothecia), are produced. These contain immense numbers of another kind of spores (ascospore), which are discharged into the air and may be blown up into the trees, where, if weather conditions are favourable, they may infect the blossoms or young fruit and cause them to rot. These trumpet-shaped growths (apothecia) have been observed in Ontario every year since 1912, and probably play an important part in initiating the disease in the spring.

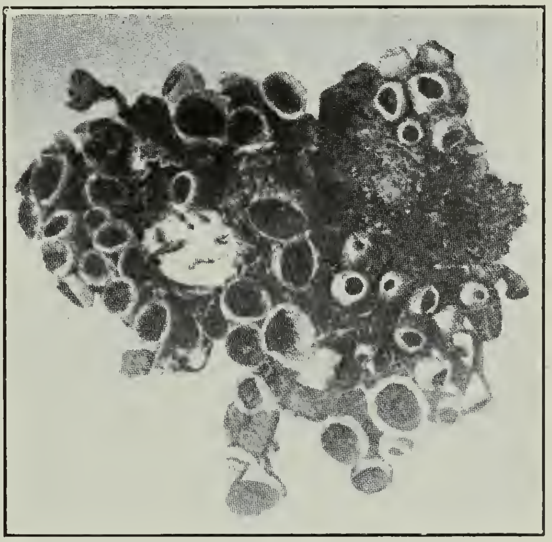
2. By means of spores produced during the summer adhering to the mummied fruits and probably to bark and bud scales. These retain their vitality and are capable of causing infection and producing disease again in the spring.

3. To a slight extent by means of dormant fungus threads (mycelium) in the blighted twigs.

It will be seen from the above account of the life history of the fungus, that the mummied fruits are chiefly instrumental in perpetuating the disease from year to year.

Prevention. Prune the trees so as to let in light and air and facilitate spraying. Spray thoroughly and at the proper times. Peaches should be sprayed with concentrated lime-sulphur, strength specific gravity 1.035 (=1 gallon commercial lime-sulphur to 7 gallons of water) early in the spring before the buds begin to swell. A second spray should be given about a month after the fruit is set with self-boiled lime-sulphur. In wet seasons, when rot is likely to be bad, it is advisable to spray again with self-boiled lime-sulphur about a month before the fruit ripens. Sulphur dust could probably be substituted for the liquid and could be applied about two weeks before picking, as it would not stain the fruit. Thin peaches so that they do not touch each other. This helps to prevent the rot spreading.

Spray plums and cherries, first, just before the buds burst, with concentrated lime-sulphur, strength specific gravity 1.035 or 1.030 (=1 gallon of commercial to 7 or 9 gallons of water); second, just after the fruit is set and the calyces have fallen with concentrated lime-sulphur, strength specific gravity 1.009 or 1.008 (=1 gallon commercial lime-sulphur to from 35 to 40 gallons of water) or with Bordeaux mixture; third, about ten days or two weeks later, depending upon the weather, with concentrated lime-sulphur, strength specific gravity 1.008 (=1 gallon commercial lime-sulphur to about 40 gallons of water) or with Bordeaux mixture. All varieties subject to rot should receive an application just when the fruit begins to colour, which is about as late as is safe, to avoid staining the fruit, with lime-sulphur, strength specific gravity 1.008 (=1 gallon commercial lime-sulphur to 40 gallons of water). Poison is not necessary at this time except where Cherry Fruit Flies are present. Dusting cherries and plums two or three days before picking with finely-ground sulphur, free from poison, promises to be very valuable, especially in saving sweet cherries.



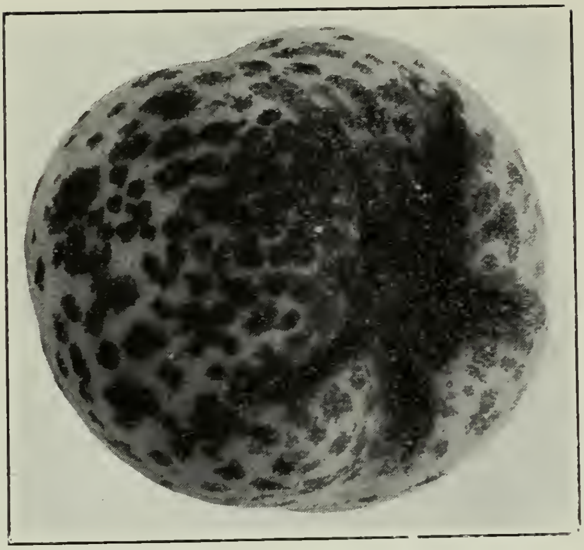
Spring stage of the Brown Rot fungus on a peach, buried just at the surface of the ground. (After McCubbin.)

The mummied fruits, being so important in carrying the fungus which causes the disease over from year to year, should, if practicable, be destroyed. Knock them off the trees in the fall and gather and burn them, or plow them under early in the spring. Gathering the mummies and burning them is the most effective method, as plowing may not turn all of them under deep enough to prevent their being sources of infection.

Peach Scab or Black Spot (*Cladosporium carpophilum, Thum.*).

This disease is seldom destructive in Ontario. It is, however, frequently seen, especially on the white-fleshed varieties.

Symptoms. Small, circular, sooty-black spots are seen on the surface of the fruits. These may be scattered all over the surface or may be more or less confined to certain areas. In severe infections the spots may be so numerous as to disfigure



Peach Scab—a very severe infection. (Original.)

badly the fruit and occasionally to cause cracking. Twigs and leaves are sometimes affected, but seldom to a noticeable extent in Ontario.

Life History. The fungus which causes the Scab winters over as dormant fungus threads (mycelium) in the twigs. In the spring these fungus threads produce spores in little pustules. These are scattered by wind, rain and insects, and infect the fruit and leaves.

Prevention. Spray in early spring with lime-sulphur as directed for Peach Leaf-Curl, and in addition spray with self-boiled lime-sulphur about a month after the fruit is set. Probably dusting with sulphur would give equally good results.

POWDERY MILDEW (*Sphaerotheca pannosa* (*Wallr.*) *Lev.*).

This Mildew attacks both the roses and the peach. It is most commonly seen on young peach trees which have not yet come into bearing, and frequently injures nursery stock severely. It does, however, sometimes occur on older trees. Certain varieties are said to be particularly susceptible to it.

Powdery Mildew on young peach twigs in nursery. Note the distorted, slender leaves, almost white with the fungus spore masses. (After Duggar.)

Symptoms. The Mildew is seen on the leaves, young shoots and sometimes on the fruit. The leaves become distorted, stunted, curled, pale, sickly, more or less folded lengthwise and covered with a dense powdery white substance, which extends over unto the twigs on which the leaves are borne. The Mildew is easily recognized by this dense white powdery covering on the affected leaves and shoots. It develops most vigorously in warm, moist weather, and is usually most abundant in late summer and autumn.

Prevention. At the first sign of the Mildew, dust with flowers of sulphur and repeat at intervals of ten days as often as may be required to hold the disease in check. Spraying with self-boiled lime-sulphur is also recommended. It is sometimes advisable to discard very susceptible varieties.

Crown Gall (*Pseudomonas tumefaciens* (*Erw.*) *Smith & Townsend*).

This is a bacterial disease which affects peaches, apples, plums, cherries, raspberries and many other plants. It is easily recognized by the woody, knot-like swellings seen on the trunk and roots. These galls vary in size. Some are not as large as a walnut, while some may be as large or much larger than a man's fist. When these galls are on the trunk they are usually at or just below the ground. The extent of injury done to the tree by Crown Gall is an open question. Many affected trees continue to grow and appear to thrive normally. There is no doubt, however, that some trees are weakened and stunted, if not killed by the presence of the galls. Hairy Root of apples, often seen in nursery stock and easily recognized by the tufts of thread-like rootlets replacing the branches on the main root, is caused by the same organism.

Prevention. In order to be on the safe side do not plant any trees showing any indication of Crown Gall. Such trees should be returned to the nurseryman with a request for healthy trees to take their place. It is not advisable to plant fruit trees where raspberries have been grown, as raspberries are very subject to this disease.

Crown Gall on Apple. (Original.)

Canker or Gummosis of Peach Trees.

In certain localities in the Niagara district, especially at Queenston, Niagara-on-the-Lake, St. Catharines, and in several orchards at Winona and Grimsby, it is a common thing to see large, black, gum-covered cankers, chiefly on the upper side of large branches. These cankers do not heal over but continue to widen out and enlarge until finally the whole branch dies. This usually takes several years.

The cankers have been attributed to various causes. Mr. W. A. McCubbin, of the Dominion Laboratory, who has made a special study of Peach Cankers, writes as follows concerning their origin :—

*"1. A very small percentage arise from holes made by borer larvæ.

"2. They may come as an after-effect from small cracks in the trunks or limbs. The percentage thus formed is also very small.

"3. A small number start from gum blisters under the bark.

"4. A few arise at the bases of twigs killed by Brown Rot. The Brown Rot fungus works back from the rotten fruit into the twig and then starts a canker in the larger limb.

"5. Wounds made by scraping the limbs, etc., are accountable for a small number.

Small cankers on peach branches. Natural size.
(Original.)

"6. Quite a few cankers start at pruning wounds.

"7. By far the greatest proportion of cankers are formed on the limbs at the bases of dead twigs. There is presumably a fungus concerned here which, after establishing itself in the dead twig, runs back into the larger limb and there starts a canker."

Field observations made by the writers, incline them to think that heavy pruning and heavy fertilizing, in combination with wet weather early in the growing season, may also have some effect in inducing the formation of cankers.

Means of Control. Mr. W. A. McCubbin, after conducting many experiments on the healing of Peach Cankers, makes the following recommendation in regard

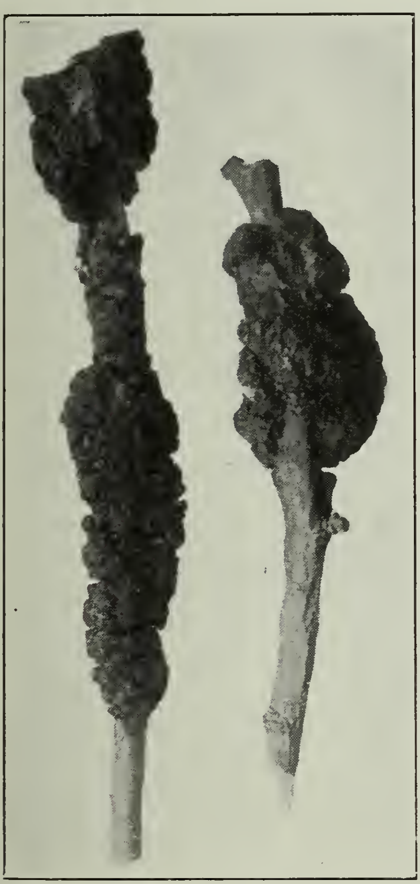
*Bull. 24, Dominion Department of Agriculture, "Fruit Tree Diseases of Southern Ontario."

to their prevention and control: Removal of the dead twigs from the main limbs, since it is found that these twigs are the starting point of the disease in such a large number of cases; destruction of Brown Rot mummies; painting of all the larger pruning wounds; removal of small limbs showing cankers, and the treatment of cankers on trunk or large limbs by cleaning out the cankers immediately after rain when the bark and gum are soft, and disinfecting the wounds with formalin diluted one to ten, or corrosive sublimate, one in a thousand, and coating them with lead paint free from turpentine.

The field observations of the writers recorded above indicate that care should be taken not to over-prune or over-fertilize peach trees, as such treatment apparently tends to induce the formation of cankers.

Black Knot of Plums and Cherries (*Plowrightia morbosa* (*Shw.*) *Sacc.*).

This is an extremely destructive disease, and in localities in Ontario where no special efforts have been made to control it, it has destroyed numerous cherry and plum trees. In well-cared-for orchards, it is kept under control and seldom causes serious injury. This is particularly true of orchards in the fruit-growing sections where spraying is generally practised and where the law requiring the cutting out of Black Knot is enforced.



Black Knot on plum twigs.
(Original.)

Symptoms. The knots usually appear first in the spring of the year. The swellings are at the start slight, but gradually increase in size. The surface becomes cracked and covered with a light green coating consisting of numerous fungus threads (mycelium) and spores. The swellings are often spindle-shaped and usually confined more or less to one side of the twig. Later in the season, as the knots mature, they lose their green colour and become dry, hard, black and cracked, with the surface studded with minute black pimples which are the fruiting bodies (perithecia) of the fungus. The knots are most abundant on the twigs and smaller limbs, but are sometimes found on the larger limbs, especially in the crotches. Occasionally they occur on the trunks.

Life History. From late spring until midsummer numerous spores are produced on the young, developing knots, so that each is a source of infection to healthy limbs on the same tree or on other trees in the neighbourhood.

During the fall and winter another form of spores (ascospores) develop in the black pimples (perithecia) on the surface of the mature knots. These spores are mature and are discharged from late winter until early spring, according to the locality and severity of the season. Many of the knots are also perennial, producing fresh crops of spores each year.

Prevention. Cut out and burn the knots, taking care to cut well below the diseased area. This should be thoroughly done at least twice a year, in the fall or early winter and in late spring.

Spray plums and cherries as recommended for Brown Rot. The early dormant wood spray with concentrated lime-sulphur, strength specific gravity 1.030 or 1.035 appears to be particularly effective in the prevention of Black Knot, and care should be taken to see that it is very thoroughly applied. The branches, main limbs and trunks should be completely covered with the solution. Black Knot attacks wild cherries and plums, and there is a possibility of its spreading from these to those under cultivation. It is advisable, therefore, to destroy wild plums and cherries in the neighbourhood of the orchard if they are affected with Black Knot. The enforcement of the clauses of the "Fruit Pests Act," regarding the cutting out of Black Knot, should make it much easier for fruit growers to keep Knot out of their orchards.

Plum Pockets (Bladder Plums) (*Exoascus pruni*).

This disease is common in Ontario on wild plums and on cultivated plums of the American varieties (*Prunus americana*). It is recorded also as sometimes

Plum Pockets or Bladder Plums. The fruit on the left is healthy, that on the right is diseased. (Original.)

occurring on the common or European plums (*Prunus domestica*). It is most prevalent in cold, wet springs. It cannot, however, be regarded as a disease of any great economic importance.

Symptoms. Soon after the fruit is set it becomes swollen, hollow, without a pit or stone, and often distorted in shape. These light, hollow, bladder-like fruits have suggested the common name "Bladder Plums."

In the early stages, affected fruits are yellowish or reddish in colour. Later they become covered with a whitish bloom. This is due to the production of numerous spore sacs (asci) on the surface. These sacs (asci) contain ascospores. After these are discharged the fruit turns dark brown in colour and falls off.

Life History. The fungus which causes Plum Pockets appears to live over winter as spores, adhering on or between the bud scales. These germinate and produce infection of the young ovaries when the buds are bursting in the spring.

Prevention. Spraying as recommended for Peach Leaf-Curl appears to prevent this disease entirely.

Plum Rust (*Puccinia pruni spinosae, Pers.*).

This disease is occasionally observed in Ontario orchards, but has never been recorded as doing any serious damage.

It produces small, dark brown pustules on the under surface of the leaves. In severe attacks premature defoliation may be caused.

Leaf Spot, Shot-Hole Fungus, Yellow Leaf Disease of Cherries and Plums.

This is a very common disease in Ontario on wild and cultivated cherries and plums. It is to be seen nearly every year and in wet seasons may very seriously injure cherry trees. Both sweet and sour cherries are frequently completely defoliated by it in wet summers. In the years 1915 and 1916, it was particularly

Leaf Spot or Shot-hole Fungus on cherry and plum. (Original.)

bad. It is usually recorded as being worst on sweet cherries, but here in Ontario it has been just as destructive, if not more so, to sour cherries.

The disease on the different species of cultivated and wild cherries and plums is not all caused by the same fungus. Three closely related species of fungi, each confined to certain species of cherries or plums, have been found to cause it. *Coccomyces hiemalis, Higgins,* causes the disease on sweet and sour cultivated cherries and on the wild pin cherry, *C. pruniphorae, H.* on cultivated plums of the European and American varieties and on two species of wild plum, *C. lutescens, H.* on wild black cherry, choke cherry and perfumed cherry.

Symptoms. These vary with different hosts. On the leaves of plums and wild cherries brown spots are produced, which soon fall out, leaving little holes, which give the leaf a "shot-hole" appearance. On cherries the spots on the leaves do not as a rule drop out so readily and are smaller. They are reddish-brown in colour and may be very numerous, so that nearly the whole surface of the leaf may be covered by them. Badly affected leaves turn yellow and drop. Cherry trees are frequently completely defoliated early in the summer. Such defoliation prevents the proper ripening of the wood and renders the tree very subject to winter killing. In the spring and summer of 1916, numerous instances were recorded of cherry trees not surviving the winter. When inquiries were made, it was found in nearly every case that the trees which were winter killed had been defoliated by Leaf Spot the previous summer.

Life History. On the surface of the spots on the leaves numerous spores are produced. These can often be seen as little white, velvety pustules in the spots, usually on the under side of the leaf. These spores serve to spread the disease during periods of wet weather in the summer. Moisture is necessary for its spread. It is only in wet seasons that it causes serious injury. The fungus which causes the disease is carried over the winter in the fallen leaves. In these it produces fruiting bodies (apothecia). These contain another form of spores (ascospores). During wet weather in the spring, about the time the new leaves are developing, these spores are discharged from the fruiting bodies in great numbers. Some of them are carried by the wind to the young leaves, where they produce the first infection of the season, from which the characteristic spots develop a week or two weeks later.

Prevention. Leaf Spot usually can be prevented by giving the three regular sprayings recommended for the control of the Brown Rot and an additional application just after the cherries are picked, with Bordeaux mixture or concentrated lime-sulphur, strength 1.009 or 1.008 specific gravity (=1 gallon commercial to from 33 to 40 gallons of water). Bordeaux seems the better remedy.

Powdery Mildew of Cherry (*Podosphæra oxyacanthæ* (*D.C.*) *DeBary*).

This Mildew is frequently noticed on cherries in Ontario. It does not usually injure old trees to any great extent. Young trees and nursery stock, however, are sometimes severely injured by it. Apples and plums are also affected by the same mildew, especially nursery stock.

Symptoms. The young shoots, tips of branches and leaves become covered with a white powdery mildew. On the leaves it is most abundant on the lower surface. In severe attacks shoots and twigs are distorted and stunted and the leaves curled. Early in the season the mildew is white and more or less powdery, especially on young shoots and twigs. Later it becomes darker in colour. If the mildew on the lower surface of a leaf is examined at this time, numerous dark specks will be seen scattered among the white threads. These impart the darker colour to the mildewed areas.

Life History. On the surface of the leaves and shoots the white threads of the fungus (mycelium) can be seen with a hand lens. During the early summer from these white threads stalks are sent up which bear chains of spores (conidia). These spores are so numerous that they give to the mildew the characteristic powdery appearance. They serve to spread the disease during the summer months. Towards autumn minute specks are seen among the fungus threads. These are at first yellow, later black in colour. They are fruiting bodies (perithecia), and each contains one large spore sac (ascus) with eight spores (ascospores) inside. These spores serve to carry the fungus over the winter. In the spring they are liberated, and some of them are blown by the wind to cherry leaves or shoots where, if there is plenty of moisture, they germinate and produce the first infection of the summer. The chains of summer spores (conidia) soon develop and new infections occur.

Prevention. Good results have been obtained in New York State by the use of commercial lime-sulphur, 1 gallon to 40 gallons of water. *"The addition of 3 pounds of iron sulphate to 40 gallons of the mixture tends to reduce the possible injury to the foliage and also increases its sticking quality. The first application should be made as soon as the disease appears. From three to five sprayings will be required in order to keep the Mildew in check." It is possible that the new dust method of preventing plant diseases would prove satisfactory with this trouble.

INJURIES DUE TO WINTER OR TO LOW TEMPERATURES.

In this province, which is subject to cold winters and great extremes of temperature, winter injury or injuries caused at other times of the year by low temperatures, are common and very important. Hence every fruit grower should have a knowledge of the forms which such injuries take and of the simple means by which some of the worst of them may be prevented.

It is impossible to go into a full account of this subject, so that the following deals only with the more common or more important types of injuries. We have already referred to the winter killing of cherry trees as a result of early defoliation brought about by the Leaf Spot or Shot-hole Fungus disease. Hence this will not be dealt with here.

SUNSCALD.

This is the most common form of winter injury. It occurs all over the province, but is worse in the colder portions. Thousands of apples, plums and cherries in almost every fruit-growing county are affected. The injury consists in the killing of the bark, often over an area three or four feet or even more in length, on the south or south-west side of the trunks, and also in the case of apples on the upper side of large branches. The death of the bark is caused by its being heated up by the sun's rays on cold, bright days, especially in February and March, and then after sunset cooling off very quickly. The great drop in the temperature thus taking place in a few hours is very injurious to the tissues of the bark, and if frequently repeated kills them. To make matters worse, the dead sunscalded area on apple trees is commonly invaded by the Black Rot fungus, which gradually extends the injury and in many cases girdles the trunk or branch and kills all the parts above. A great many of the Black Rot cankers start in this way from Sunscald. On plums and cherries it is chiefly the trunks that are affected and here, too, the injury may be increased by fungi or by borers working around the margins of the dead bark. Sunscalded trees, of course, often live for many years, and may bear almost as well as if the bark on the affected area had not been killed.

Methods of Control. (1) When setting out new orchards incline the trees a little to the south-west and head them low. This helps to shelter the trunks from the sun.

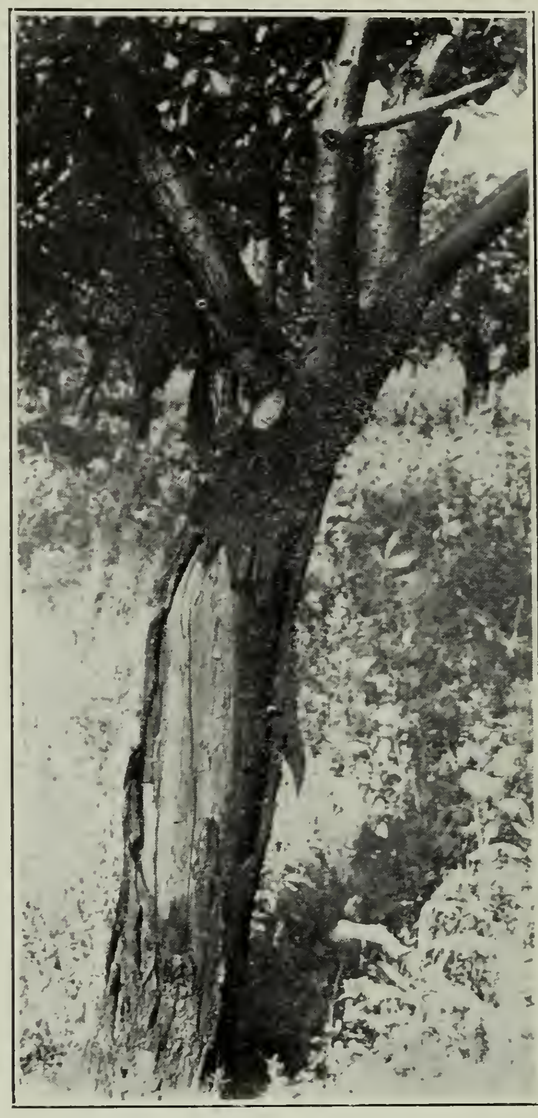
(2) In dehorning or pruning apple trees, never remove all the centre, thus exposing large branches to the direct rays of the sun. Such open centres are not only unsightly, but lessen the bearing capacity of the tree.

---

*Bull. 358, Cornell University, Agricultural Experiment Station of the College of Agriculture.

(3) The trunks and branches of Transcendent or Martha Crab apples are very resistant to Sunscald and the roots to root-killing, hence if these were planted and the desired variety of apples grafted or budded on their branches, much of the danger of Sunscald, Root-killing and Collar Rot would be avoided.

(4) All dead sunscalded areas, especially on the trunks, should have the bark removed with a drawknife, and the wound painted with white lead or with coal tar. This will keep out the Black Rot and other fungi.



Effect of Sunscald on the southwest side of the trunk of a European plum tree. Most of the bark on the injured area has been killed and fallen off. (Original.)

(5) The trunks may be protected against the sun's rays by various devices, such as wrapping them with white building paper, or using veneer, or corn stalks, or even by tacking a board up against the south side. Whitewashing the trunk heavily about the end of January also helps. If building paper is used and is put on in late autumn and a little earth thrown up around the base, it will also keep off mice. Any form of protection against Sunscald should always be applied not later than about the middle of January.

Crown Rot or Collar Rot.

This is the name commonly given to that form of injury which consists in the death of the bark around the base of the trunk of trees. The girdling may be either complete (and in such cases the whole tree soon dies) or may be partial, only one side or portions here and there being girdled. In the latter cases, the branch or branches just above the dead bark may die, but often the whole tree may remain alive and healthy. There is a great tendency, however, for these semi-girdled trees to become completely girdled after a few years. Crown Rot is fairly common in apple orchards in most parts of the province, and is by no means limited to the colder districts. King of Tompkins is specially subject to it, but many other varieties also suffer.

There are several theories as to the cause of this Collar Rot, but the writers are convinced that the chief cause is low temperatures acting upon succulent tissues which have not been properly hardened up for winter. The bark at the crown is much more tender than that higher up on the trunk, and hence where trees have been over-fertilized and cultivated too late this is the part that is most likely to be killed, especially if not protected by snow.

The death of the bark around the base of the trunk of peach trees and also of sweet and sour cherries, sometimes extending a short distance below the ground, is probably very closely allied in nature to the Collar or Crown Rot of apples. It is usually found where the trees are in exposed situations or where wind currents sweep through the orchard, especially if the trees were very thrifty the previous summer.

Methods of Control. (1) Do not plant on their own stock King of Tompkins or any other variety known to be very subject to this disease. If these varieties are desired, they should be grafted on immune or nearly immune stock, such as Tolman Sweet or Transcendent or Martha Crab.

(2) Do not over-fertilize or cultivate so late that the trees will not have their wood and bark hardened up for winter. Cultivation, even in the warmer districts, should usually close about July 1st, and a week or two earlier in the colder districts. A cover crop should be sown as soon as cultivation is finished. This will help to hold the snow on the ground.

(3) Never plough away from the trees in autumn, but see to it that the soil around the trunk is high enough so that no water will remain there.

(4) It is very probable that on exposed positions peach trees could be saved from this trouble and also from root-killing by first banking up a little earth around the trunk and then placing about six inches deep of manure around this for a width of two or three feet. It is better not to have the manure in contact with the trunk itself.

(5) Where trees are only partially girdled, especially apple trees, it is a good plan to remove the dead bark and cover with coal tar the wood thus exposed. Rotten bark favours the entrance of fungi, hence the reason for its removal.

Black-Heart.

After a very cold winter or after sudden extremes of temperature many apple, pear and peach trees will, on examination, be found to have their wood killed and darkened, even though the bark and cambium are still alive. Young trees, including nursery stock, are more subject than old trees to this trouble, but the branches even of old trees may be affected. Where the injury occurs in the same tree a couple of years in succession, or where rot-producing fungi get entrance through some wound into the wood, the tree may become so brittle and weak that it will break off as a result of any slight strain. Such trees are, of course, worthless. Very often, however, trees, especially bearing trees, may be black-hearted, and yet live and bear good crops, though there is a great tendency on such trees for large branches to die from time to time. Some varieties of apples and pears are much more subject than others to Black-Heart; in fact the more tender the variety the more subject it seems to be to this disease. Peach trees, owing to the rapidity with which they make new wood, recover more fully from Black-Heart than apples or pears.

Methods of Control. (1) Do not plant any variety that experience shows is too tender for your district. Baldwins especially should not be planted in the colder portions of the province or in counties subjected to great extremes of weather. Some of the hardiest good varieties of apples are Duchess, Yellow Transparent, Wealthy, McIntosh, Fameuse and Tolman.

(2) Avoid late cultivation and over-fertilizing, (see under Collar or Crown Rot), yet on the other hand the trees must not be weakened by starvation and neglect. A golden mean is what is desired.

Bark Splitting on Trunk.

This is moderately common. Fruit growers used to believe that it was due to trees being as they called it "hidebound," but it is now known to be caused by a great sudden drop of the temperature which contracts the bark much more rapidly than the sapwood, with the result that it gives way at some one or more places, and once a rupture occurs the splitting readily extends up and down with the grain of the bark. Deciduous shade trees are also subject to bark splitting. Sometimes the splitting extends into the wood for some distance, but usually it is only the bark that is affected. In some cases the bark is not only split, but is also torn away from the wood for an inch or more on each side of the split.

Methods of Control. (1) Trees that have made a very great growth and are not hardened for winter seem to be more subject to splitting; hence the remarks above on avoiding late cultivation apply here.

(2) If the bark has separated from the wood it will be well to remove it back to where the union is intact and to paint the exposed wood with white lead. Cracks may be filled with grafting wax to keep out water. Trees are not often killed by this form of winter injury.

Crotch Injury.

In the colder portions of the province many trees are injured during winter at the crotch or fork, the bark at this part being killed. Bark at crotches is apparently more tender than on trunks or branches. If this dead bark is allowed to remain, and if there is not good drainage to carry off moisture, it will not be long until rot-producing fungi will gain entrance and cause the wood itself to decay, with the result that one or more large branches may break off or the whole tree be ruined.

Methods of Control. (1) Hardy varieties are not nearly so subject as tender varieties to this injury, hence in the colder districts too great care cannot be taken to set out only varieties that will be suited to the climate.

(2) When forming the head of young trees, distribute the main branches so that they will not come out together and thus form a weak crotch. It is a good plan to have a central leader for the lower part of the head.

(3) Where crotch injury appears, remove the dead bark and paint the wound with white lead or cover with grafting wax. Never use cement in a crotch, as it will crack.

Killing Back of New Growth.

It is a very common thing, especially after a severe winter, to find that numerous twigs, especially on peaches, have been killed by winter. The killing may extend two feet or more back from the tip. Trees that made a late growth in summer and autumn are usually the ones that suffer most.

Methods of Control. The general principles in regard to cultivation and fertilizing mentioned under Collar Rot apply here. If time permits the dead twigs should be cut out as soon as observed.

Killing of Fruit Buds.

Nearly every year many fruit buds on peaches are killed, though the leaf buds are uninjured. This is the chief reason that peaches require a mild climate. Cherry and plum buds are also subject to winter killing, but will stand much greater extremes than peaches. The killing of apple and pear buds is not common. If a dead peach bud is cut through with a sharp knife, the centre will be seen to be brown or black.

Bud killing seems to be due chiefly to a sudden great drop or drops of temperature. If the buds have become somewhat too advanced through the occurrence of very mild weather, such as we often have in January, their destruction seems to take place more readily.

Methods of Control. The presence of a large body of open water by moderating the climate helps to prevent this injury. Apart from the choice of situation, all that one can do would seem to be to follow the well-known good methods of cultivation, fertilizing and pruning. Good air circulation is also valuable; hence in choosing a site for an orchard avoid air pits or places where the air circulation may be expected to be poor. Air drainage is almost as important in an orchard as soil drainage.

Killing of Blossoms and Young Fruits.

Late frosts during bloom or soon after may destroy numerous blossoms or even young fruits. The latter seem to be just as tender as the blossoms. Sometimes enormous losses are caused by these late frosts. Orchard heaters are used in some countries to prevent this injury. They have not, however, been much tested in Ontario. The question of sites is also important here, as frost is always more destructive where air drainage is poor.

Russeting of Fruit and Crinkling and Rupturing of Leaves.

Late frosts, soon after or as the fruit is setting, may result in very conspicuous russet bands around apples and pears. These bands may be at the calyx end, or around the middle or nearer to the stem end. They are probably due to frost and moisture combined injuring the skin.

Some years the leaves are much crinkled and sometimes have the upper surfaces separated from the lower through spring frosts. There is apparently no practical method of preventing such injuries.

SPRAY CALENDAR

PLANT AND PESTS.	1ST APPLICATION.	2ND APPLICATION.	3RD APPLICATION.	REMARKS.
APPLE. Scab or black spot, canker, leaf spot, codling moth and other biting insects, scale insects, blister mite and aphids. (Consult bulletins 187, 194, 198 and 219).	Either before or soon after the leaf-buds burst, preferably the latter. Use A1 or B. For San José Scale prune severely, scrape off loose bark and drench the whole tree, paying special attention to outer twigs.	Just before the blossoms open. Use A2 or D, with 2 or 3 lbs. arsenate of lead to each 40 gals. of the liquid.	Immediately after the blossoms have all, or nearly all, fallen, and before the calyces close. Use A3 or D, with 2 lbs. arsenate of lead to each 40 gals. This is the application for codling moth.	For Scab, a 4th application about 10 days after the 3rd is necessary if June is wet, also an intermediate one between the 2nd and 3rd with A3, *without any poison,* if the interval, owing to cool damp weather, threatens to be long. Spraying with the weaker A3 early in August is an insurance against sooty fungus and late scab. If Aphids are annually troublesome, delay 1st application till buds begin to burst, then add Black Leaf 40 or nicotine-sulphate 40 per cent. to A1 or B and cover every bud. For Cankers cut out diseased bark, disinfect and cover with white-lead paint free from turpentine. For Blight on young trees keep suckers rubbed off trunk and main branches and cut out promptly any diseased branches or twigs well below the diseased bark. Always disinfect both cuts and tools with corrosive sublimate (1 to 1,000).

Stages for 1st application. Stage for 2nd application. Stage for 3rd application.

PEAR. Scab or cracking, blight, codling moth, other biting insects, scale insects, blister mite, psylla and slug. (Consult bulletins 176, 187 and 219.)	Shortly before or just after the bud bursts. Use A1 or B. For San José Scale see above under Apple.	Just before the blossome open. Use A3 or D, with 2 or 3 lbs. arsenate of lead to 40 gals. of liquid.	Just after blossoms have fallen. Use A3 or D, with 2 lbs. arsenate of lead to 40 gals.	Pears subject to Scab should always receive a 4th application 10 days later than 3rd with same mixture. For Blight cut out carefully in winter all blighted branches and twigs, cutting several inches below the diseased part. Also remove and burn trees too severely blighted to save. Throughout growing season watch for and remove promptly in the same way all blighted twigs or branches. Disinfect at once tools and all cuts with corrosive sublimate (1 to 1,000). For Psylla delay 1st spraying with A1 or B until leaf buds have burst and add Black Leaf 40 or nicotine-sulphate 40 per cent. to Codling Moth spray if necessary. Arsenate of lead will kill Slugs (3 lbs. to 40 gals.).
PLUM AND CHERRY. Black knot, brown rot, leaf blight or shot-hole fungus, curculio, slug, aphids and cherry fruit - flies (Consult bulletins 219, 226, 227 and 230.)	Just before or as the buds are bursting. Use A1 or B. For San José Scale see above under Apple.	Soon after the fruit is set. Use A2 or D, with 3 lbs. arsenate of lead to 40 gals.	Just before the cherries begin to color. Use A3 or D, with 3 lbs. arsenate of lead to 40 gals.	For Rot keep fruit well covered with A3 or D or sulphur dust in moist weather. May dust just before picking. For Cherry Fruit-flies (the cause of the little white headless maggots in cherries) use 3 lbs. arsenate of lead to 40 gals. of water. Apply to all cherry trees just as Early Richmonds are getting a reddish blush, and again to only Montmorency and late varieties about 10 or 12 days later. Cut out and burn all Black Knots in winter and whenever seen in summer. For Slugs see under Pear above. For Aphids on Sweet Cherries postpone the 1st application until the buds are just bursting, and then add nicotine-sulphate 40 per cent. or Black Leaf 40. Good pruning with plenty of sunlight and air help against Rot.
PEACH. Leaf-curl, scab or black spot, yellows, little peach, curculio, borer, San José scale, shot-hole borer. (Consult bulletin 241.)	Before the buds begin to swell. (All must be done before any sign of bursting of buds.) Use A1 or B. This is usually the only spraying peach trees receive.	Soon after fruit is set. Use 2 or 3 lbs. arsenate of lead and 1 or 2 lbs. freshly slaked lime to 40 gals. water for curculio. Omit if curculio is not troublesome.	About one month after fruit is set. If troubled by Brown Rot use C or dust with sulphur. Good pruning and thinning the fruit help to control this disease.	If brown rot is likely to be troublesome use C again about one month before fruit ripens, or dust with sulphur. Destroy mummied fruit in autumn. Remove at once and burn any tree attacked by yellows or little peach and also all suspected trees. Dig out borers at base of tree with knife in May and again in October. For shot-holt borer cut down and burn before April all dead or dying trees or branches, and leave no brush heaps near orchard.

Note.—A1=Concentrated lime-sulphur strength 1:030 specific gravity (1:035 for San José scale) (1:030=1 gal. commercial to 9 gals. water, and 1:035=1 gal. commercial to 7 gals. water).

A2=Concentrated lime-sulphur strength 1:010 or 1:009 specific gravity=1 gal. Commercial to from 30 to 35 gals. water.

A3= " " " 1:009 or 1:008 specific gravity=1 gal. Commercial to from 33 to 40 gals. water.

B =The old home-boiled lime sulphur, 20.15.40 formula. **C** =Self-boiled lime-sulphur. **D** =Bordeaux mixture, 4.4.40 formula.

FORMULAE FOR INSECTICIDES

INSECTICIDES FOR BITING AND LAPPING INSECTS.

1. ARSENATE OF LEAD PASTE.

Use 2 to 3 lbs. to 40 gals. of water, or of lime-sulphur or of Bordeaux mixture.

2. ARSENATE OF LEAD POWDER.

Use 1 to 1½ lbs. to 40 gals. of water, or of lime-sulphur or of Bordeaux mixture.

3. ARSENATE OF LIME (Calcium arsenate).

Use ¾ to 1 lb. if in powder form to 40 gals of Bordeaux mixture. Double the amount if in paste form. (There is some doubt yet whether this poison is always safe with lime-sulphur. It is not safe alone).

4. PARIS GREEN.

Use ¼ to ½-lb. with 40 gals. of Bordeaux mixture. (This poison is not safe with lime-sulphur.)

FORMULAE FOR FUNGICIDES

I.—BORDEAUX MIXTURE.

Copper Sulphate (Bluestone) 4 lbs.
Unslaked Lime .... 4 lbs.
Water . . ..40 gals.

Dissolve the copper sulphate in a wooden or brass vessel with hot water, pour into a barrel and add cold water to make 20 gals.; slake the lime, preferably with hot water; add cold water to make 20 gals. Stir both barrels well and pour lime into the copper sulphate barrel. (Never mix concentrated milk of lime and copper sulphate solutions).

A stock solution of each may be made and kept indefinitely if not mixed:—Dissolve 40 lbs. copper sulphate in 40 gals. of water by suspending just below the surface of the water in a coarse sack. Each gallon of the liquid will now contain 1 lb. copper sulphate. Slake any desired quantity of lime and put into a box or barrel in shaded place, or sunk in the ground. Keep covered with small amount of water to exclude the air. Calculate how much is required for 4 lbs. lime if well stirred.

To test Bordeaux mixture, let a drop of ferro-cyanide of potassium solution fall into a little of the mixture in a saucer. If this causes it to turn reddish brown, add more lime until no change takes place.

II.—LIME-SULPHUR WASH.

1. Home Boiled (for use on dormant wood only):

Fresh stone lime ....20 lbs.
Sulphur (flour or flowers)..15 lbs.
Water . . ..40 gals.

Slake 20 lbs. of lime in about 15 gals. or more of boiling water in a kettle or other boiling outfit. While slaking add the 15 lbs. sulphur made into paste by the addi- 240 divided by 30=8. This means that each gallon of such a wash must be diluted to 8 gals. with water to give us a strength of 1:030, the proper spring strength. For the second application 1:009 is about the right strength. To get it divide the 240 by 9, which gives 26⅔, or roughly speaking 27. This means that each gallon of a wash of the strength of 1:240 must be diluted to 26⅔ or 27 gals. to make the right strength for the second application. For the third application and any later ones 1:008 is about the right strength, and to get this we proceed in the same way and divide 240 by 8=30, so that each gallon must be diluted to 30 with water for this application. If the strength of the concentrated were 1:212 or any other number, you would in the same way divide the three figures to the right by 30, 9 and 8 respectively to get the proper dilutions for each spraying.

TABLE FOR CHANGING BEAUME READINGS INTO THEIR EQUIVALENT SPECIFIC GRAVITY READINGS.

Beaume.		Specific Gravity.	Beaume.		Specific Gravity.
18	=	1:141	27	=	1:230
19	=	1:150	28	=	1:240
20	=	1:159	29	=	1:250
21	=	1:168	30	=	1:260
22	=	1:178	31	=	1:271
23	=	1:188	32	=	1:282
24	=	1:198	33	=	1:293
25	=	1:208	34	=	1:305
26	=	1:219	35	=	1:317

Note.—Commercial lime-sulphur should be tested with the hydrometer and diluted according to the same rules as the home-made concentrated form.

INSECTICIDES FOR SUCKING INSECTS ONLY.

1. LIME-SULPHUR.

For scale insects, Blister Mites and Red Spider.

2. TOBACCO EXTRACTS.

For Aphids, Leaf-Hoppers, Psyllas, etc.

(*a*) BLACK-LEAF 40, strength to use is indicated on the cans.

(*b*) NICOTINE-SULPHATE 40%. Strength is indicated on the cans. (Practically same as Black Leaf 40).

(*c*) HOME-MADE EXTRACT. Soak 1 lb. tobacco refuse in 1 gal. water for 24 hrs. with occasional stirring, or steep 1 lb. in 1 gal. water for 1 hr. Make up for water that evaporates. Use at once without dilution: spoils in a few days if not used.

3. KEROSENE EMULSION.

Kerosene (Coal Oil) ....2 gals.
Rain Water ....1 gal.
Soap ....½ lb.

Dissolve the soap in water by slicing and boiling; take from fire, and while hot pour in kerosene and churn vigorously for five minutes. For use dilute with 9 parts of water, so that the above 3 gals. of stock emulsion will make 30 gals. of spray mixture.

4. WHALE OIL SOAP.

For brown or black aphids, 1 lb. in 4 gals. rain water. For green aphids, thrip and leaf-hopper, 1 lb. in 6 gals. rain water.

tion of a little water. Boil vigorously, with stirring, for 1 hour. Dilute to 40 gals. with cold or hot water. Strain and apply at once.

2. COMMERCIAL LIME-SULPHUR. (Factory-made concentrated lime-sulphur).

This as purchased is usually about 1.290 specific gravity strength or 33° Baume.

3. HOME-MADE CONCENTRATED LIME-SULPHUR.

This may be used as a substitute for commercial lime-sulphur, but is only about ⅔ as strong as a rule.

Sulphur (a fine grade).....100 lbs.
Fresh stone lime, high in percentage of calcium... 50 lbs.
Water . . ..40 or 50 gals.

Put about 10 gals. water in the boiling outfit, start fire, add sulphur, stir to make paste and break lumps, then add remaining water, and when near boiling put in lime. Stir frequently while slaking and until all the sulphur and lime are dissolved. Add water from time to time to keep up to 40 or 50 gal. mark. Boil 1 hour, then strain through a screen of 20 meshes to inch into storage barrels. Make enough at once for season's work. Cover well to keep out air, or pour oil of any kind over surface to depth of ⅛ inch for same purpose.

To determine how much to dilute for different applications use a hydrometer with specific gravity readings, and apply the following rule:

Put the hydrometer in the clear liquid when it is cold and the sediment has all been settled for a day or two. Note the number to which it sinks. Suppose this is 1:240. The strength for use before the buds burst should be 1:030 or stronger. To determine how much to dilute a strength of 1:240 to get 1:030, divide the three figures to the right in 1:240 by 30, that is

4. SELF-BOILED (chiefly for use on peach foliage).

Fresh stone lime .... 8 lbs.
Sulphur (flour or flowers).. 8 lbs.
Water . . ..40 gals.

Best prepared in quantities of 24 lbs. at a time to get sufficient heat. Place 24 lbs. lime in a half barrel, add enough cold water to start it slaking well and to keep the sulphur off the bottom. Dust the 24 lbs. sulphur over the lime, having first worked the sulphur through a screen to break lumps, then add whatever further amount of water is necessary to complete the slaking. Stir well with a hoe to prevent the lime caking on the bottom. As soon as the slaking is over, add enough cold water to cool the whole mass and prevent further combination. Strain into spray tank. Keep well agitated while spraying.

5. DUST.

For biting insects and fungus diseases the substances used now are 85 to 90% of sulphur and 10 to 15 % of arsenate of lead powder. Dusting at this date (1917) is only in experimental stage.

III.—DISINFECTANTS (for pruning tools and for wounds on trees):—

1. CORROSIVE SUBLIMATE, 1 part to 1,000 by weight=1 tablet to 1 pint of water. Apply with a swab on end of a stick.
Caution.—Corrosive sublimate is a deadly poison to man or beast if taken internally. It will also corrode iron or metal, so use in a glass or wooden vessel and be sure to wash these out very thoroughly when through using them.

2. LIME-SULPHUR about twice spring strength, or bluestone, 1 lb. dissolved in about 14 gals. water, may be used to disinfect wounds or cankers, but is not satisfactory in case of Pear Blight.

CONTENTS

	Page
Introduction	1
What Fungus Diseases are	1
Spray Outfits	2
Some Suggestions on Spraying	2
Dusting Trees for Insects and Diseases	4
Spray Calendars	4
Apple Scab	5
Thoroughness in Spraying	9
Pruning as an Aid	9
Black Rot Canker	10
Leaf-Spot of Apple	10
Sooty Blotch or Fly Speck	12
Stippen or Baldwin Spot or Bitter Pit	13
Pink Rot	14
Pear Blight or Fire Blight or Twig Blight	15
Pear Scab	19
Leaf-Spot of Pear	19
Leaf Blight of Pear and Quince	20
Peach Leaf-Curl	21
Peach Yellows	22
Little Peach	22
Brown Rot of Stone Fruits	25
Peach Scab or Black Spot	28
Powdery Mildew of Peach	28
Crown Gall and Hairy Root	29
Canker or Gummosis of Peach	30
Black Knot of Plums and Cherries	31
Plum Pockets or Bladder Plums	32
Plum Rust	33
Leaf-Spot or Shot-Hole Fungus or Yellow-leaf Disease of Cherries and Plums	33
Powdery Mildew of Cherry	34
Injuries Due to Winter or Low Temperatures	35
Sunscald	35
Crown Rot or Collar Rot	37
Black Heart	37
Bark Splitting on Trunk	38
Crotch Injury	38
Killing Back of New Growth	39
Killing of Blossoms and Young Fruits	39
Russeting of Fruits	39
Crinkling and Rupturing of Leaves	39
Spray Calendar	40

BULLETIN 258] [JANUARY, 1918

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

The More Important Fungus and Bacterial Diseases of Vegetables in Ontario.

By J. E. Howitt and D. H. Jones.

INTRODUCTION.

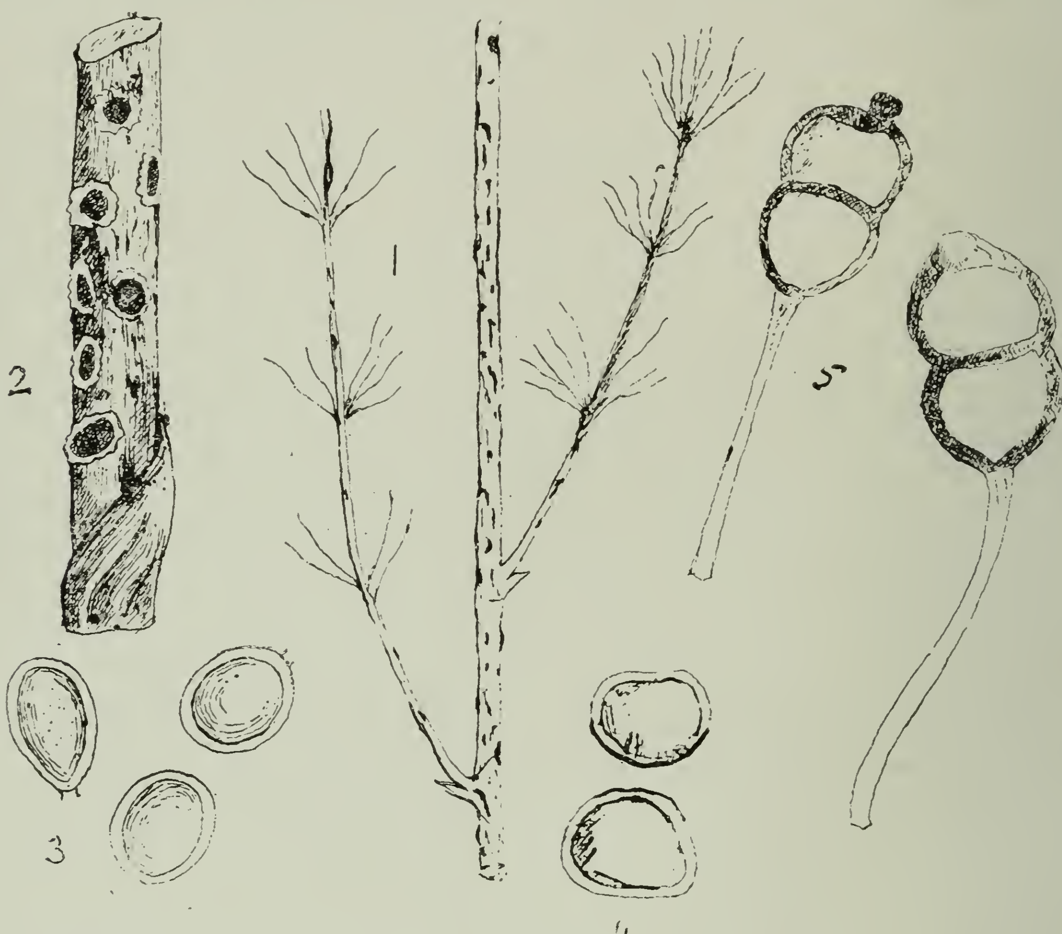
The object of this bulletin is to furnish all who are interested in the growing of vegetables with information which will enable them to identify the more common fungus and bacterial diseases of vegetables and to apply intelligently the treatments which experience has proved to be the most effective in each case.

In a bulletin of this nature it has been thought wise to include the bacterial with the fungus diseases, in order to place in the hands of the grower a complete and convenient manual of all the more important diseases of vegetables.

The majority of the diseases of vegetables are what are known as fungus diseases. It is important that those having to deal with them should understand fully the cause of such diseases, in order that they may apply intelligently remedies for their control. Fungus diseases are caused by plants known as fungi. These plants, unlike ordinary flowering plants, have no green coloring matter (chlorophyll) and are unable, therefore, to manufacture their own food. All their nourishment must be obtained from decaying animal or vegetable remains or from living plants or animals. Those fungi which derive their nourishment from living plants in so doing injure them in various ways, and thus give rise to what are known as fungus diseases.

The bodies of fungi which cause plant diseases are usually extremely small and very simple, consisting of very fine, delicate, thread-like structures (hyphæ), some of which become modified and produce reproductive bodies called spores, which may be considered similar to the seeds of flowering plants. Sometimes the fungus threads live upon the surface of the plants and obtain their nourishment by sending down little suckers (haustoria) into the cells below. Most frequently, however, they live within the plants, either in or between the cells. Two kinds of spores are usually produced—thin-walled summer spores, which spread the disease during the growing season, and thick-walled resting or winter spores, which serve to carry the disease over the winter. Spores are scattered by various agencies, chief among which are wind, water and insects. On coming in contact with a suitable host plant, they send out little threads (germ tubes), which enter the plants through the breathing pores on the leaves (stomata), through the skin or through wounds. Once within the plant, these little threads grow rapidly, drawing their nourishment from the cells of the host plant and setting up a diseased condition.

Generally speaking, in combating fungus diseases methods of prevention only are practicable, as once a fungus is within the plant nothing can be done to destroy it. Care should be taken to keep the crops in a healthy growing condition and free from injury by insects. Unthrifty plants and those attacked by insects are more liable to fungus diseases than healthy ones. Rotation of crops should be practised, so that the winter spores left in the soil may not infect the next season's crop. Weeds should be destroyed, as they frequently harbor fungi. Diseased crop refuse should be burned and not thrown on the manure heap. Fresh manure should be avoided, as it frequently contains living spores of parasitic fungi.



Asparagus Rust.

1. Attacked stem showing spore clusters.
2. Cluster-cup form.
3. Spores from cluster-cup.
4. Spores from summer stage (uredospores).
5. Resting or winter spores (teleutospores).

Intelligent and thorough spraying with Bordeaux or other fungicides will do much to prevent the spread of fungus diseases. It should be kept in mind, however, that spraying is done not to cure, but to prevent disease. In other words, the object of spraying is to cover the surface of the leaves, fruits or other parts of the plant with a substance poisonous to the spores of fungi, in which they cannot grow and penetrate the plant. Spraying, therefore, in order to be effective, must be timely and thorough. The spray mixture must be on the plant before the spores reach it, and the surface of the leaves, fruit and other parts of the plant must be covered so completely that there is not the smallest space on which a spore can germinate.

ASPARAGUS.

Rust (*Puccinia asparagi*, DeC): This disease is very common in Ontario, and is familiar to nearly every grower of asparagus. Sometimes it is reported as causing serious injury to asparagus plants.

The disease has three distinct stages. The first is known as the "cluster-cup" stage or the spring form. In this stage the spores are produced in cup-shaped pustules, which are grouped in oval clusters and are orange-yellow when mature. This form is seldom noticed by the growers. The second or summer stage is the one that is usually first noticed and called by them the Red Rust, on account of the elongated reddish-brown pustules which are seen breaking through the skin on the stem. In these pustules reddish, one-celled spores are produced, known as uredospores. It is in the summer or red rust stage that the disease spreads most rapidly and appears to do the greatest amount of harm. Towards fall, or whenever the vitality of the asparagus plants is reduced, the third and final stage known as the black rust or winter rust appears, owing to the fact that the red spores in the pustules are replaced by dark brown, two-celled, thick-walled spores, known as teleutospores. These germinate in the spring and give rise to the first stage again. The rust organism is, therefore, carried over the winter chiefly as spores on the old stems of the asparagus plants.

Prevention. Let no plants, not even wild ones, mature during the cutting season. Late in the fall, when growth is nearly over, cut out and burn the old plants. Plant Rust-resistant varieties. The Palmetto variety is said to be more resistant than many of the other common varieties. Spraying with Resin Bordeaux from July to September at intervals of ten days to two weeks, is recommended by some American investigators. This, however, is a difficult and costly undertaking, and it is doubtful whether it will pay here in Ontario.

BEANS.

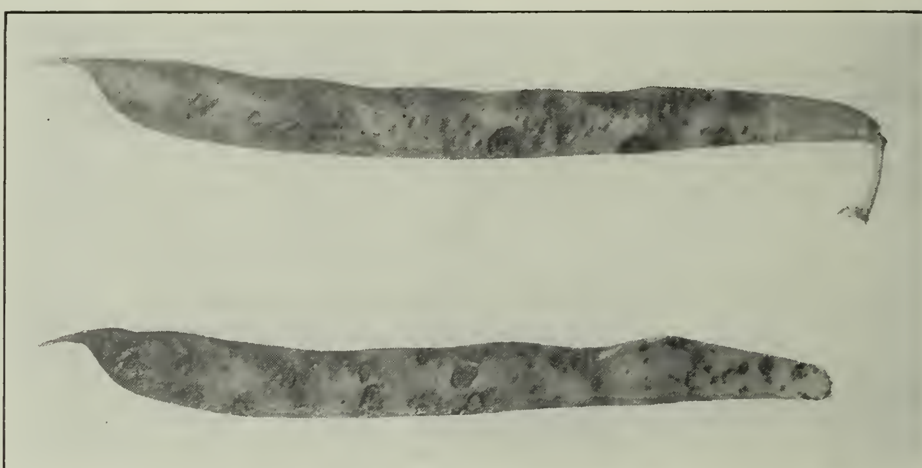
Anthracnose or Pod Spot (*Colletotrichum lindemuthianum*, (Sacc. & Magn.) Bri. & Cav.): The commonest and most serious disease to which beans are liable. In wet seasons it causes great loss, particularly in the bean-growing sections of Kent County.

Pods, seeds, leaves and stems are affected. On the pods sunken, reddish-brown or black spots, usually with rusty brown borders, are seen. In the centre of these spots pinkish masses may be noticed frequently. Affected seeds show dark brown or rusty discolored spots. These are often very minute. On the leaves the chief symptom is the brown and rusted appearance of the main veins underneath. Sometimes these appear as if cut or eaten out by the fungus. Occasionally small holes appear in the leaf, due to the destruction of the veins by the fungus. On the stems, rusty brown, elongated spots are sometimes seen. Occasionally these spots are so deep as to cause the stem of the leaf to break at this point.

The fungus which causes this disease is carried over the winter as dormant fungus threads (mycelium) in the seed. In the spring the disease first appears on the seed leaves (cotyledons) of the young plants. On these the first crop of spores of the season is soon produced. During wet weather the disease spreads very rapidly. The pods are attacked and the fungus penetrates through the tissue of the pod into the seeds. Here it remains in a more or less inactive condition until the seed is sown.

Prevention. Since the disease originates with infected seed, the most important point is to secure, if possible, clean seed. How are we going to obtain such seed? Seeds that are badly infected may be readily recognized by the discolored spots. Hand-sorting of the seed previous to sowing should help to reduce the amount of Anthracnose, but as a certain percentage of apparently healthy ones may contain the fungus the only sure way of obtaining non-infected seed is by gathering it from pods which are free from spots, the fungus, so far as is known, only infecting the seed through the pod. Hand-sorting of disease-free pods may not be practicable for large areas, but is quite practicable for small garden plots and for seed plots from which to obtain seed for the general crop where a large acreage of beans is grown. The seed plot should be watched closely and any diseased plants removed.

If possible a rotation of crops should be practised, beans not being sown on the same land more than once in three or four years. Bean straw should not be used for manure in fields where beans are to be grown. If the disease is present in the field, care should be taken not to work among the plants when they are wet with rain,



Bean Anthracnose Pods, showing the spots characteristic of the disease. (Original.)

since it is at this time that the spores are ready to be distributed, and each spore may start a new spot.

Spraying with Bordeaux mixture does not appear to be effective in controlling this disease. Treating the seed with formalin or other chemicals has not yet proved a practical success for the prevention of this trouble.

Rust (*Uromyces appendiculatus* (Pers.) Lev.): This disease is occasionally seen in Ontario, but seems to be of very little economic importance. It appears as small, round, rusty-brown, raised spots, chiefly on the under surface of the leaves, though leaf-stalks and pods may also be affected.

Prevention. It seldom calls for any particular treatment in Ontario, but if it should become serious it would be advisable to spray with Bordeaux mixture and burn the remains of diseased plants.

Bean Blight—Bacteriosis of Beans. Causal organism, *Ps. phaseoli* (Smith): Whilst there has been no record of heavy losses from this disease in Ontario, we get every year bean plants suffering from the disease forwarded to us. Letters accompanying these plants often state that considerable damage was done to the fields from which the plants were taken, many plants being attacked in the same way. Scarcely a season passes but what more or less of this disease is present in the beans of the College garden and in the bean plots in the experimental grounds. In the United States where wax beans and lima beans are grown extensively, heavy losses are caused by the disease, and it is getting more general in Ontario.

Beach of the Geneva Station established the bacterial character of the disease on lima and wax beans in 1892, and Halstead of the New Jersey Station in the same year arrived at similar conclusions after making a series of experiments. Erwin Smith in 1897 first described the causal organism, *Ps. phaseoli.* Work dealing with this disease has also been done in this laboratory.

Appearance of the Disease. The disease may be found on the foliage, the stems, the pods and the beans within the pods. At first the disease on the pods appears as small, water-soaked areas. These areas gradually enlarge and usually are outlined by a reddish-brown border. As the disease progresses and the areas continue to enlarge, the whole of the affected area becomes a light brown, and does not develop the black or pink color or the sunken spots produced by anthracnose. The foliage becomes spotted and yellowed in large areas of the leaf surface, soon withers and falls away.

Method of Infection.

Leaves. The disease usually begins at the margin of the leaf, or where the leaf has been torn by insects, wind or hail. Here the germs find entrance into the tissues through the wound. A yellow spot is formed and the green color destroyed. The spot increases in size rather slowly, and the diseased tissue becomes brown and papery, turning dry and brittle in the sun and soft in the rain, and then is often torn away, leaving ragged margins and holes in the leaf. The whole leaf may die and fall to the ground or remain withered on the stem.

Stems and Pods. The disease usually enters the stem by way of the leaf stalk, and advances in the stem to other leaves and to young pods. In severe cases the pod may wilt and die, and on opening it the half-grown seeds will be found shrivelled and discolored by irregular, brownish areas outlined by the characteristic reddish-brown margin. The beans may be apparently sound or only slightly discolored or they may be much discolored. The whole plant does not usually die outright, but lingers through the season. Separate infections may occur at any place on pod or stem.

Seed Beans. In germination tests of diseased beans less than half the number sown germinated. The remainder rotted. Those that germinated never produced healthy plants, but plants that were weak and soon wilted. Healthy seed sown under the same conditions germinated ninety-eight per cent., and produced vigorous, healthy plants.

The germs live over winter in the bean tissue and infect the plant on germination.

In appearance the disease is somewhat similar to Bean Anthracnose or "pod spot" caused by the fungus Colletotrichum lindemuthianum, but this latter may be distinguished by its making rather deep pits in the affected areas, which are pinkish and produce spore-bearing pimples.

In morphology and cultural characteristics, *Ps. phaseoli* is practically identical with *Ps. campestris,* which causes wilt or black rot of cabbages. But while it is pathogenic for beans, peas and lupines, it is not pathogenic for cabbage or cauli-

Bacteriosis of Beans. (Original).

1. Diseased pods.
2. Diseased beans from diseased pods.
3. Healthy beans.
4. Bean plant badly affected with bacteriosis in foliage and pods.
5. *Ps. phaseoli*, the cause of the disease.

flower. And while *Ps. campestris* is pathogenic for most crucifers, it is not pathogenic for the legumes.

The organism has been isolated by Delacroix from French grown plants at Paris.

Eradication and Control.

1. Do not sow seed from diseased plants. Affected seed will usually be more or less shrunken or shrivelled or have a varnish-like shiny yellowish or amber-colored appearance. This varnish-like coating of the seed is due to an exudate from the diseased pod in which the seed has been produced, and it contains thousands of the bacteria, many of which live over until the next season, ready to develop after the seed is sown, when they will attack the young seedling.

2. Carefully look over the crop when growing and remove and burn any plants showing indications of the disease. If affected plants are allowed to remain growing in the crop, the disease will be spread from them to the surrounding healthy plants by insects, and during cultivation or other handling.

3. Do not throw straw from diseased crop on to the manure pile, but carefully rake up and burn.

BEET.

Leaf Spot (*Cercospora beticola*, Sacc.): This disease is very common in Ontario, but seldom causes serious injury to garden varieties. The leaves of Sugar Beets, however, are sometimes destroyed by it. It is easily recognized by the small white or brown spots with purplish margins, which are scattered irregularly over the leaves. In the later stages these spots become ashy-grey in color. When they are very numerous the leaf tissue is, to a large extent, destroyed, and the value of the leaf to the plant correspondingly lessened.

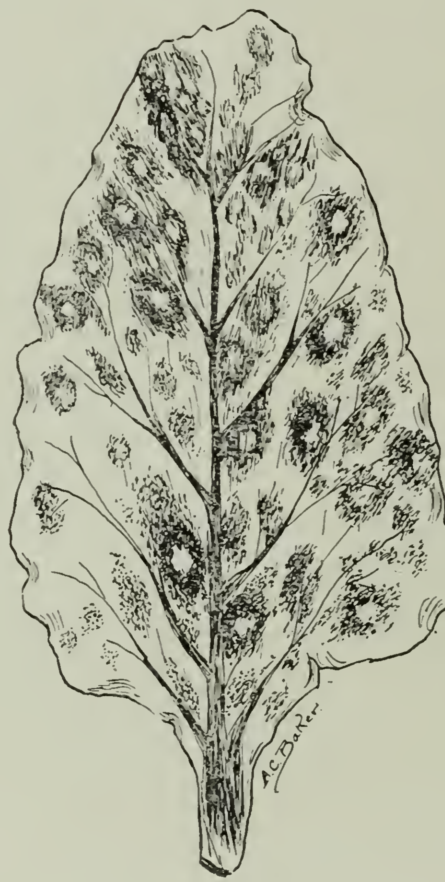
Prevention. This disease is seldom bad enough to require treatment. Spraying with resin Bordeaux at intervals of ten to fourteen days, beginning about the middle of July, is recommended.

CABBAGE AND CAULIFLOWER.

Club Root (*Plasmodiophora brassicæ*, Wor.): This disease attacks cabbage, cauliflower, turnips, radishes and other members of the Mustard family (*Cruciferæ*). It is a very troublesome disease in the Maritime Provinces and has been found in Ontario, but does not appear to be established in this province.

It is caused by a slime fungus. Affected plants are noticed to flag or wilt markedly, and if their roots are examined, irregular thickenings and knob-like swellings are found upon them. These often reach the size of a man's fist. The tops of diseased plants develop very slowly, cauliflower and cabbage attacked forming little or no head. The plants are often completely killed, since the swellings on the root prevent the proper absorption of water. The cells of the swellings when examined under a microscope are found to be large and filled with irregular brownish masses of protoplasm. Each such mass represents the vegetative body of a single organism. These vegetative bodies feed and grow at the expense of the cell contents, and when the food supply is exhausted each one divides into a large number of spores which, when the diseased roots decay, are set free into the soil in thousands. Naked, motile pieces of protoplasm emerge from the spores when they germinate. These enter the plant through the root hairs. The organism may remain in the soil for several years. It is chiefly spread in manure, by means of infected seedling stock, and possibly by spores adhering to the seed.

Prevention. Great care should be taken to prevent this disease being introduced and established in this province. Seed, if possible, should be obtained from a locality where the disease does not occur. If the seed has been obtained from an unknown source, as a precaution it is advisable to disinfect by soaking it for fifteen minutes in a solution of corrosive sublimate, of the strength of one part by

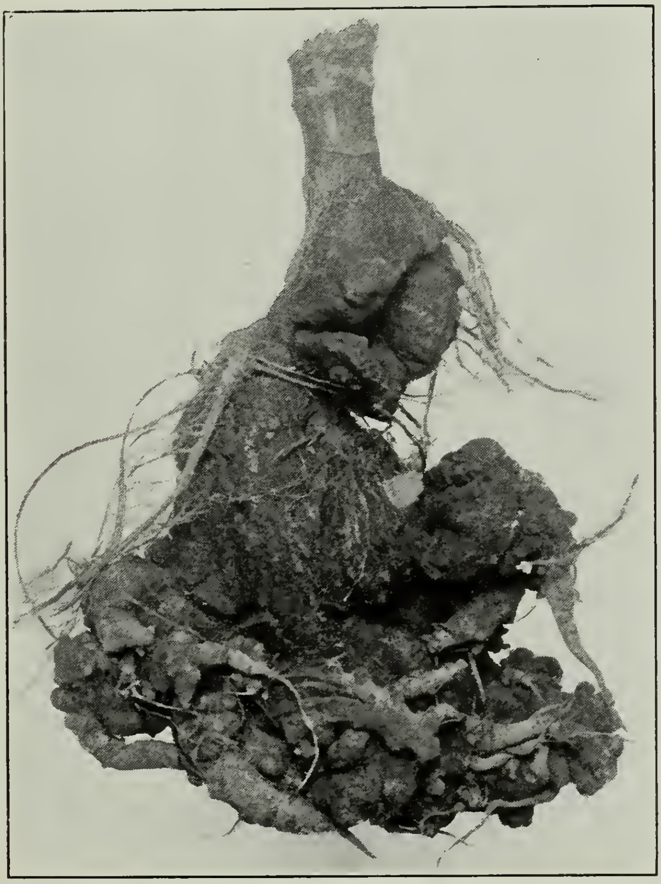


Leaf of beet attacked by leaf-spot fungus (*Cercospora beticola*).

weight to 1,000 of water. Tablets can be purchased, of which one tablet to a pint of water gives a solution of the required strength. Notice well that corrosive sublimate is a deadly poison, and should be kept away from children and stock. It also corrodes metal, and therefore should be mixed in wooden pails. Care should also be taken not to plant seedlings showing any signs of the disease.

If a few plants in the field develop the disease, dig them up, taking care to get all the root, and burn them. If the disease becomes established in a field a four or five-year rotation of crops should be practised, so as to avoid growing turnips or cabbages on the same soil for a number of years. Applications of lime every few years are of great value in lessening the severity of the attacks. Two to three tons per acre of air-slaked lime should be applied, preferably three or four years before sowing or planting a cruciferous crop. Lime the seed bed for cabbage and cauliflower in the same manner. Burn all refuse from diseased crop. If it is necessary to feed diseased turnips or other roots they should be thoroughly boiled before feeding. Do not use manure containing cabbage or cauliflower refuse, and if possible keep down weeds belonging to the Mustard family (*Cruciferæ*). These may harbor the disease.

Bacterial Wilt of Cruciferæ (Black Rot of Cabbage, Turnip, Rutabaga, etc.). Causal organism.—*Ps. campestris* (Pammel). This wilt, commonly known as Black Rot of Cabbage and sometimes as Brown Rot, is a very bad disease, and causes much loss to the kitchen gardener. It is found attacking many cruciferous plants, including cabbage, cauliflower, collards, Kohl rabi, kale, Brussels sprouts, broccoli, rutabagas, turnips, wild radish and mustard, the latter, unfortunately, only to a very slight extent.



Club Root of Cabbage. (Original.)

It is widely distributed, occurring throughout Canada, the United States, Great Britain, Holland, Germany, Denmark, Austria, France, Switzerland and other countries.

The specific cause of the disease was first ascertained by Pammel of Ames College, Iowa, in 1895, when, on investigating a bad outbreak of a black rot of rutabagas he isolated a germ which he named B. campestris, grew it on various culture media, and, by inoculating healthy plants with the cultures so obtained, produced in them the disease and from these plants reisolated the germ. Bulletin 27, Iowa College Experiment Station, 1895).

Erwin Smith, in 1896 (see Centralblatt für Bakteriologie, II Abte., Vol. 3, 1897), on investigating a brown rot of turnips and a black rot of cabbages, infected material of which was forwarded to his laboratory, isolated a germ which proved

2

to be identical with that isolated by Pammel the year before from rutabagas. He conducted numerous inoculation experiments and established the germ as being the specific cause of the wilt of many cruciferous plants which is so common in moist weather, and which causes heavy losses to market gardeners.

Appearance of the Disease. In the growing cabbage plant the disease manifests itself as a yellowing or browning of the leaves. This yellowing occurs in irregular areas sharply defined, which gradually enlarge until the whole leaf becomes browned, wilted and shrivelled.

If the plant be attacked by the disease when young, it will not develop normally, but will be dwarfed, and will present a pale, sickly appearance, and often no head will be produced in the case of a cabbage, and no bottom produced in the case of a turnip or rutabaga. (See illustration.)

The browning and wilting of the leaves is due to the supply of sap being cut off in the veins and midribs that are situated near or within the brown areas.

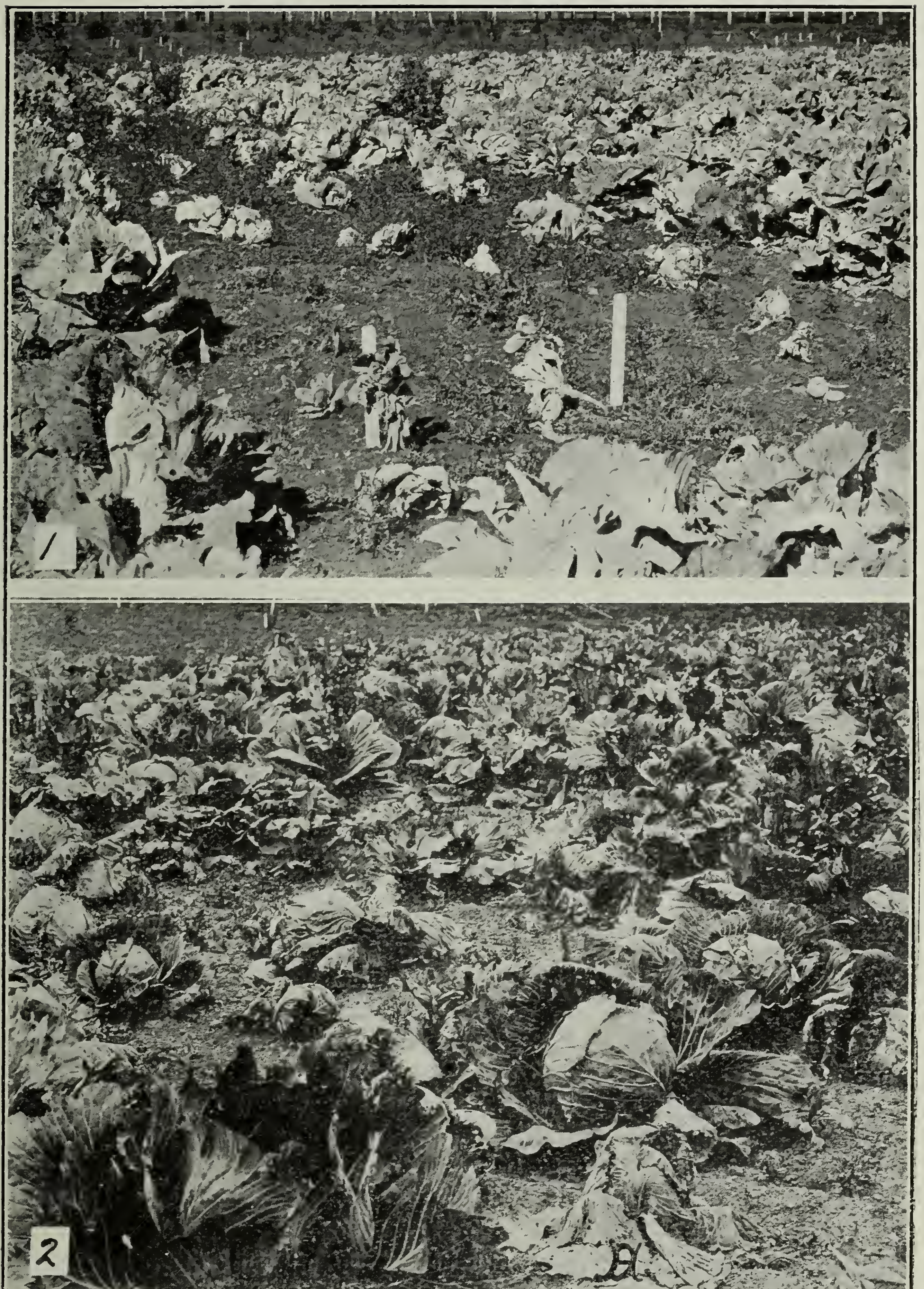
If the midrib of a diseased leaf or the veins leading from a diseased part of a leaf be cut it will be noticed that the vascular bundles or fibres are black or dark brown instead of yellow or white. This discoloration is due to the presence and action of immense numbers of the disease-producing bacteria within the veins or fibro-vascular bundles. Here they feed on the sap, multiply rapidly and choke up the passages so that the supply of sap is cut off from the surrounding tissue, thus causing it to yellow, wilt and die.

If the whole head of cabbage be yellowish, sickly and wilted, or if several leaves of a cabbage present such an appearance, a section of the stalk, either cross or longitudinal, will almost invariably reveal the disease in the blackened vascular bundles forming the vascular ring, the woody portion of the stem. In such a case the germs will have spread almost throughout the entire vascular system of the plant, passing down the veins of the stem to veins of other leaves until the whole plant became affected and worthless. (See illustration.)

Means of Infection.—Infection is most common at the water pores around the margin of the leaf. In the early morning, especially in moist weather, dewdrop-like beads of water may be noticed around the leaf margins of growing cabbages. This is usually water of exudation given off by the plant through the water pores. If the atmosphere were dry this water would not be found there, as it would evaporate as soon as it came to the surface of the plant. But when the atmosphere is moist this evaporation does not take place, and so the water extruded from the pores forms little beads.

Should the disease germs by any chance get into these drops of water it is very easy for them to enter the vascular system of the plant through the open pores. Thousands of cases where such has been the means of entrance of the germs into a plant have been observed.

The question remains: How do the germs get into the drop of water? This may occur in several ways. Slugs and caterpillars crawling around after feeding on or crawling over a diseased plant may carry and deposit the germs wherever they crawl on the healthy plants. The cultivator, in passing along the rows, may brush against and wound a diseased plant, and some of the germs thus get on to the cultivator, and so be carried along and brushed off on healthy plants. In transplanting the hands of the workman may become contaminated from handling a diseased plant, and plants subsequently handled have the germs deposited on them from the hands of the workman. Even should the plant be dry at the time it is so contaminated, the germs may remain alive on the plant for days until the right conditions



Bacterial Wilt of Cruciferеae (Black Rot of Cabbage). (Original).

1 and 2. Views in a cabbage plantation, showing numerous cases of the disease in all stages of development.

occur, that is, sufficient moisture be present in the atmosphere and in the soil to allow of the formation of water drops at the water pores when infection would take place.

Again, biting insects, caterpillars, slugs, and other forms of animal life which feed on growing cabbages, may, after feeding on a diseased plant, inoculate directly a healthy plant by biting through one of the small leaf veins and depositing there some of the germs adhering to their mouth parts after their visit to the diseased plant. Such means of inoculation have been observed again and again. Caterpillars and slugs feeding on diseased leaves have been transferred by hand to healthy plants, and in a large percentage of cases the disease has subsequently developed in the healthy plants at the point where the caterpillar was placed.

Infection through contaminated seed may occurr. By a series of experiments conducted at the New York Experiment Station, Geneva, it has been proven that the germ can live on dry seed for longer than nine months. Such contaminated seed, when germinating, is liable to infect the young plant, and cases of such infection may occur in seed beds.

Again, seed beds are often badly contaminated with the germ by spreading on them material from the manure pile or compost heap where diseased plants have been deposited to rot. And while it is very doubtful that the germ enters the plant through the root hairs, any injury to the root, or leaves that are near the ground, may result in the inoculation of the plant with the disease. Caterpillars and slugs crawling over such soil would be very liable to inoculate the plants growing there by crawling over and feeding on them.

Control of the Disease. The best way to keep the disease under control is to prevent its development.

Disinfecting the seed. It was proven at the Geneva Station that germs on the seed may be killed without any injury to the seed by soaking it for fifteen minutes either in a corrosive sublimate solution or in formalin.

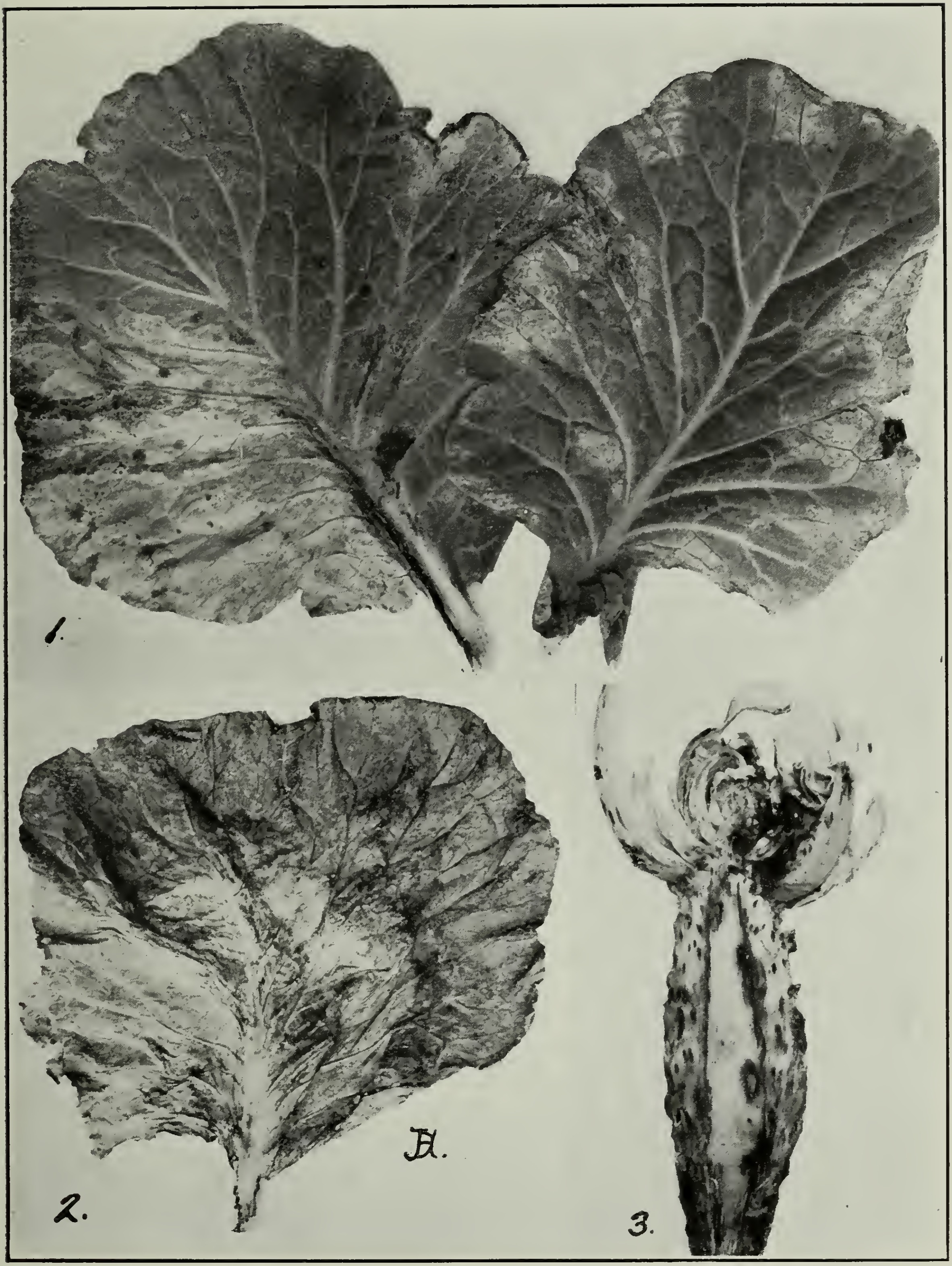
If corrosive sublimate is used, the strength of the solution should be one part corrosive sublimate to one thousand parts of water. The most convenient method of preparing this solution is to use the corrosive sublimate tablets sold by druggists for making disinfecting solutions. One tablet, costing one cent, is sufficient to make a pint of solution, which is about the quantity required to treat one pound of seed. The seed should be soaked in this solution fifteen minutes and then spread out to dry.

If formalin is used the strength of the solution should be one part formalin (40 per cent. formaldehyde) to 240 parts of water and the seed soaked for fifteen minutes.

A convenient method of treating the seed is to place it in a small bag made of any loose cloth readily penetrated by water and suspend the bag in the disinfecting solution for the required length of time. The seed should be dried without delay in the shade.

Handling Diseased Plants. Should the disease be noticed among seedlings in the seed bed, the diseased plants should be removed and burned. If they are not burned the germs within them are liable in many ways to get transferred to the healthy stock, and so the disease be spread instead of being checked.

Seedlings that show signs of the disease should not be planted out. It is not usually of much service simply to break a diseased leaf from what appears to be an otherwise healthy plant. If the disease is confined to the marginal areas of the leaf entirely, then breaking off the leaf would prevent the rest of the plant from



Bacterial Wilt of Crucifereae (Black Rot of Cabbage). (Original).

1. Cabbage leaves affected with the bacterial wilt or black rot. The lighter-shaded areas around the outer edge of the leaves are the diseased parts showing natural inoculation through the water pores on the edge of the leaves; the light-shaded areas were yellow.
2. The lighter shade part of the leaf near the base indicates the diseases, and the blackened vascular bundles of the stem, where it is cut, indicates that the disease entered this leaf from the main stalk of the cabbage.
3. Cabbage stalk and stunted head; the blackened vascular bundles indicate that the disease was general throughout the plant. The leaf of Fig. 2 was taken from this plant.

developing the disease. But should the vascular bundles in the midrib of the leaf at the point of its contact with the plant stalk be discolored brown or black, we may take it for granted that the germs are already established in the vascular bundles of the stalk. So, after breaking off a diseased leaf, one should look to see if any discoloration of the vascular bundles exists, and should there be any, the whole plant should be destroyed.

If an entire bed, or a considerable portion of a bed be badly attacked, all the plants should be pulled and burnt and the broken leaves, etc., raked up and burnt also. Cabbage or turnips should not be planted again on such ground for one or two years.

Insects and caterpillars, slugs, etc., should be kept in check, as they are noted carriers of the disease germ by feeding on diseased plants and then going to healthy plants.

CELERY.

Late Blight or Septoria Leaf-spot (*Septoria petroselini,* Desm. var. apii, Br. & Cov.): The common and destructive celery blight in Ontario. In wet seasons it is very injurious and ruins large quantities of celery. It is not usually noticed by the grower until late in the season, but a careful observer usually can find a little of it in the field shortly after the plants are set out.

On infected leaves irregular brownish spots usually develop. In these may be seen numerous minute black specks—the fruiting bodies of the fungus (pycnidia). The spots may be numerous and close together, and the leaf may wither and die. When the disease is bad, however, on many of the leaves the characteristic spots may not develop, but the whole leaf may be affected at once, become covered with minute black specks, dry and wither up. The lower leaves are nearly always the first to show the symptoms of the disease. The stems also are affected. On these irregular, rusty-brown, somewhat water-soaked areas with the characteristic minute black specks are seen. The disease develops further after the plants are lifted, and may subsequently cause serious rotting in storage.

The fungus which causes this disease is carried over the winter by spores in the diseased leaves, both in soil and manure. Infected seed is thought to be another means by which the fungus may winter over. In our experiments to determine this point, we have failed to secure any conclusive evidence that infected seed produces blighted plants. Our experiments, however, are still in progress, and it is yet too early to come to any definite conclusions from them.

Prevention. Spray with Bordeaux mixture (4.4.40 formula), commencing when the plants are in the seed bed and repeat at intervals of ten days or two weeks. The spraying should be continued as late as possible, leaving only a sufficient interval for the stain of the Bordeaux mixture to disappear before harvesting the celery. When the plants are large it is necessary to apply the spray with a good pressure in order to insure covering every portion of them. To do thorough work it is often advisable to go over every row twice at each spraying. Only thorough spraying pays. Our experiments in spraying to control Late Blight of celery have been carried on for four successive years, and the results show conclusively that loss from this disease can be prevented by spraying as recommended above. Experiments conducted under the direction of S. C. Johnston, Vegetable Specialist for the Ontario Department of Agriculture, have proved that such spraying is a commercial success. It is now practised by many of the large celery growers in Ontario.

It is not advisable to attempt to store for any length of time celery affected with Late Blight; before such celery is placed in storage the blighted leaves should be stripped off. Diseased celery tops should not be left lying on the ground or thrown on the manure heap, but should be raked up and burned.

EARLY BLIGHT OR CERCOSPORA LEAF-BLIGHT (*Cercospora apii,* Fr.): This disease appears to be of little importance in Ontario. It is seen to some extent nearly every year, but the writer has never observed it causing serious injury. Affected leaves are characterized by more or less circular spots, greyish-green in color at first, then becoming brown and later ashy. Separate spots generally have a well marked border. When numerous they run together in irregular patches.

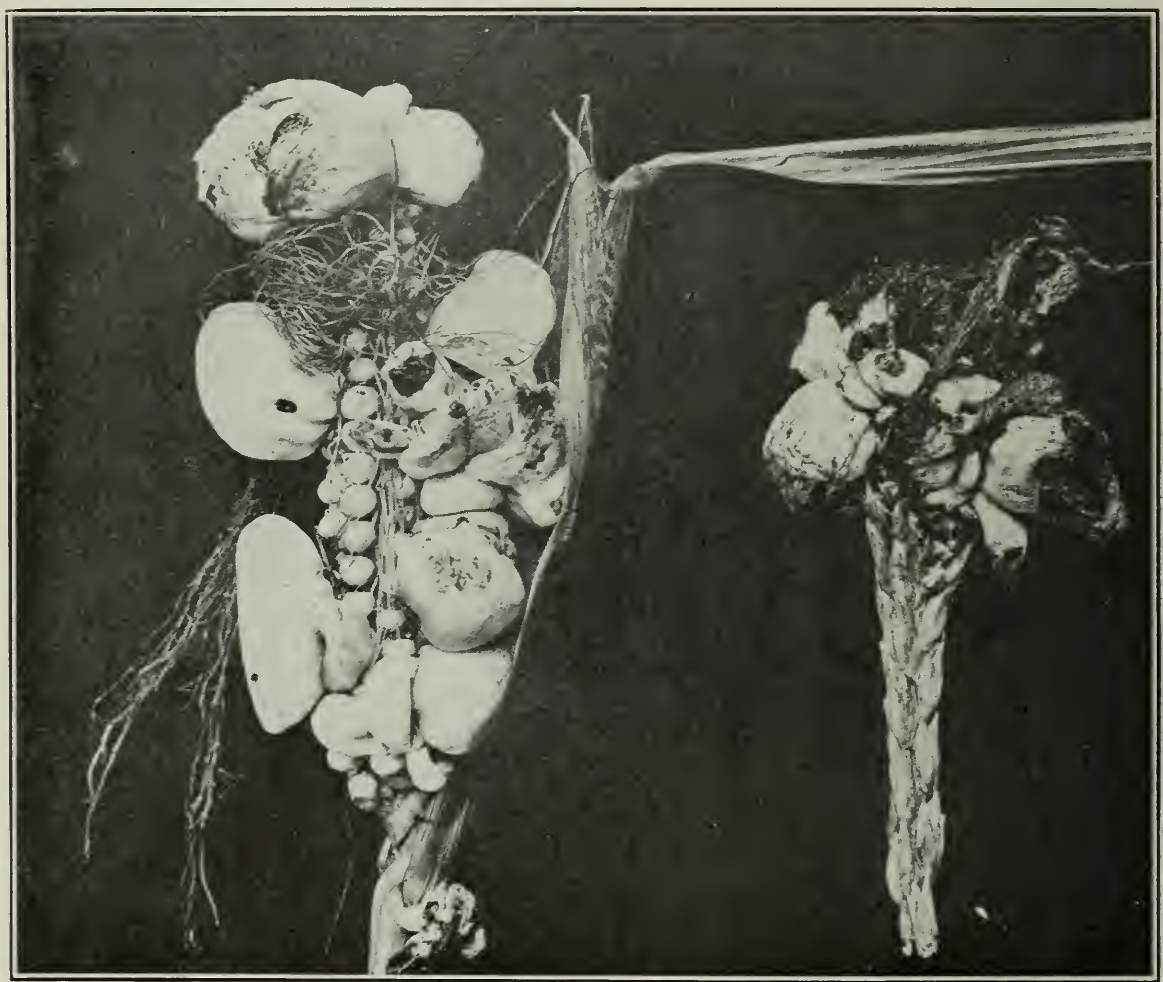
Prevention. Spraying and cultural methods as recommended for Late Blight will also prevent this disease.

Late Blight of Celery. (Original.)

CORN.

CORN SMUT (*Ustilago zeæ* (Beckm.) Ung.): This smut is exceedingly common and familiar to nearly everyone who grows any corn. The sugar or table corns seem to be more subject to smut than the field corns, but no varieties are entirely free. Corn Smut attacks the ears, stalks, leaves and tassels. It produces on the parts affected peculiar growths, frequently spoken of as "boils." These "boils" are sometimes six inches or more in diameter. They are white and polished in the early stage, but become dark as they mature and finally rupture and expose a brownish-black mass of powder, consisting of millions of spores.

As soon as the "boils" mature and rupture the spores are scattered by the wind and other agencies. In the soil or in manure they germinate and produce great numbers of secondary spores, which may infect any of the tender growing tissues of corn plants. Thus the disease is spread during the growing season. The organism which causes the disease is carried over the winter as spores in the soil or in manure. The soil and manure may be contaminated in various ways. The spores may be scattered by the wind or the spore masses may be left in the field or thrown on the refuse or manure pile. Smutted corn may be used for fodder, and it is thought that the spores may pass through the alimentary canals of the cattle without being injured, and thus get into the manure pile. It is believed that the spores of Corn Smut not only live through the winter in the manure pile, but that they actually grow and increase in number in the warm fermenting manure. The Smut organism may live for a considerable time in the manure heap before dying out.



Corn Smut on Ear and Tassel. (About one-half natural size).

Prevention. Treating the seed with formalin or bluestone will not prevent Corn Smut, since the organism is carried over the winter as spores in the soil and in manure.

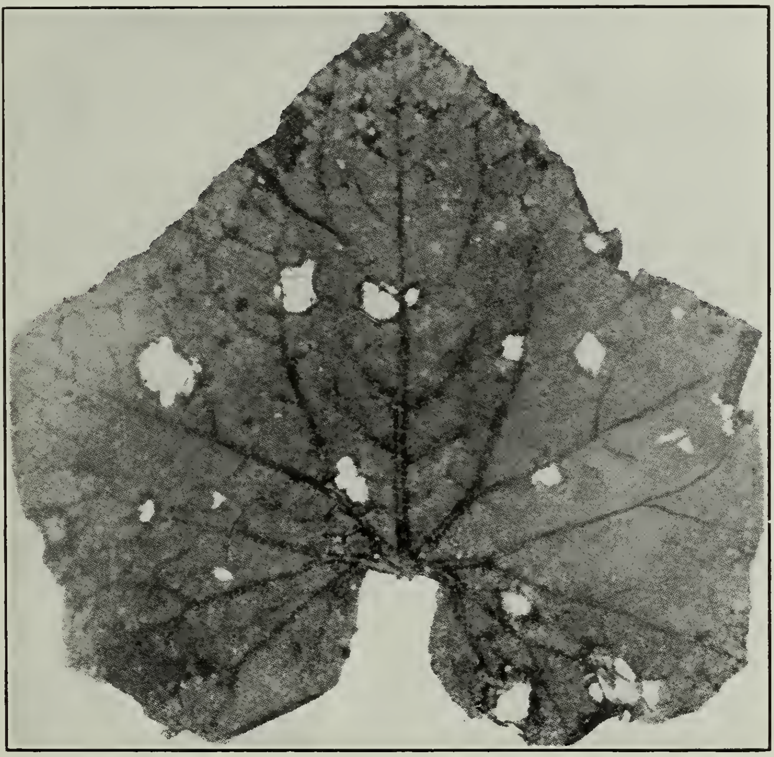
Go through the field and remove and burn all Smut growths as soon as they appear, as each "boil," when it matures, is a source of infection to the healthy plants around it. Avoid fresh manure, as it is very likely to contain live Smut spores. If possible, practise a rotation of crops. Corn Smut spores in the soil will not live for many years, and those which are in the soil cannot injure any other garden crop. After three or four years corn may be planted again with less danger, as many of the spores will have lost their vitality by this time.

RUST (*Puccinia sorghi*): A common but not serious disease. On affected leaves elongated reddish-brown pustules are seen on both surfaces. It is never serious enough to require treatment.

CUCUMBER.

Downy Mildew or Blight (*Plasmopora cubensis,* (B. & C.) Humphrey): This disease affects cucumber, melon, squash and pumpkin plants, damaging and in bad cases destroying the foliage. It appears as yellow spots, indefinite in outline. If the weather conditions are favorable to the fungus, these rapidly enlarge and finally the entire leaf withers up.

Prevention. Spray early with Bordeaux mixture, beginning when the plants begin to run. If the weather is dry, spraying every ten days will be often enough. If, however, the weather is wet, more frequent spraying will be necessary. For the early application use weak Bordeaux (2 lbs. copper sulphate, 4 lbs. lime and 40 gallons water). Later, when the plants have formed runners the 4.4.40 formula can be used. It is important that both sides of the leaves be covered at each spraying.



Downy Mildew of Muskmelon.
(After F. C. Stewart.)

Anthracnose of Cucumbers, Squash and Watermelons (*Colletotrichum lagenarium,* (Pass.) Ell. & Hals.): A disease frequently seen in Ontario, especially on cucumbers, the foliage of which is often badly damaged by it. On the leaves of affected plants brown, dead, circular spots are seen. These are frequently very numerous, so that the whole leaf is destroyed. On the stems elongated, light brown areas are observed. On affected fruit, especially on the watermelon, water-soaked, sunken spots appear. These often have pink centres.

Prevention. Spray with Bordeaux mixture as recommended for Downy Mildew of Cucumber. Rake up and burn the refuse from a diseased crop. If possible, practise a rotation of crops.

Bacterial Wilt of Cucurbits, Causal Organism, *Bacillus tracheiphilus* (Smith): This wilt often causes serious losses to the growers of cucumbers, squashes, melons and other cucurbits. Whole plantations of these plants are sometimes completely destroyed, and the disease will pass rapidly through a house of cucumbers.

A diseased plant loses its bright green color and turns to a dull, dirty yellowish green. The leaves and stems become flaccid and droop, hang down limp and lifeless, having lost all turgidity. The fruit, when affected, becomes soft and appears somewhat water-soaked, and if squeezed will readily yield to pressure, and often under such treatment the skin will rupture and a slimy, clear liquid will ooze out. If this liquid be touched with the finger or any instrument, it will be found to be viscid, slimy or gummy, and will string out in long strands. If a diseased stem be broken or cut, similar conditions will be found to exist, i.e., the plant juice will be viscid, slimy, and will string out in long strands when the cut surface is scraped with a knife or rubbed with the finger.

This sliminess or viscidity is the most characteristic feature of the disease, for a plant may wilt for lack of moisture and present an appearance something like a diseased plant. But if such a plant be cut and its juice expressed, this juice will prove to be quite watery and will not draw out in threads.

A microscopic analysis of the slimy juice from a diseased plant will show millions of bacteria within the smallest drop that can be obtained, while a similar preparation made from the juice of a healthy plant or a plant that has wilted merely from the lack of moisture will not show a single germ.

If a little of this slimy juice from a diseased plant be transferred on the point of a needle to the inner tissue of a healthy plant by puncturing the healthy plant with the contaminated needle, in a day or two the plant will wilt, the bacteria inserted on the point of the needle having multiplied so rapidly and spread through the vascular system of the plant.

Pure cultures of the germ on artificial media are rather difficult to obtain, as the germ will not grow readily on the ordinary media. However, pure cultures have been obtained on special media, and these inoculated into healthy plants have rapidly produced the disease.

In the stem and leaf the disease germ is found mostly in the vascular bundles, in the plant juice of which it lives and multiplies, spreading up and down and plugging the sap channels. Eventually the walls of the vascular bundles are broken down and the organism gets into the surrounding tissue to a limited extent.

The flesh of diseased fruit is transparent and water-soaked in appearance.

The plant juice in all affected parts becomes slimy or viscid, and strings out in long strands.

Methods of Spreading.—1. The disease is spread from plant to plant mostly by biting and sucking insects, particularly the Striped Cucumber Beetle and the Squash Bug. These insects, after feeding on a diseased plant, have their mouth parts covered with the germs of the disease, and on subsequently feeding on healthy plants they inoculate the healthy tissue with the disease.

2. The gardener, in removing and destroying the diseased plants, cannot help but get his hands and the tools used badly contaminated with the disease germs, even when exercising the greatest care, and so if he does not take the precaution to disinfect his hands and the tools used before handling any healthy plants, he is very likely to inoculate them with the germs of the disease.

Methods of Control. All diseased plants should be carefully removed and burned immediately. If they are allowed to lie around insects will swarm about

Bacterial Wilt of Cucurbits. (Original).

1. Bacterial wilt of cucumber.
2. Bacterial wilt of cucumber.
3. Bacterial wilt of squash.
4. Stained microscope preparation from the viscous slimy exudate of a vascular bundle of a wilting cucumber plant, showing the bacteria (B. tracheiphilus), (× 1000 di).

them, get themselves contaminated with the germs, and thus spread the disease wherever they go.

Hands and tools used in removing and destroying diseased plants should be thoroughly disinfected by washing them in five per cent. carbolic acid, or in corrosive sublimate of a strength one to one thousand, or some other good disinfectant.

Biting and sucking insects, especially the Striped Cucumber Beetle and Squash Bug, should be kept under control by spraying and hand picking.

LETTUCE.

"DROP" (*Sclerotinia libertina,* Fckl.) : This is the most serious disease to which lettuce is liable. It begins with a wilting of the outer leaves, which droop and fall flat on the ground. All the leaves of the plant are soon affected in the same way and in a few days the entire plant is dead and lying flat upon the ground. This sudden and total collapse of the plants has given rise to the name "Drop."

The greatest loss seems to occur when the plants are almost full grown. The fungus appears to spread almost entirely by the mycelium growing through the soil. Dense, compact portions of this mycelium form little masses (sclerotia) by means of which it is enabled to pass over unfavorable conditions intervening between successive crops of lettuce.

Prevention. If the disease becomes bad, sterilize the soil with steam by the inverted pan method, as described on page 47. Covering the surface with sterilized sand or earth has been found to lessen the disease materially, the effect being proportionate to the thickness of the layer added. If these treatments cannot be applied, the only alternative is to change the soil for each crop of lettuce.

Two other fungus diseases, the DOWNY MILDEW (*Bremia lactucæ,* Reg.) and LEAF SPOT (*Septoria consimilis*) are seen on lettuce to some extent in Ontario, but never seem to be serious enough to require any special attention when the crop is properly managed.

ONION.

ONION BLIGHT or MILDEW (*Peronospora schleideniana,* De Bary) : This is the commonest disease of the onion in Ontario, and in some parts of the province it frequently decreases very materially the onion crop by destroying the leaves, and thus reducing to a marked extent the size of the bulbs. It usually makes its appearance in late June or July.

Affected leaves first show peculiar violet tinted areas, due to the fuzzy, spore-bearing portions of the fungus on the surface. They very soon become pale or yellowish in spots and collapse and break down. If examined they are seen to be more or less covered with the spore-bearing parts of the fungus, which give to the surface of the leaves a furry appearance. In severe attacks all the leaves in a field or patch are very soon destroyed. They are often, however, quickly replaced by a new crop, which in turn may be destroyed by the disease, and from this second attack the onions do not usually recover.

Two kinds of spores are produced by the fungus, namely, thin-walled summer spores, borne on the minute, branched, spore-bearing parts of the fungus covering the surface of the attacked leaves, and thick-walled resting spores (oospores) formed in the tissues of the dead leaves. The summer spores are freely scattered by the wind during the summer, and new leaves thus become infected. In this way the disease spreads very rapidly, especially during damp, muggy weather. Dead leaves containing the thick-walled resting spores lie on the ground during the winter, and in the spring the spores germinate and give rise to the disease, if onions are planted again on the same ground.

Prevention. Spraying with resin Bordeaux is recommended by some American authorities for the control of this disease. So far, however, as experiments have been conducted in Ontario, such spraying has not proved satisfactory, but more experiments must be made before we are in a position to say that it will not prevent Onion Blight. American authorities recommend spraying thoroughly with resin Bordeaux, beginning about the end of June and repeating at intervals of ten days or two weeks throughout the growing season. Other preventive measures: rake up and burn the diseased tops, as by so doing many of the resting spores will be destroyed; if possible, practise a rotation of crops, as the disease is carried over the winter by the resting spores on the ground, and it is believed that they retain their vitality for two or three years; plant onions on well drained land, over which there is free circulation of air.

Black Mould (*Macrosporium parasiticum,* Thiem.): This fungus frequently follows Downy Mildew, causing the dead and dying leaves to become blackened and covered with a thick brownish-black fungus growth. This fungus does not attack healthy leaves and, therefore, its appearance on dead and dying tops should not cause any alarm.

Onion Smut (*Urocystis cepulæ,* Frost): This very injurious disease is, fortunately, not very common in Ontario. Outbreaks of it, however, have occurred from time to time in isolated districts, and onion growers should be on the watch for it in order to prevent it from becoming established in their fields, as the organism which causes it remains in the soil for at least twelve years.

This disease attacks onions grown from seed. It destroys large numbers of seedlings shortly after they appear above the ground. Affected seedlings which are not completely killed in the early stage are so severely injured that they die subsequently or produce small misshapen bulbs. The Smut is also sometimes seen on mature bulbs in the fall. Affected leaves are enlarged and often distorted and dark in color with black streaks. If they are broken they are found to be filled with a black powdery mass, which is composed of the spores of the fungus. Black masses of these Smut spores are also sometimes found on the bulbs.

The fungus which causes Onion Smut is a soil organism, and, as already stated, will remain in the soil for at least twelve years. It can infect the plants only when they are very small. It is carried long distances on the bulbs, and may be spread from field to field on implements and shoes, and washed from high to low land by heavy rains. It may also be introduced into new fields through the use of manure containing refuse from a diseased crop.

Prevention. If the soil is Smut infested, grow the onions on Smut-free soil, then transplant. This is a certain prevention, but involves considerable labor. Rotation of crops will reduce very considerably the amount of Smut. When sowing onions on infected fields apply a formalin solution of the strength of one pint of formalin to 30 gallons of water. This should be applied with a drip attachment on the seed drill at the rate of 125 to 150 gallons per acre (500 to 800 gallons per acre for sets). The same results can be obtained in open furrows by applying the solution with a sprinkler after the seeds are scattered until they are well moistened, then covering promptly with earth.

PEA.

Blight or Leaf-Spot of Pea (*Mycosphœrella pinodes* (Berk. & Blax.) Stone): This disease is commonly seen in gardens in Ontario, but seldom causes enough injury to attract attention. It originates from infected seed. Stem, leaves, pods and seeds are affected. Stems of infected plants show discolored areas of dead tissue, sometimes extending completely round them and destroying the shoot. Infected leaves show round or oval discolored spots, from one-eighth to one-half an inch in diameter. On the pods sunken spots much like those of Bean Anthracnose are seen, but pale in color.

The fungus passes the winter as dormant fungus threads (mycelium) in the seed.

Prevention. This is seldom required in Ontario, but if the disease should become prevalent, seed, free from disease, should be sown. This may be obtained by selecting it from healthy pods. Spraying with Bordeaux mixture, beginning when the plants are from two to four inches high and repeating at intervals of five to ten days according to the weather, is also recommended. Such treatment would hardly be worth while on the general crop, but it might be advisable to apply it on a small scale to plants set apart for seed production, since healthy pods bear healthy seeds, and healthy seeds will produce a clean crop the following year.

Powdery Mildew (*Erysiphe polygoni,* DeC.): This Mildew usually appears late in the season. Leaves, stems and pods become covered with a whitish or greyish mildew. Later, minute black fruiting bodies (perithecia) are to be seen scattered over the mildewed surface.

Prevention. The disease is seldom serious enough to call for any special treatment, but if it should become prevalent spraying with Bordeaux mixture should control it.

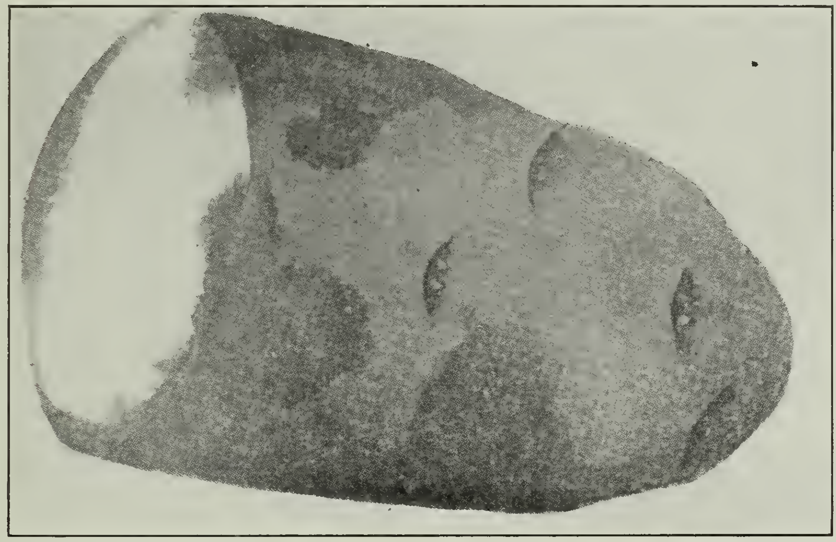
POTATO.

Late Blight and Rot of Potatoes (*Phytophthora infestans,* (Mont.) De Bary): This is the most destructive disease of potatoes in the province. In wet seasons it frequently destroys a large proportion of the crop. The effects of the disease are not noticed usually until late summer—August or September. Frequently, however, if the weather is wet about the middle of July, the disease may be seen in the fields by the middle or end of the month. Conditions which favor its spread and development are wet weather accompanied by relatively low temperatures and excessive moisture in the soil. It is nearly always worse on low, poorly drained lands and on heavy clay soils.

Leaves, stems and tubers are affected. On the infected leaves irregular dark spots or areas are observed. These are usually first seen on the lower leaves, often at the margins. They have a water-soaked appearance when held up to the light. On the under surface of the spots, especially around the margin, a delicate white fungus growth may frequently be seen. In wet weather the spots enlarge and the whole leaf is involved, becomes soft, brown, rotten and droops. In this way the tops may be all destroyed in a few days. In dry weather the spots do not enlarge but become dry, brittle and brown. On the stems brown streaks are sometimes seen. On some of the infected tubers, pits or more or less depressed areas, sometimes with a somewhat purplish tinge and a water-soaked appearance, are seen. If such tubers are cut, brown patches and streaks are found in the flesh beneath.

Infected tubers may dry-rot in the field or in storage. A wet, soft rot, however, usually develops in wet seasons. This is frequently observed when the potatoes are dug, and is thought to be due to organisms which gain entrance to the tubers through the dead areas produced by the fungus which causes the Late Blight and Rot. At harvest time, even if the tops have been badly blighted, there may be very little sign of rot. The tubers, however, are almost sure to be infected, and rot is very likely to develop after they have been stored.

The fungus which causes Late Blight and Rot is spread rapidly through the crop during wet weather by means of numerous spores produced on the lower surface of affected leaves and dispersed by wind and rain. Some of these are washed off the leaves down through the soil on to the tubers, which they are able to infect. The fungus is carried over the winter as fungus threads (mycelium) within infected tubers. Some of these tubers are used for seed, and a few of them produce stunted plants; when these are growing the fungus spreads into the developing shoots, grows up with them, and finally produces the first crop of spores of the



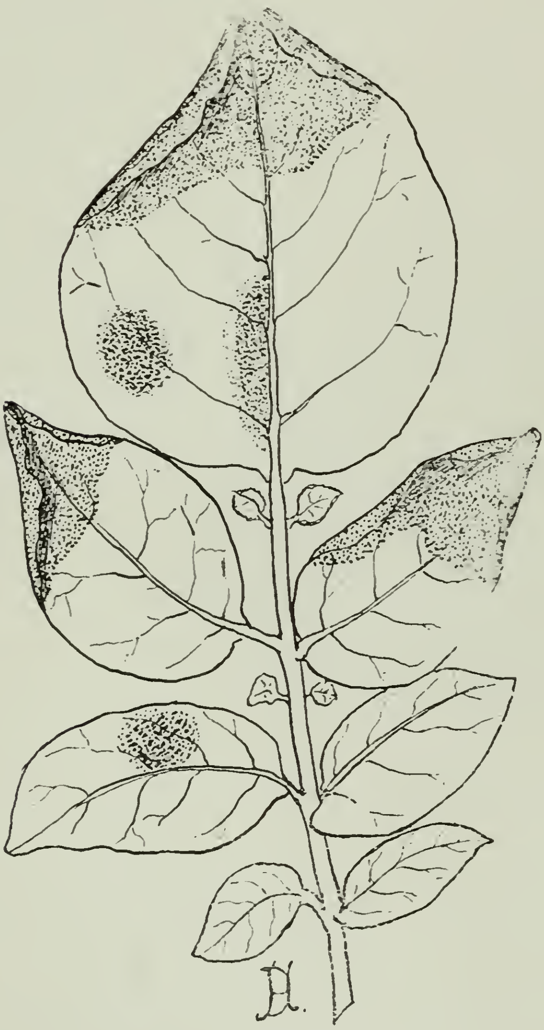
Characteristic Rot due to the Late Blight and Rot Fungus.
(After Gussow.)

season on their stalks and leaves. From a very few of these infected plants here and there in a field the fungus may spread over the whole crop if climatic conditions are favorable to its development.

Prevention. Spray with Bordeaux mixture. Commence spraying when the plants are from five to eight inches high, and keep the foliage covered with Bordeaux throughout the season. Take special precautions to see that the spraying is very thoroughly done if the weather is at all damp about the 15th of July, as Blight often begins about this time. Add a poison to each application when necessary for Potato Beetles—arsenate of lead paste 3½ pounds to each 40 gallons of the liquid spray, or Paris green 2 pounds to 40 gallons, or a mixture of 2 pounds of arsenate of lead paste and 1 pound of Paris green to 40 gallons. From three to seven applications should be made, depending upon the season; the wetter the weather the larger the number. Do not put off spraying because it looks like rain. If the spray is on the plants half an hour before rain comes it will be dry, and sufficient of it will stick to prevent infection, which takes place during or soon after the rain. Spraying as described above should prevent not only Late Blight and Rot, but also Early Blight and Potato Beetles. For Late Blight and Rot only, it is not necessary to commence spraying until about the 10th of July; but in Ontario it is usually advisable to spray for all three.

Other means which are recommended to prevent loss from this disease are, planting the more rot-resistant varieties (see O.A.C. Bulletin 239) and avoiding soils which are not thoroughly under-drained, either naturally or artificially.

Early Blight or Leaf-Spot Disease (*Alternaria solani,* E. & M.): This disease is common and in some years causes noticeable damage. It sometimes appears when the plants are from six to eight inches high, but is most abundant



Late Blight.

Early Blight.

about the time the potatoes are in flower. In severe cases the foliage is badly damaged and the tubers remain small. Unhealthy plants and those attacked by the Flea Beetle suffer most from this disease.

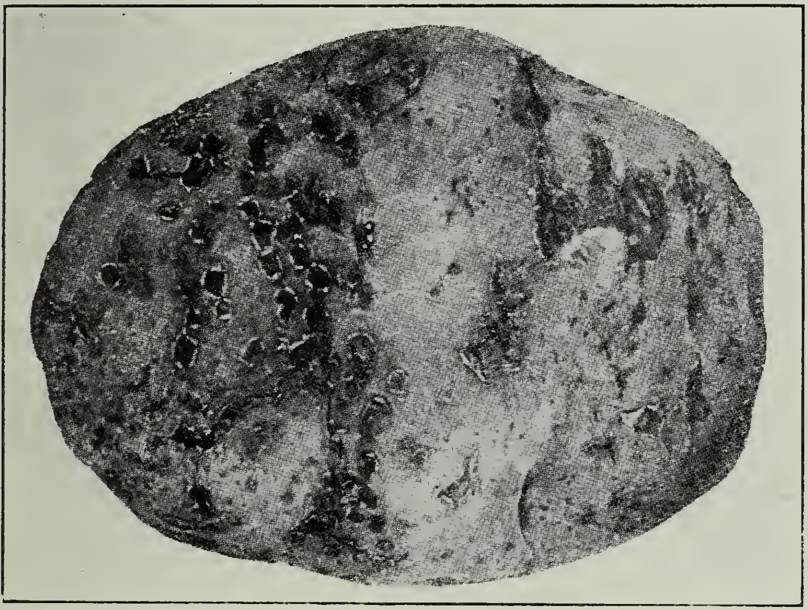
Small, scattered, greyish-brown circular spots are first observed on the leaves. These take on a minutely velvety appearance and gradually become larger and run into each other until in some cases half the leaf may become brown and curled. As the spots enlarge faint, concentric rings appear on them, described as "target brand" markings. It is thought that the organism which causes this disease passes the winter as dormant fungus threads (mycelium) in the dead tops and as spores in the soil.

Prevention. Spray with Bordeaux mixture and Paris green or arsenate of lead, as recommended for Late Blight and Rot, giving special attention to the early applications. Rake up and burn diseased tops after the potatoes are dug.

TIP BURN. This is a so-called physiological trouble, that is, it is not due to any organism, but to some condition within the plant itself, probably induced by its environment. It is very frequently seen in abundance in Ontario in hot, dry summers. The leaves brown and curl at the tips and margins. This browning and curling when the trouble is serious may extend to the mid-rib or near it over a considerable portion of the leaf.

Prevention. Keep the soil rich in humus and see that the potatoes are repeatedly and thoroughly cultivated after they are up in the rows to keep down weeds and conserve moisture. Spraying with Bordeaux mixture as for Late Blight and Rot has been found to lessen this trouble.

COMMON SCAB (*Actinomyces cromogenus,* Gasperini): This Scab is familiar to nearly every potato grower. It is easily recognized by the roughened, corky spots



Powdery Scab (after Morse).

Common Scab. (Original.)

on the skin of the tubers. These may be few and scattered or numerous and close together, so as to disfigure badly the potatoes. Sometimes there are also blackened, pocket-like cavities, probably due to mites working in the Scab spots. Scab does not injure the flesh of the tubers to any extent, but renders them unsightly and hence they are not readily saleable.

The organism which causes Common Scab is carried over the winter on seed potatoes and in the soil. A few scabby potatoes in a bag may contaminate the whole lot. The Scab parasite remains in the soil for many years after a crop of scabby potatoes has been produced on it. It will also pass through the intestines of stock fed on scabby potatoes. It thrives best on an alkali soil and is checked by acidity.

Prevention. For seed select smooth, sound potatoes, as free as possible from Scab, and disinfect by soaking them before they are cut for two hours in a solution made by adding half a pint of commercial formalin to fifteen gallons of water. Then spread out on clean grass to dry. Wash all crates, bags, etc., which are used in handling the potatoes in the same solution. The same formalin solution can be used to treat successive lots of potatoes. Fifteen gallons is sufficient to treat from 20 to 25 bushels if ordinary precautions are taken not to waste too much of the fluid as each lot of tubers is dipped. If the potatoes are not all treated the same day, it is advisable to make up fresh formalin solution for each day's work. If possible plant on clean soil, that is, soil that has not produced a crop of scabby potatoes. Practise a rotation of crops. If Scab is very bad it is not advisable to plant potatoes on the same land oftener than once in five years. Heavy applications of barnyard manure should not be made to the potato crop, but if necessary given at some other point in the rotation. Plant potatoes after clover sod if possible. Avoid alkali fertilizers such as lime and wood ashes. Cook scabby potatoes before feeding to stock.

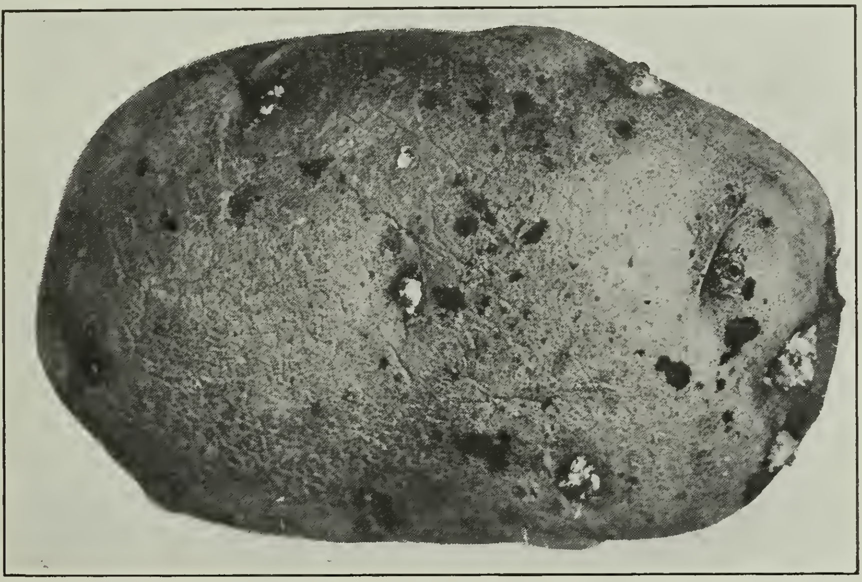
Powdery Scab (*Spongospora subterranea* (Wallroth), Johnson): This disease was first reported as occurring in Canada about 1912. It was found in Prince Edward Island, Nova Scotia, New Brunswick, Quebec and Alberta. In 1914 it was found in one locality in Northern Ontario. Measures were at once taken to stamp it out. Since that time it has not been found in the Province. It seems safe to conclude, therefore, that at the present time Ontario is free from Powdery Scab. There is great danger, however, of it being reintroduced into the Province on seed potatoes, and those who grow potatoes should be on the watch for it, as it is very undesirable that Powdery Scab should become permanently established in Ontario, since it appears capable of causing appreciable damage to the potato crop.

Tubers infected by the Powdery Scab fungus become covered with conspicuous scab spots, which are more clearly defined, more elevated and smoother on the surface than the spots of Common Potato Scab. When the skin of the scab spot is broken the cavity beneath is seen to be filled with a brownish or greenish powder. As is the case with Common Scab, the chief injury is due to the unsightly appearance of the tubers. In severe cases, however, the potatoes may be stunted and malformed, and it is said that there is always a greater tendency for infected tubers to shrivel in storage.

The fungus which causes Powdery Scab is spread mainly on seed potatoes. It is introduced into new localities chiefly through planting seed which is infected or which has come in contact with infected tubers, or with bags, crates, implements, etc., which have been used in handling them. Once the fungus gains entrance to the soil it will apparently remain there for a number of years.

Prevention. If possible secure seed potatoes from a district known to be free from Powdery Scab. Plant only sound tubers free from Scab and as a precaution disinfect them; use corrosive sublimate rather than formalin for the prevention of this disease. (See directions for the use of corrosive sublimate, page 27.) Such treatment will not render tubers from an infected crop entirely safe for seed, but will destroy spores on the surface and thus prevent the risk of the organism being introduced on healthy tubers which have been in contact with infected tubers or with bags, crates, implements, etc., contaminated with spores. If Powdery Scab is found in a field, report its occurrence at once to the Dominion Botanist, Central Experimental Farm, Ottawa, or to the Botanical Department, Ontario Agricultural College, Guelph, and information will be sent regarding the best method of stamping it out.

Rhizoctonia, Black Scurf (*Corticium vagum*, B. & C. var. solani, Burt.): This disease is very frequently met with in Ontario and in seasons of excessive rainfall often results in a noticeable reduction of the crop. Tubers are very frequently seen with what appear to be lumps of hardened soil adhering to them. These when wet are black in color. They vary in size from mere specks to one-quarter of an inch in diameter. Sometimes they are very numerous and quite noticeable. They are known as sclerotia, and consist of compact masses of resting fungus threads (mycelium). The flesh of the potato beneath is not injured by them. If tubers, however, with these sclerotia adhering to them are planted, the fungus may spread to the developing sprouts and kill them before they get above the ground, this being one cause of potato failures. Later in the season several other symptoms may develop. Young shoots may wither and die and if these are pulled up and examined there will be found at the base of the stem brown dead areas often encircling it. Sometimes at the base of the stem of affected plants a cluster of small tubers may be found, and very often small greenish potatoes are seen on the stem above ground. Such aerial tubers are very characteristic of the disease, but may result from other causes such as injury to the stem by cultivation. The chief means by which the fungus is spread is through planting potatoes with sclerotia



Hard black lumps (sclerotia) of Rhizoctonia on Potato.
(Original.)

adhering to them. The fungus attacks many cultivated plants besides potatoes and very frequently causes the damping-off of seedlings.

Prevention. Since the fungus lives on many different plants, once it gets established in a field it is practically impossible to "starve it out" by a rotation of crops. Care should be taken therefore to avoid as far as possible introducing it into the soil. Disinfecting the seed with corrosive sublimate is recommended. Formalin is said to be unreliable and often worthless for the prevention of this disease. When it is troublesome, select tubers as free as possible from the little hard dark lumps (sclerotia) and disinfect by soaking them before they are cut for three hours in a solution of two ounces of corrosive sublimate in 25 gallons of water. (N.B.—Corrosive sublimate is a deadly poison. Potatoes treated with it are rendered unfit for food).

Soft Rot and Black Leg of Potatoes: The diseases to which potatoes are subject are numerous. Various species of fungi are responsible for most of them, but bacteria are involved in some cases. This is particularly so with Soft Rot and Black Leg.

Black Leg of Potato. (Original.)

Black Leg of Potato.

Young potato plants suffering from "Black Leg" or basal stem rot, natural infections. They were from a crop of Davies' Warriors growing in the Experimental plats (O.A.C.), July, 1916. The seed tubers had been carefully picked over and treated with formalin for scab before planting. They were planted on land that had produced considerable rot of the same kind during 1915. Hot dry weather prevailed at the time the plants were picked.

The seed tubers of Nos. 1, 2, 3, and 4, were all rotted away with a wet, slimy rot, at the time the young plants were carefully removed from the soil. A bit of skin with slimy tissue, remains of the seed tuber, is attached to No. 1.

Microscopic examination of portions of rotting stems showed:

No. 1. Heavy bacterial invasion and some Fusarium mycelium.
No. 2. Heavy bacterial invasion and traces of Rhizoctonia mycelium.
No. 3. Ditto, ditto.
No. 4. Ditto, ditto.
No. 5. Heavy bacterial invasion and soft rot of lower part of stem, starting in a bacterial soft, slimy, rotting area of the seed potato; remainder of seed potato still sound. No Rhizoctonia or Fusarium found.

During wet, backward seasons, and in wet, poorly-drained soils, these diseases are liable to be much in evidence.

In the years 1904 and 1905, Prof. F. C. Harrison, then of the Bacteriology Department of the Ontario Agricultural College, made an extended investigation of serious outbreaks of soft rot of potatoes at Guelph and isolated from diseased specimens a bacillus which he named *B. solanisaprus*, which, on inoculation into healthy potatoes, induced soft rot.

About the same time that Prof. Harrison was investigating the disease at Guelph, Dr. Appel, of Germany, was, investigating a disease of young potato stems more or less common in Europe, and he isolated a bacillus from diseased specimens, which he named *B. phytophthorus*. He considered this to be the cause of the potato stems turning black and soft rotting and he named the disease "Black Leg of Potatoes."

It is now considered that the disease described by Harrison as Bacterial Soft Rot of Potatoes and the disease described by Appel as Black Leg of Potatoes are probably one and the same, the term "black leg" applying to the disease when present in the stems of growing potatoes, and the term "bacterial soft rot" applied to the disease in the plant in general, but particularly in the tubers. Harrison found that this organism caused a black discoloration and rot of the stems of young plants, but laid most emphasis on its soft rotting effect on the tubers later in the season. Hence he named the disease "Bacterial Soft Rot of Potatoes."

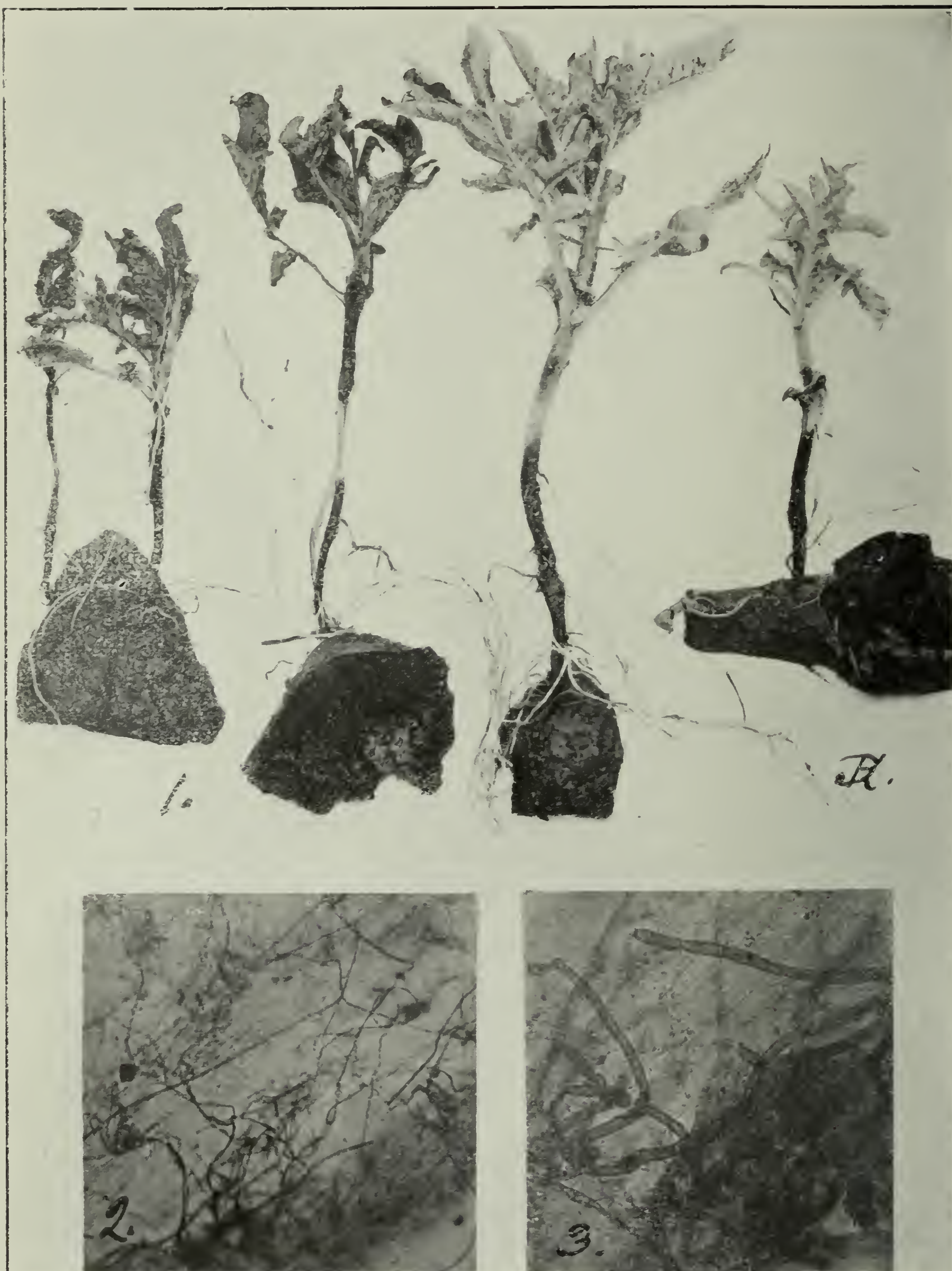
The following is a partial quotation of Prof. Harrison's description of the disease as published in the Centralblatt für Bakteriologie, 2 Abte. Vol. 17, 1906-7:

General Appearance of the Disease in Growing Potatoes.

In the majority of cases the first symptoms appear when plants are in full vigour of growth. A plant here and there will present a sickly appearance—drooping leaves, discoloured yellowish. In a few days the stems gradually droop, finally rest on the ground and shrivel up.

When the leaves are turning yellow, black areas may be seen on the stems and petioles, and if these are cut through, the fibro-vascular bundles and adjacent tissues will be found brown or black according to the progress of the disease. The stems are usually most discoloured near the ground. The leaves occasionally turn black without previous yellowing.

The tubers show the most characteristic indications of the disease. Even when the plant appears in a fairly thrifty state, the tubers may be badly diseased, out of all proportion to the apparent vigour of the plant. At first sight, most of the potatoes appear to be sound, but on closer examination the skin over certain areas may be found discoloured a reddish-brown, something like a bruise, with a firm consistency,



Black Leg and Rhizoctonia. (Original).

1. Young potato plants showing Black Leg. The three stems to the left killed; the two to the right badly affected. (Both Rhizoctonia mycelium and soft rot bacilli found in affected parts).
2. Small portion of epidermis from affected areas, showing Rhizoctonia mycelium, low magnification.
3. Small portion (Fig. 2) under high magnification.

but as the disease progresses, the flesh beneath the dark portion becomes soft. There is a sharp line of demarcation between the healthy and diseased portions, frequently marked by a black line, the darker colour being toward the sound part of the potato and gradually shading to a lighter brown on the diseased portion.

On breaking the skin a white, turbid liquid which may contain gas bubbles can be pressed out. This liquid rapidly turns black on exposure to the air. The skin over the diseased area easily peels away and the exposed flesh is watery and white, but soon discolours in the air, becoming almost black. In later stages of the disease the flesh softens to a watery pulp and becomes highly offensive with a putrefactive odour. In the final stage the potato becomes a mass of black soft pulp.

Several modifications of these conditions may be noticed. Thus the discolouration and blackening may be confined to only one portion of the tuber, and at other times the whole of the tuber beneath the skin is softened and discoloured with the centre portions quite sound. In some cases the most rotten tuber was the seed potato, in others the new potatoes.

The rot seemed to extend from the one first infected to the rest, infection evidently caused by actual contact.

If the potatoes are allowed to dry out, the tissues between the healthy and already softened portions undergo a corky modification.

After the potatoes are dug, and the apparently sound ones are put into a cellar or pit, the disease continues to spread, and in cutting open affected potatoes they will be found with brown or blackened areas. Such areas are not confined to the fibro-vascular ring, but may be of any size and in any portion of the potato.

Natural Method of Infection. One of the principal means of infection is the diseased condition of the seed potato when planted. In a large number of plants examined in the field the seed potato was found to be badly rotted and the young potatoes around were infected on the side nearest the rotted tuber. While it is doubtful if the potato rot bacillus can penetrate the unbroken epidermis, yet, if a small amount of rotted potato is placed on the unbroken surface of a healthy tuber, it will in a short time cause infection. This is probably due to the large amount of cytase in the rotted mass, which is able to bring about a solvent action on the cement substance of the cells of the healthy potato.

In the event of the organism being in the soil, infection may take place through wounds made while cultivating.

During the season of 1915 Black Leg and Soft Rot of Potatoes was very common in many districts in Ontario. The writer received many specimens of diseased plants from Peel, Norfolk, Lambton, Grey, Dufferin, Nipissing, Simcoe and Brant counties, and devoted considerable time to a study of the disease throughout the season as it developed in the neighborhood of Guelph. Bacilli were isolated from some specimens very similar to the species described by Prof. Harrison, which, on inoculation into growing potato stems produced Black Leg and when inoculated into tubers produced a soft, slimy rot.

Many of the specimens of Black Leg examined, however, were also affected with the fungus Rhizoctonia, and from continued observations and a number of experiments conducted during 1915 and 1916, the writer came to the conclusion that most of the trouble with Black Leg during those seasons was due primarily to affection of the young sprouts from the seed potatoes with this fungus, followed by invasion with the bacteria.

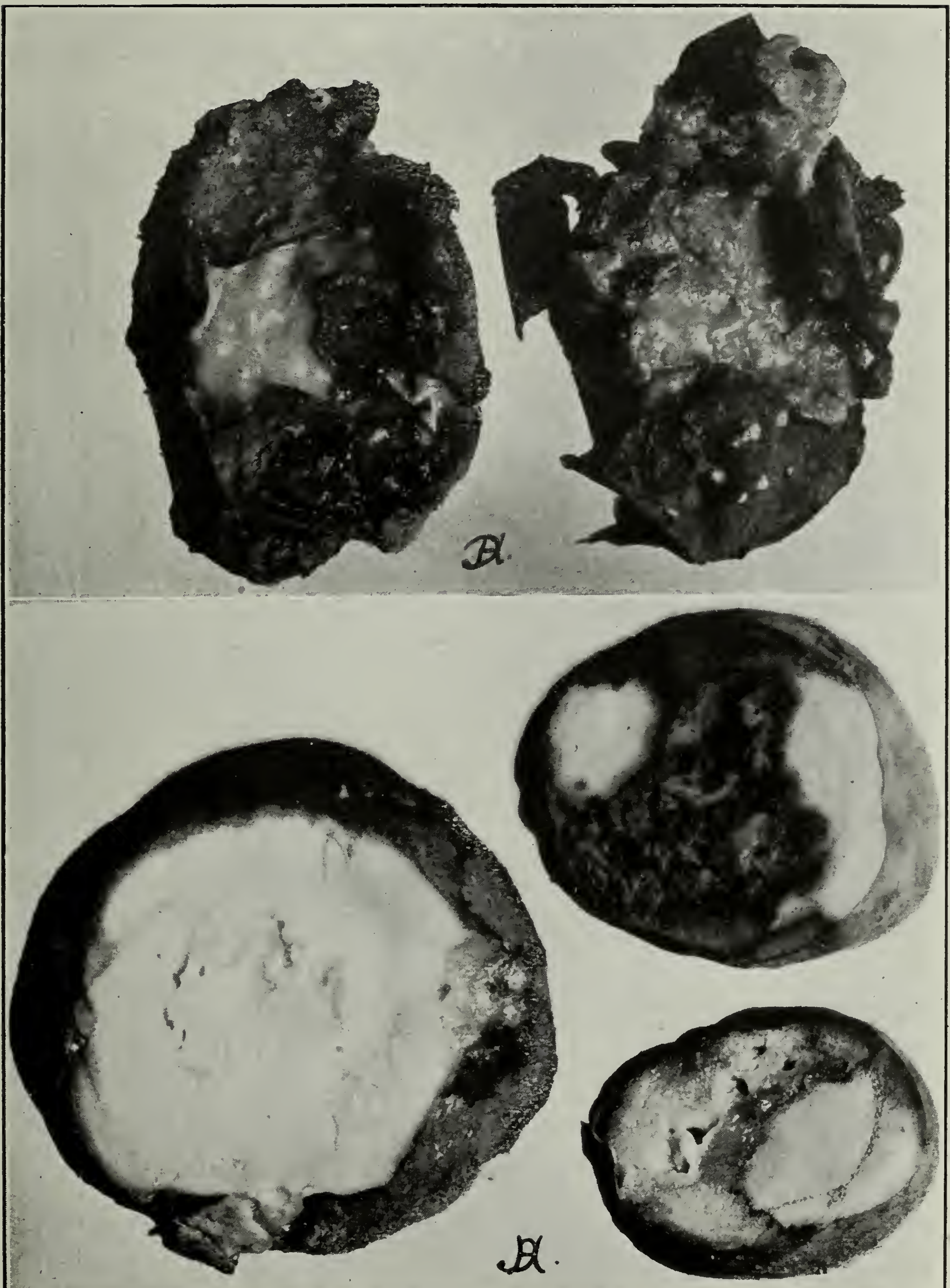
This being the case, it will be advisable to pay particular attention to the seed potatoes to see if they are affected with the sclerotia or Black Scab, which Rhizoctonia produces on the tubers. For treatment for seed potatoes so affected, see the article on Rhizoctonia on page 27.

Control of the Disease.

1. Do not plant potatoes that show any brown discoloration or other indications of either wet or dry rot.
2. Plant in well-drained land.
3. Carefully remove from the soil and destroy by burning all diseased plants and tubers.

Potato Tubers, showing Bacterial Soft Rot in various stages of development, some tubers entirely rotted, others only partially affected. (Original).

1. Six tubers that contracted the disease directly through the stem from the parent plant.
2. Six tubers that contracted the disease at the eye end from coming in contact with other diseased tubers.



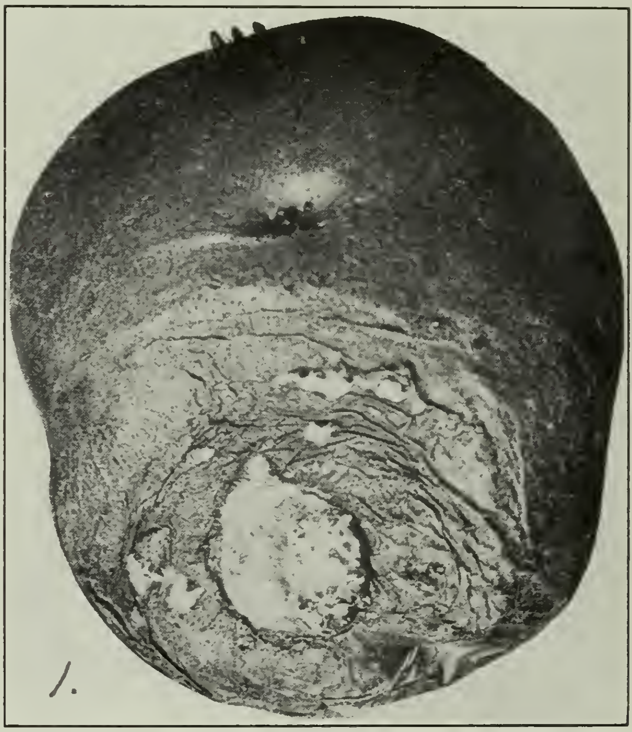
Tubers in advanced stages of the Bacterial Soft Rot, taken directly from the field. (Original).

4. On land where the disease has been prevalent, do not plant potatoes or tomatoes for several years, as both B. solanisaprus and Rhizoctonia will live in the soil a considerable time, how long has not been determined.

5. Soak seed potatoes before cutting for 3-6 hours in corrosive sublimate solution, 1 ounce to 10 gallons of water in a wooden vessel (corrosive sublimate is a strong poison), or in formalin solution of 1 pint of formalin to 30 gallons of water for 2 hours.

6. When cutting seed potatoes, have two or three knives and a jar containing disinfectant on hand. After cutting into a tuber which shows brown discoloration inside, drop the knife into the disinfectant, discard the diseased tuber, and take a fresh knife for the next cutting.

FUSARIUM WILT AND DRY ROT (*Fusarium oxysporium,* Schlecht): This disease appears to be common in the province. The chief loss is due to the dry

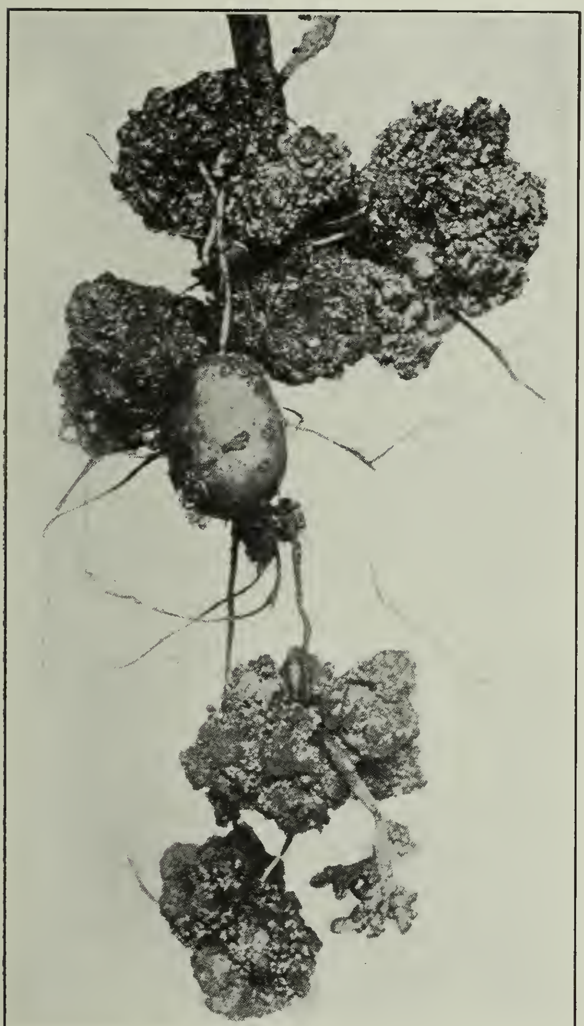


Fusarium Dry Rot of Potatoes. (Original.)

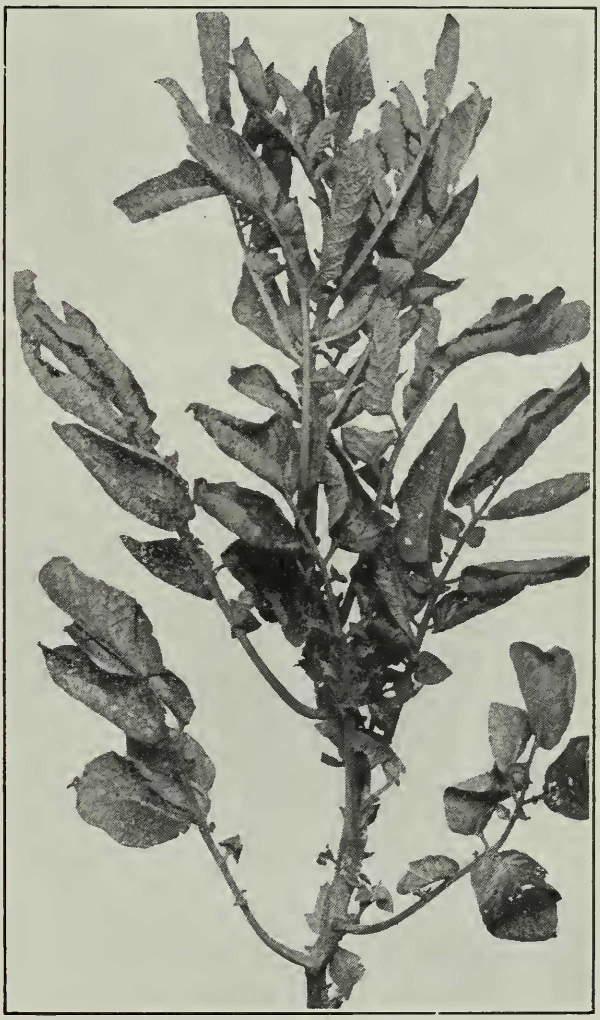
rotting of potatoes in storage. The fungus which induces it invades the underground parts of the plant, causing the foliage to become unhealthy in color and finally curl, wilt and die. This wilting of the tops is seldom prevalent enough in Ontario to attract much attention. In storage affected tubers are often noticed. These show a peculiar shrivelling and dry-rotting of the stem-end. Some of the affected tubers, however, may have no external evidence of the disease, but when cut a brownish or blackish ring is seen at the stem-end in the flesh, about one-quarter of an inch below the skin. However, not all tubers with this discolored ring at the stem-end are affected by this disease. The writer has examined tubers with this ring extending for a short distance from the stem, but they proved to be entirely free from any fungus. The cause of the discolored ring in such cases is unknown. It does not appear to develop further in storage. When the ring is due to the Dry Rot fungus some of the tubers will have indications of shrivelling at the stem-end and there will be more or less development of the characteristic Dry Rot in storage.

Prevention. Wilted plants should be dug up and destroyed whenever noticed during the summer. Potatoes with the discolored ring at the stem-end should not be used for seed. Do not plant potatoes again for several years in a field which has produced a crop badly affected with Fusarium Wilt and Dry Rot. Spraying will not prevent this disease nor will treating the seed with formalin.

Potato Canker or Wart Disease of Potatoes (*Chrysophlyctis endobiotica,* Schilb.): This disease was found in Canada in 1912, and prompt measures were taken to stamp it out. These were apparently effective, as it is not known to exist in the Dominion at the present time. It is a very serious disease and it is therefore important that Ontario growers should be able to recognize it, in order



Potato Canker. (After Gussow.)



Leaf Roll. (Photo by R. E. Stone.)

that they may report its presence promptly should it at any time appear in their crop.

Potato Canker is not usually observed until harvest time. Badly affected tubers are simply brownish-black masses of warty excrescences, not in the least resembling potatoes. Tubers showing the early stages of the disease have some of the eyes slightly protruding and composed of simple or compound groups of small nodules, brown in color. At this stage the disease is very likely to be overlooked by the casual observer.

Prevention. Be on the watch for this disease and if suspected potatoes are found, send samples to the Dominion Botanist, Central Experimental Farm, Ottawa, or to the Botanical Department, Ontario Agricultural College, Guelph.

Leaf Roll: The cause of this disease is unknown. It has been observed in numerous fields in the potato growing districts of Old Ontario. In some fields examined this summer (1917) over 60% of the plants were affected with Leaf Roll.

Experiments and observations show that Leaf Roll may reduce the yield to a very marked extent. In experiments conducted by Mr. Murphy, Assistant in Charge of the Dominion Field Laboratory of Plant Pathology at Charlottetown, P.E.I., it was found that the average yield of plants diseased with Leaf Roll in Prince Edward Island is 1.66 ozs., while healthy plants of the same variety yield 19.0 ozs. The corresponding yields per acre would be 26 bushels and 297 bushels.

* Symptoms of Leaf Roll are very variable. Affected plants are always more or less dwarfed and in some varieties the leaves assume a characteristic upright, almost staring habit instead of drooping over in the normal way. This symptom is sometimes absent, the plants presenting instead a low-headed, bushy appearance. When the crop is badly affected the poor growth of the foliage is very noticeable. It is practically never as green on affected plants as on healthy ones and occasionally on certain varieties it takes on a purplish or reddish color at the tips and around the margins of the leaves. Rolling of the lower leaves is always associated with the disease. This is often rather inconspicuous and may not extend beyond the leaves lying close to the ground, although it may affect the intermediate and even the topmost leaves. Marked rolling of the upper leaves, however, is often seen on plants not affected with Leaf Roll. The rolled leaves on plants affected with this disease begin to die early. The harsh, leathery texture of such leaves is a constant symptom. This point may be tested by feeling them with the fingers. The tubers of affected plants are small and are borne generally on very short tuber-branches (stolons) or even attached in a cluster to the stem.

Leaf Roll is chiefly transmitted through the seed. Tubers from affected plants invariably produce diseased plants. There is also evidence to show that the disease may spread from plant to plant in the field. Just how is unknown, as up to the present time no parasite has been found associated with Leaf Roll.

Prevention. The surest way of avoiding loss from Leaf Roll is to secure fresh seed from districts free from the disease. Fortunately, this is possible, as Northern Ontario and certain sections of New Brunswick, Nova Scotia and Prince Edward Island are comparatively free from this trouble.

Mosaic: The cause of this disease is also unknown. It has been observed in many fields in Ontario. When it is severe there is a very noticeable reduction in the crop.

*The foliage of plants affected with Mosaic is somewhat wrinkled or corrugated and mottled, with faint, light green or yellowish spots. These symptoms vary considerably, being well marked in some cases and not so noticeable in others. The stalks of diseased plants are often more bare near the ground than those of healthy ones, partly because the affected foliage does not spread out and droop down normally and partly because the lower leaves sometimes fall off in the last stages of severe attacks. The tubers of affected plants are normal-looking and sound and their keeping or eating qualities are not impaired.

Like Leaf Roll, Mosaic is transmitted through the seed and is spread very largely by the use of seed from diseased plants. It is also thought to be spread from plant to plant in the field, probably by insects as is the case with related diseases.

---

* Adapted from description supplied by Paul A. Murphy.

Prevention. If the disease is not very prevalent in a field, remove the affected plants so as to secure seed as free as possible from Mosaic. If the Mosaic is very abundant, secure fresh seed from a field or district free from the disease. It may be necessary to discard susceptible varieties in order to avoid loss from Mosaic.

Curly Dwarf: Another disease of unknown cause, frequently met with in Ontario, especially in unthrifty fields of potatoes. It appears to cause a very noticeable reduction in the crop. Plants affected with Curly Dwarf are stunted and the foliage is markedly curled and wrinkled. This disease is known to be transmitted through the seed.

Prevention. Remove affected plants so as to secure seed free from Curly Dwarf or secure fresh seed from a field or district free from the disease.

TOMATO.

Leaf-Spot or Blight (*Septoria lycopersici, Speg.*) The most destructive disease of tomatoes in Ontario. It attacks the leaves and stems of tomatoes, and it is very hard to control.

Small, greyish-brown, angular spots containing minute black specks appear upon the leaves and stems. The lower leaves are first attacked, and the disease spreads upwards, often almost completely destroying the foliage of the plants. The organism which causes the disease is carried over the winter in the soil of the field, greenhouse or hotbed.

Prevention. Spray with Bordeaux mixture (4.4.40 formula), commencing when the plants are in the seed bed and repeating at intervals of ten days or two weeks until there is a danger of staining the fruit. With small patches of tomatoes it is often advisable to stake and tie up the plants for greater convenience in spraying. The diseased tops should be raked up and burned, and, if practicable, a rotation of crops should be followed.

Leaf Mould, Scab (*Cladosporium fulvum*, Cke.): This disease sometimes causes injury to tomatoes under glass. It is easily recognized by the olive-brown, felt-like fungus growth which is seen on the upper side of the leaves, and is accompanied by brown discolorations on the lower surface. In severe cases the leaves may turn brown, shrivel and die.

Prevention. Proper ventilation of the forcing house is the best preventive. Spraying with Bordeaux mixture at intervals of ten days or two weeks will hold this disease in check, but is seldom necessary when proper ventilation is provided, so that the foliage of the plants does not become excessively moist.

Blossom End or Point Rot: This is another of the so-called physiological diseases, not being due to any organism, but to some condition within the plant itself, probably induced by its environment. It is sometimes seen in Ontario, and has occasionally been reported as causing serious loss by rendering useless tomatoes both under glass and in the field. It was very prevalent this summer (1917). The fruits only are affected.

The first symptom of the trouble is the appearance of irregular, water-soaked areas near the tip of the fruit, usually when it is about half-grown. These water-soaked areas later become flattened or sunken and dark green to dark brown in color, and of a hard, leathery texture. Various fungi and bacteria may gain entrance through these injured spots and induce rot, which may destroy the whole fruit.

Prevention. There is very little exact knowledge concerning the cause or the control of this disease. Over-forcing of the plants, especially in the early stages of their development, irregular watering and heavy applications of farmyard manure seem to make the plants liable to develop the trouble. Outdoors it is usually worst on light, sandy soils.

Tomato Mosaic: A disease of unknown cause frequently seen in Ontario, both in the field and under glass. The leaves of affected plants may be mottled with light green or yellow, or they may be dwarfed and have a peculiar, fern-like appearance. Sometimes the leaflets are so narrow and slender as to appear almost thread-like.

Prevention. As yet there appears to be no satisfactory method of controlling this disease. It is well known that it can be transmitted from plant to plant, and

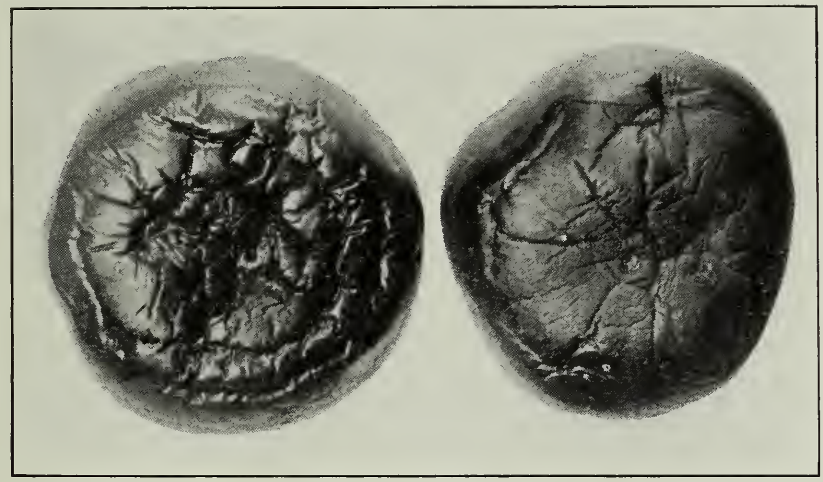
Leaf Spot of Tomato. (Attacked leaves and stem).
(From Ohio Bulletin 73).

that it frequently spreads through the beds when tomatoes are grown under glass. There is some evidence that it may persist from year to year in the soil in the greenhouse. Any tomato plants growing under glass showing symptoms of Mosaic should be pulled up at once and burned, in order to prevent the disease from getting established in the house.

Bacterial Soft Rot of Vegetables: Bacterial soft rot is a disease liable to attack fleshy vegetables and flowers, particularly carrots, cauliflower, turnips, celery, tomatoes, potatoes, German iris and calla lily, and in a lesser degree onions, asparagus, salsify, sugar beet, mangel, muskmelons, and some others. Occasionally the disease results in heavy losses to the grower of these crops.

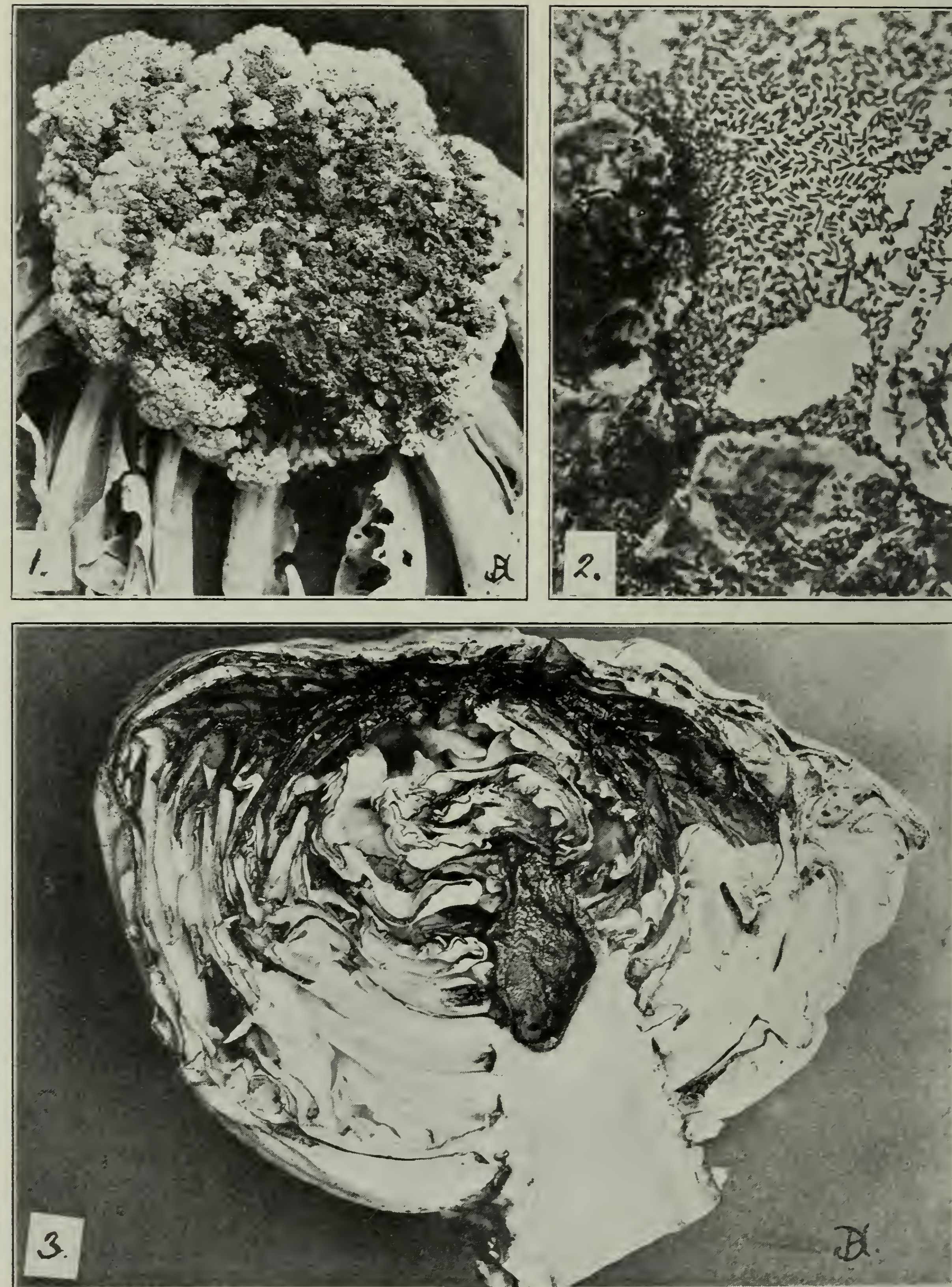
General Appearance of the Disease. As the name signifies, the disease results in a soft, wet rot of the plant attacked. The rotted portion of the plant is darker in color than the rest of the plant. The color of the diseased part varies from a light, reddish-brown to a very dark brown in the case of white or creamy fleshed plants, such as cauliflower, turnips or heart of celery, and a very dark green, almost black, in case of the green tissues which are attacked. The diseased tissue is very soft and mushy, and frequently has a strong and offensive odor. There is a clear line of demarcation between the diseased and healthy tissues, the disease inducing complete destruction of the tissue as it advances from the point of inoculation.

Cause of the Disease, B. carotovorus, L. R. Jones. (The Vegetable Soft Rot Bacillus.) The cause of the disease is a bacillus which has been given a variety of names by different men, who at different times in various countries have studied the disease in different species of plants. Prof. L. R. Jones, of Vermont, studying the disease in a crop of carrots, named the casual organism *Bacillus carotovorus.* Prof. Harrison, of Ontario, studying the disease in an outbreak in a crop of cauliflower, named it *Bacillus oleraceæ;* Prof. Potter, in England, studying the disease found it to be destructive to quite a number of varieties of plants, and named it *Pseudomonas destructans;* N. J. Giddings, of Vermont studying the disease in a crop of melons, named it *Bacillus melonis;* C. O. Townsend, of Washington, studying the disease in a greenhouse of calla lilies, named it *Bacillus aroideæ.* More recent investigations have shown that the disease is practically one and the same in all the plants mentioned. While to the bacteriologist there may be a few slight differences in the nature of the bacillus causing the disease in the melon from that causing the disease in the lily, or that causing the disease in carrots, turnips and cauliflower and other vegetables, yet the disease is for all practical purposes to the horticulturist one and the same—soft, wet rot of the plant attacked.



Blossom End or Point Rot of Tomatoes. (Original.)

Histology of the Disease. When the soft rot bacillus gets on to a freshly made wound, either small or large, in plants liable to the disease, it feeds on the plant juice which emerges on to the wounded surface, and on this it grows and rapidly multiplies. As it multiplies it produces pectinase, a cytolytic enzyme which dissolves the middle lamellæ, the thin strip of tissue which lies between adjacent plant cells. The lamellæ are quickly dissolved and form good food for the multiplying bacilli, which, as they multiply, pass along between the cells, filling the intercellular spaces and separating the cells from one another. The protoplasm within the plant cells is plasmolised, that is, it is made to shrink from contact with the cell walls and to contract into an irregular mass within the cell, by the action of the enzymes produced by the bacilli in the intercellular spaces. In this way the collapse of the tissue is brought about, and such tissue constitutes the rotted part of the plant.

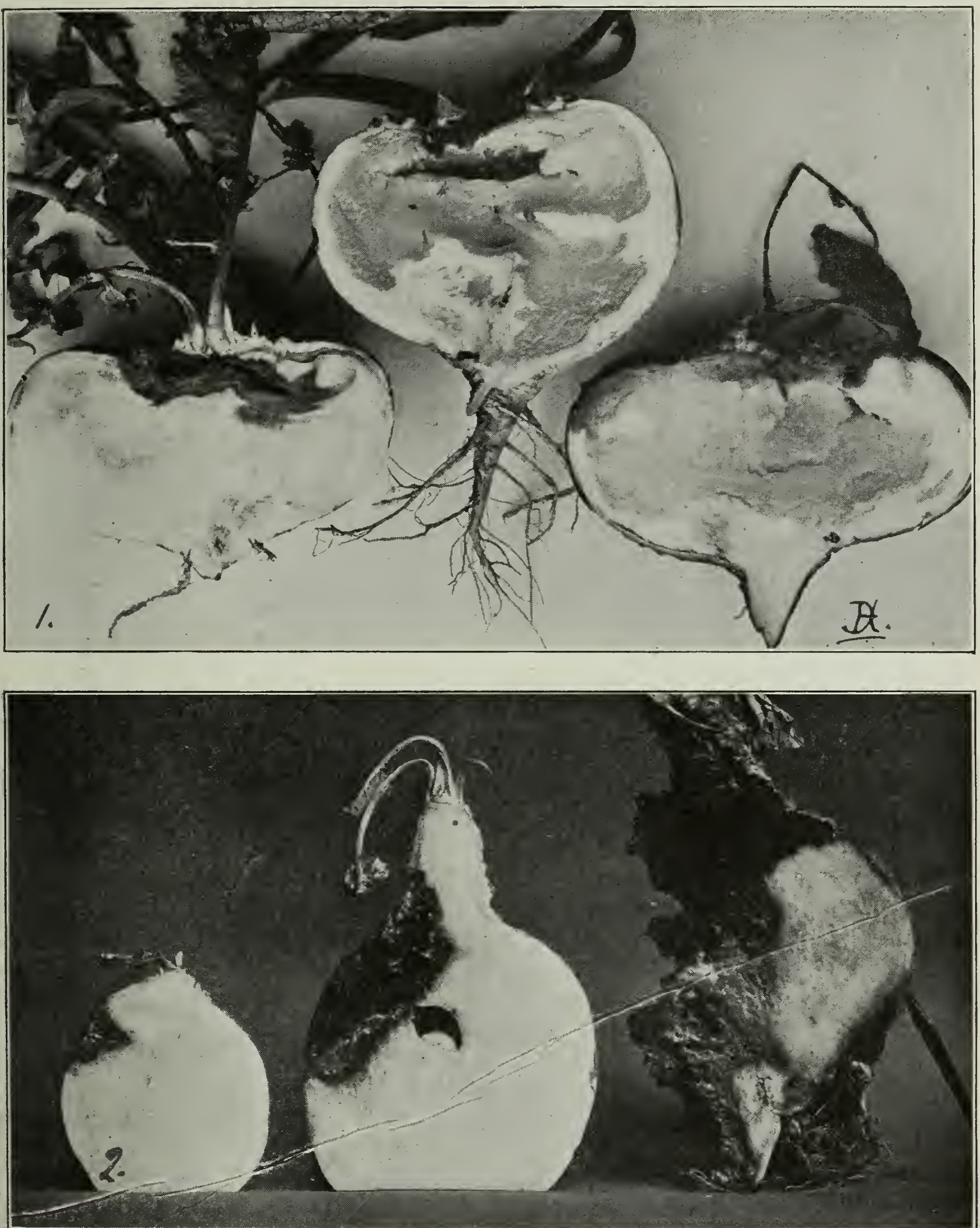


Bacterial Soft Rot of Cauliflower and Cabbage. (Original.)

1. Bacterial soft rot of cauliflower, natural infection; specimen taken direct from garden.

2. *B. carotovorus*, the vegetable soft rot bacillus seen between cells of broken-down, rotting cauliflower. (x 1000 di.)

3. Bacterial soft rot of cabbage. Artificial stab inoculation of a pure culture of *B. carotovorus* in healthy cabbage. Photo taken twenty days after inoculation.



Bacterial Soft Rot of Turnip. (Original.)

1. Turnips direct from field badly affected with bacterial soft rot. Shaded areas were soft, pulpy and strong smelling. Evidently inoculated near the crown, probably through wounds made by slugs or caterpillars or during cultivation.

2. Soft-rotting turnips direct from field, in which the disease had been prevalent the previous year. These had evidently been inoculated from the soil through wounds made while hoeing or cultivating.

In *Cauliflower* the disease is found more often in the flower than in the leaves or stem; the latter parts, however, are also subject to attack.

The disease in the flower is very easily noticed, the normal color of the flower being white or creamy and that of the diseased portion light to dark brown and very soft, and having an offensive odor. The writer has noticed a number of times dark brown areas varying in size, which looked at first sight like soft rotted areas, but which, on investigation, proved to be discolorations due to excreta of cabbage caterpillars, which had been feeding on the leaves overhanging the flower. In such cases the tissue immediately below the surface of the discolored area is not softened as it is in the case of the rot, and the discoloration is only on the surface. Observations have shown, however, in a number of such cases that the rot has later developed within such discolored area, thus indicating that in all probability the caterpillar had previously been feeding on a rotted plant, and all the bacilli in the portion consumed had not been killed in the process of digestion, but had passed through the alimentary tract of the caterpillar with the excreta, or that the mouth parts and feet of the caterpillar had been contaminated from a diseased plant, and on crawling over the surface of the healthy plant had inoculated it.

In the stem the disease results in a complete softening of the interior, the softened tissue becoming a dirty grey in color with strong odor. The disease may enter the stem from injury to the exterior caused by the breaking of leaves, or the biting of insects, slugs and caterpillars during cultivation, etc., and from the stem pass up into the flower, or the stem may become so far rotted that the head will fall off. The stem may also become infected through the flower.

In the leaves the disease is more often found in the petiole or midrib rather than the blade. It appears as a dirty grey, softened area, which, when in the petiole, soon results in collapse of the leaf.

In *Turnip* the disease most frequently enters at or near the crown through caterpillar or slug attack, or through injuries received during hoeing or cultivation. It softens or rots the leaf petioles at their base, causing them to fall over, and spreads slowly in dry weather, rapidly in wet weather, through the tissue of the root, inducing a brown colored soft rot with strong odor.

In *Carrot* the disease enters and develops in much the same way as described for the turnip. It is more apt to spread rapidly through a crop that is thickly sown and not well thinned out, the shade produced by the heavy tops making ideal conditions by keeping the ground moist for the development of the disease when once it gains entrance, and harboring slugs and caterpillars that spread the disease. Carrots which crack beneath the ground are liable to be attacked by the disease, the soft rot bacillus gaining entrance to the tissue through the cracked surface.

In *Celery* the disease is not very common, but when present is most often found starting at or near the tops of the young growth. The affected parts become dark brown and very soft and mushy. The parts so affected cease growing, the growing tips being destroyed, and the disease slowly passes down the stem, completely rotting the tissue as it progresses. If the disease starts below the end of the stem, the upper part soon topples over as a result of the softening of the part attacked. The disease spreads from plant to plant through the agency of slugs, caterpillars, etc., and during the process of handling when cultivating and banking up. When the plants are stored away for winter use, if a plant having the disease is stored with the healthy plants, the rot is liable to spread to the healthy specimens.

In *Tomatoes* the disease is very common during wet seasons. It is found most frequently in the fruits that are in contact with the soil after they have commenced to ripen. The bacillus will not readily penetrate through the unbroken skin of the tomato. But when a tomato is resting on the damp earth, that part of the skin

Bacterial Soft Rot of Celery. (Original).

1. Artificial needle inoculation of pure culture of B. carotovorous (isolated from rotting cauliflower) into the young and vigorous growth of celery. Five days after inoculation, kept at 25° C.
2. Same as Fig 1, five days later.
3. Same as Fig. 1, ten days later.
4. Same as Fig. 1, three weeks after inoculation, showing complete collapse of plant.
5. B. carotovorous, the vegetable soft rot bacillus, between the cells of rotting celery tissue (x 1000 di.).

in contact with the soil is frequently weakened, thus providing a means of access to the bacillus. This, however, is not the only means whereby the disease enters the fruit. Slugs are very partial to tomatoes just ripening. In their attack on the fruit they eat through the skin, leaving the interior flesh exposed. This exposed surface is an ideal medium for the bacillus of soft rot to develop in. The writer has found many tomatoes, particularly in wet seasons, when slugs are plentiful, that have contracted the disease in this way.

Eradication and Control of the Disease. Spraying with fungicides, which is so effective in controlling the fungus diseases of plants, is of no avail with bacterial diseases, as the bacteria which cause the disease act in the interior tissue rather than on the surface; hence the spray will not reach them.

Spraying with insecticides is helpful indirectly, as it tends to keep in check the insects, slugs, caterpillars, etc., which are one of the most common means of spreading bacterial diseases from one plant to another.

As a rule the best method to adopt in dealing with a plant affected with bacterial disease is to carefully remove and burn it. Insects, garden tools, etc., coming in contact with it, will spread the disease to the plants with which they come in contact later. This is particularly the case with the bacterial soft rot of plants, as the affected tissue is so very soft and pulpy that it cannot be touched without heavily contaminating whatever touches it.

Again, if affected plants are allowed to remain on the ground they infect the soil with the organisms of the disease to such an extent as frequently to cause the disease to establish itself in the succeeding crop of any plants which are susceptible to the disease, but particularly plants of the same species.

Some time ago we received for examination a box of rotting, half-developed turnips from a farmer, who said that five per cent. of his crop were similarly affected. Upon enquiry we found that the affected ones were growing on soil on which turnips had been grown the year previous, and 25 to 30 per cent. of these having been affected with the same rot, had been allowed to remain on the ground at harvest time, and later were plowed in. It was evident that the soft rot bacilli from the diseased turnips had remained alive in large numbers in the soil, and that many of the turnips of the subsequent crop had been inoculated with these bacteria during cultivation and possibly by insect attack also, see page 41. The hoe or the teeth of the cultivator would get contaminated from the soil, and accidental wounding of a turnip with such an implement would result in the inoculation of the turnip with the germs of the disease.

Another man sent a head of celery for examination, which we found to be suffering from the bacterial soft rot in the young growing tips. In reply to our enquiries he sent word as follows: "I had celery on this ground two years ago, and the row that was where the rot is worst now was so bad then that I lost all, but only that row was affected. This year two rows had it, but one a great deal worse than the other. There were five rows in this patch all planted about the same time. The healthy rows matured away ahead of the two which were diseased." Here it is evident that the soft rot bacteria had remained in the soil for two years, and that cultivation had spread the bacilli to some extent through the soil, as on the second occasion that celery was grown on that patch the plants in two rows developed the disease.

The writer had under observation a garden where turnips and carrots were both affected with the bacterial soft rot. The affected plants were not removed, but were dug in. The next year tomatoes were planted on the same ground. The disease did not develop in the growing plants, as care was taken not to wound them. However, about 60 per cent. of the fruit became affected before it was fully ripe. The affected specimens were either those that were in contact with the soil or had been bitten by slugs. The soft rot bacteria, which cannot penetrate through the sound skin of a tomato, found entrance through the slug bites or through the weakened skin that had been in contact with the soil.

Therefore, in order to prevent losses from bacterial soft rot of plants, remove and burn affected plants, or parts of plants, as soon as observed; be careful during cultivation not to wound plants, and keep caterpillars, slugs and biting insects in check. Affected plants should never be put on the compost heap or manure pile.

Harvesting and Storing. When harvesting and storing turnips, cauliflower, cabbage, celery, tomatoes or other vegetables from crops in which the disease has been present, great care should be taken not to include any specimen that shows the slightest appearance of the disease, or to smear the healthy specimen with the soft rotted parts of diseased specimens. If these precautions are neglected, the disease is liable to establish itself and spread more or less rapidly through the entire crop stored.

Damping-off of Seedlings.

The seedlings of many plants are liable to be affected by a disease which weakens the stem at or near the ground, causing the plant to fall over and ultimately die. Several different species of fungi cause this trouble, which is commonly known as Damping-off. Rhizoctonia, species of Fusarium and Pythium de Baryanum are among the commonest of the fungi inducing this disease.

Prevention. For a seed bed secure well-drained soil not previously infested with the disease. Avoid thick sowing, shade and over-watering. Affected plants should be removed as soon as noticed, together with the adjacent soil. When the disease becomes troublesome in greenhouses, if the soil cannot be renewed, it should be sterilized with steam or formalin as described on page 47.

FUNGICIDES.

The principal fungicide used for vegetables is Bordeaux mixture. Lime-sulphur has been tried for the control of Late Blight and Rot of potatoes and for Blight on celery, but has not given satisfactory results.

Formalin and corrosive sublimate are quite extensively used for the disinfection of potato tubers and vegetable seeds, in order to prevent certain diseases, the germs or spores of which are carried over from season to season adhering to them.

Bordeaux Mixture.

Formula.

Copper sulphate (Bluestone)	4 pounds.
Unslaked Lime	4 "
Water	40 gallons.

Dissolve the copper sulphate in a wooden or brass vessel with hot water. Pour into a barrel and add cold water to make 20 gallons. Slake the lime, preferably with hot water, and add cold water to make 20 gallons. Stir both barrels well and pour the lime into the copper sulphate solution. (Never mix concentrated milk of lime and copper sulphate solution.)

A stock solution of each may be made, and can be kept indefinitely if not mixed. Dissolve 40 pounds of copper sulphate in 40 gallons of water by suspending just below the surface of the water in a coarse sack. Each gallon of the liquid will now contain one pound of copper sulphate. Slake 40 pounds of lime in hot water, then add cold water to make 40 gallons. Each gallon of the solution will now contain one pound of lime. A tub or half barrel will be found most handy for slaking the lime in. It is often more convenient to work with smaller quantities of the stock solutions, such as 20 pounds of copper sulphate or bluestone to 20 gallons of water and 20 pounds of lime to 20 gallons of water.

When stock solutions are prepared Bordeaux mixture of the required strength (4.4.40 formula) can be made up directly in the spray pump barrel by filling it half full of water (20 gallons), then adding two gallons of the stock solution of copper sulphate and two gallons of the stock solution of lime, after which the barrels can be filled with water nearly to the top and two more gallons of each of the stock solutions added. The barrel after this should be full. If it is not, add more water. If a tank larger than a 40-gallon barrel is used proportionate amounts of the stock solution should be added when half full of water and when nearly filled. Stir the stock solutions well and strain them when putting into the spray pump barrel.

To test the Bordeaux mixture let a drop of ferrocyanide of potassium fall into a little of the mixture in a saucer. If this causes it to turn reddish-brown add more lime until no change takes place.

Resin Bordeaux.

The surface of some plants like onions, cabbages and asparagus, is so smooth that Bordeaux will not readily stick to it. This makes effective spraying difficult. This difficulty, however, may be overcome by using the following preparation:—

Resin	2 pounds.
Sal Soda crystals	1 pound.
Water	1 gallon.

Boil together in an iron vessel (preferably out of doors) until the mixture is of a clear brown color. This will take from one to one and a half hours. Add the above quantity to each 40 gallons of Bordeaux mixture.

Formalin.

Formalin is a clear liquid disinfectant. It is a 40% solution of formaldehyde gas in water. It can be purchased from almost any druggist, and costs from 25c. to 50c. per pint. It is sold under the names of "formalin" and "formaldehyde." It is important that the purchaser, whatever name he buys it under, secures a guaranteed solution of full strength 40% formaldehyde. The stock solution should always be kept in a well-corked botte. Formalin, when diluted with water for treating seed potatoes, is not a dangerous poison, although the strong fumes will make the eyes smart, and a strong solution will harden the skin temporarily.

For Potato Scab soak the tubers before they are cut for two hours in a solution of ½ pint of formalin to 15 gallons of water.

For Black Rot of cabbage and cauliflower, soak the seed for 15 minutes in a solution of ½ pint of formalin to 15 gallons of water.

For Onion Smut 1 pint of formalin to 30 gallons of water, applied as directed on page 21.

Corrosive Sublimate (Mercuric Chloride).

Corrosive sublimate may be obtained from any druggist. It is a deadly poison, and should be so labelled, and kept out of the way of children and stock. It is usually sold in the form of tablets, one of which dissolved in a pint of water gives a solution of the strength of one part by weight of corrosive sublimate to 1,000 of water. It is not very readily soluble, and hot water should be used to dissolve it. It corrodes metal and, therefore, should be mixed in wooden or earthen vessels. It is an excellent disinfectant, but even in dilute solutions it is deadly poison. Great care, therefore, must be used in handling it. Potatoes disinfected with it should never be used for food for man or beast, and vessels which have contained it should be very thoroughly washed with hot water before they are used for any other purpose.

For disinfecting seed potatoes to prevent Black Leg, Rhizoctonia and Powdery Scab of Potatoes, soak the tubers before they are cut for three hours in a solution of corrosive sublimate of the strength of 1 part to 2,000 of water. For Club Root of cabbage and Black Rot, cauliflower and turnip, soak the seed for 15 minutes in a solution of corrosive sublimate of the strength of 1 part by weight to 1,000 of water. Corrosive sublimate can be used effectively for the prevention of the common Potato Scab, but it is not recommended here, as formalin is a safer and just as reliable a disinfectant for this purpose.

STERILIZATION FOR GREENHOUSE SOIL.

This is often required in order to rid the soil of fungi, which live over from year to year in the beds and cause disease of the crops grown on them. Lettuce Drop, Rhizoctonia and Damping-off are among the diseases which can be prevented by soil sterilization.

Steam sterilization is the most satisfactory. What is known as the "inverted pan method" is the one which is most generally used in greenhouses. The apparatus consists of a galvanized iron pan about 4 ft. x 10 ft. and 6 inches deep. This is inverted over the soil to be sterilized, the steam being emitted through a hose connection at one end of the pan. The sharp edges are forced down into the soil to prevent the steam escaping. Fertilizers should be applied before the sterilization is done. The steam should be kept at as high a pressure as possible, 80 to 100 pounds, and the sterilization continued from three-quarters of an hour to one and one-half hours, depending upon the pressure maintained. This treatment will destroy both spores of fungi and weed seeds in the soil.

Sterilization with Formalin. This method can be employed when live steam is not available. All plants should be removed from the beds and the earth thrown up loosely. The soil should be dry when the sterilization is done. The formalin is diluted in water, 2 pounds to 50 gallons. This solution should be applied to the soil at about the rate of 1 gallon to the square foot. Two men can do this work best, one man applying the solution with an ordinary sprayer or watering can, the other man spading over the soil as the solution is applied. As soon as the soil can be worked without puddling after treatment, it should be thrown up loosely to permit the evaporation of the formaldehyde. The beds should not be planted for about two weeks after treatment, and before planting is done they should be thoroughly spaded over several times. When live steam is available, the "inverted pan method" as described above, will be found much more satisfactory than the formalin sterilization.

HOST INDEX

ASPARAGUS: PAGE
- Rust ... 3

BEANS:
- Anthracnose or Pod Spot ... 3
- Rust ... 4
- Bean Blight, Bacteriosis of Beans ... 4

BEET:
- Leaf Spot ... 7

CABBAGE AND CAULIFLOWER:
- Club Root ... 7
- Bacterial Wilt of Cruciferae (Black Rot of Cabbage, Turnip, Rutabaga, etc.) ... 9
- Bacterial Soft Rot ... 42

CARROT:
- Bacterial Soft Rot ... 42

CELERY:
- Late Blight or Septoria Leaf Spot ... 11
- Early Blight or Cercospora Leaf Blight ... 15
- Bacterial Soft Rot ... 42

CORN:
- Smut ... 15
- Rust ... 16

CUCUMBER:
- Downy Mildew or Blight ... 17
- Anthracnose ... 17
- Bacterial Wilt of Cucurbits ... 17

LETTUCE:
- Drop ... 20
- Downy Mildew ... 20
- Leaf Spot ... 20

MELONS (See Cucumber).

ONION:
- Onion Blight or Mildew ... 20
- Black Mould ... 21
- Smut ... 21

PEA:
- Blight or Leaf Spot ... 22
- Powdery Mildew ... 22

POTATO:
- Late Blight and Rot ... 22
- Early Blight or Leaf Spot Disease ... 24
- Tip Burn ... 25
- Common Scab ... 25
- Powdery Scab ... 26
- Rhizoctonia, Black Scurf ... 26
- Soft Rot and Black Leg of Potatoes ... 27
- Fusarium Wilt and Dry Rot ... 34
- Potato Canker or Wart Disease of Potatoes ... 35
- Leaf Roll ... 36
- Mosaic ... 36
- Curly Dwarf ... 37

SQUASH (See Cucumber).

TOMATO:
- Leaf Spot or Blight ... 37
- Leaf Mould, Scab ... 37
- Blossom End or Point Rot ... 37
- Mosaic ... 38
- Bacterial Soft Rot ... 44

TURNIP (See Cabbage and Cauliflower).

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

BULLETIN 259

Books on Agriculture and Household Science

BY

O. J. STEVENSON, M.A., D.Paed.

Professor of English.

Massey Hall and Library, O.A.C., Guelph

TORONTO, ONTARIO, FEBRUARY, 1918

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

INTRODUCTION

The names of the books in the following lists have been supplied, in most cases, by the instructors in charge of the various departments at the Agricultural College and Macdonald Institute. A brief note has been added in each case, which will help to give some idea as to the contents and character of the book. Books such as these should be available in all public libraries to which the farmer has access; or they may be purchased from local dealers, or through the Students' Co-operative Association, Ontario Agricultural College, Guelph.

It should be noted, however, that the prices given in the bulletin are in all cases subject to change, owing to war conditions.

BOOKS ON AGRICULTURE

THE SOIL.

Soils. By S. W. Fletcher; published by Messrs. Doubleday, Page & Co., New York, 1907; 438 pages. Price, $1.75.

This book deals with soil formation, the qualities of different soils, soil moisture, tillage, methods of ploughing and cultivating, drainage, manures and commercial fertilizers.

The Soil. By A. D. Hall; published by Messrs. E. P. Dutton & Co., New York, 1908; 286 pages, illustrated. Price, $1.50.

This is a simple treatment of soil problems. It deals with the origin of soils, questions involved in texture, movement of water, temperature, organisms and the chemical nature of soils. This involves a discussion of temperature, power of soil to absorb salts, causes of fertility and sterility of soils, etc. It is a practical book.

Soil Fertility and Permanent Agriculture. By C. G. Hopkins; published by Messrs. Ginn & Company, Boston, 1910; 653 pages, illustrated. Price, $2.70.

This book is divided into four parts. The first part deals with science and soil, referring to the formation of soils and the plant food contained therein. The second part deals with systems of permanent agriculture and the conservation of the plant food constituents. Part three deals with the results of soil investigations. Part four deals with various fertility factors, including loss of plant food from soil, fixation of food in soils, amount removed by plants, etc.

Soil Management. By F. H. King; published by The Orange Judd Company, New York, 1914; 311 pages, illustrated. Price, $1.50.

This book treats of the productiveness of the soil, soil moisture, earth mulches, lime soils, soils in relation to crops, reclamation of swamp lands, and other matters relating to soil management.

Text-Book of Land Drainage. By J. A. Jeffrey; published by The Macmillan Company of Canada, Toronto, 1916; 256 pages, illustrated. Price, $1.25.

This book, as the title suggests, deals almost wholly with drainage systems and drainage problems.

Crops and Methods for Soil Improvement. By Alva Agee; published by The Macmillan Company of Canada, Toronto, 1912; 246 pages, illustrated. Price, $1.50.

This book is intended to point out the facts relating to crops, methods and fertilizers that help to make and keep the soil productive.

AGRICULTURAL CHEMISTRY.

Manual of Agricultural Chemistry. By H. Ingle; published by The D. Van Nostrand Company, New York, 1902; 412 pages, illustrated. Price, $3.00.

This is an excellent book, with a little more technical treatment of the problems relating to the feeding of crops, soils, etc.

Chemistry of the Farm. By R. Warington; published by Messrs. Vinton & Co., London, England, 1900; 247 pages. Price, $1.00.

This is a small book, but the treatment is very concise and complete. The first half of the book deals with how plants grow, the atmosphere and soil as a source of food to the plant, manures and fertilizers, crops and their characteristics as a basis of crop rotation. The second part of the book deals with problems of animal nutrition, foods, relation of food to animal requirements, relation of foods to manure, etc., etc.

GENERAL AGRICULTURE.

Elements of Agriculture. By G. F. Warren; published by The Macmillan Company of Canada, Toronto, 1909; 434 pages, illustrated. Price, $1.10.

This is a general text-book in agriculture. It deals with such subjects as propagation of plants, plant food, the soil, fertilizers, farm crops, and animals.

Successful Farming. By Wm. Rennie, Sr.; published by Wm. Rennie's Sons, Toronto, 1905; 254 pages, illustrated. Price, $1.50.

An attempt to explain in simple language the scientific principles which are essential to successful farming. A practical book, covering the whole field of farm operations.

FIELD CROPS.

Productive Farm Crops. By E. G. Montgomery; published by the J. B. Lippincott Company, Philadelphia, 1916; 501 pages, illustrated. Price, $1.75.

A practical reference book, covering all of the cultivated crops, including grains, potatoes, grasses and legumes, root crops and tobacco.

The Small Grains. By M. A. Carleton; published by The Macmillan Company of Canada, Toronto, 1916; 699 pages, illustrated. Price, $1.75.

This book contains chapters dealing with the four principal cereals—wheat, oats, barley and rye, treated separately. Other chapters treat of cultivation, weeds, insects and fungus pests, and uses of cereals.

The Cereals in America. By T. F. Hunt; published by The Orange Judd Company, New York, 1908; 421 pages, illustrated. Price, $1.75.

A statement of farm methods and of experimental results relating to cereals—wheat, corn (maize), oats, barley, rye, rice, sorghum and buckwheat.

Forage Plants and Their Culture. By C. V. Piper; published by The Macmillan Company of Canada, Toronto, 1914; 618 pages, illustrated. Price, $1.75.

Contains information with regard to each of the forage crops grown in America, including timothy and other grasses, alfalfa, clover, peas, beans and root crops used as forage.

Fodder and Pasture Plants. By G. H. Clark; published by The Department of Agriculture, Ottawa, 1913; 143 pages, illustrated. Price, 50c.

Summarizes the chief facts regarding the different varieties of grasses and legumes. Written in non-technical language. Contains a number of coloured plates.

A Text-Book of Grasses. By A. S. Hitchcock; published by The Macmillan Company of Canada, Toronto, 1914; 276 pages, illustrated. Price, $1.50.

Part I contains an elementary treatment of forage plants, pastures, meadow plants, hay and green feed, lawns, and weeds. Part II presents in systematic form the botanical information regarding different kinds of grasses.

The Book of Alfalfa. By F. D. Coburn; published by The Orange Judd Company, New York, 1907; 336 pages, illustrated. Price, $2.00.

The purpose of this volume is to give information as to the best methods to be employed for the growth, care and use of alfalfa.

The Potato. By A. W. Gilbert; published by The Macmillan Company of Canada, Toronto, 1917; 318 pages, illustrated. Price, $1.50.

This book is intended to give brief and practical suggestions on the growing, breeding and marketing of potatoes.

The Corn Crops. By E. G. Montgomery; published by The Macmillan Company of Canada, Toronto, 1913; 347 pages, illustrated. Price, $1.60.

The first two divisions of the book contain a technical description of the plant and its production as related to climate and soils. The third and fourth divisions deal with adaptation and methods of culture, and are written in a more popular style.

Bean Culture. By G. C. Sevey; published by The Orange Judd Company, New York, 1907; 130 pages, illustrated. Price, 60c.

Aims to give, in a concise form, practical information relating to beans.

LIVE STOCK.

FARM ANIMALS.

Productive Horse Husbandry. By C. W. Gay; published by the J. B. Lippincott Company, Philadelphia, 1914; 331 pages, illustrated. Price, $1.75.

This book deals with the management, showing, and judging of horses.

Sheep Farming in America. By J. E. Wing; published by The Sanders Publishing Company, Chicago, 1907; 332 pages, illustrated. Price, $1.00.

Although relating more particularly to conditions in the United States, it will be found fairly applicable to Canadian conditions.

Productive Swine Husbandry. By G. E. Day; published by the J. B. Lippincott Company, Philadelphia, 1913; 330 pages, illustrated. Price, $1.50.

A well-written book, with excellent illustrations dealing with breeds of swine, their feeding and management, marketing and curing, diseases, etc.

Dairy Cattle and Milk Production. By C. H. Eckles; published by The Macmillan Company of Canada, Toronto; 342 pages, illustrated. Price, $1.60.

This book deals generally with the problems relating to the feeding and management of dairy cattle.

Shorthorn Cattle. By A. H. Sanders; published by The Sanders Publishing Company, Chicago, 1900; 872 pages, illustrated. Price, $2.00.

This book should be in the hands of every breeder of pure-bred shorthorns..

The Story of the Herefords. By A. H. Sanders; published by The Sanders Publishing Company, Chicago, 1914; 1,087 pages, illustrated. Price, $2.00.

A new book, well illustrated and invaluable to every breeder of "whitefaces."

FEEDING FARM ANIMALS.

The Feeding of Animals. By W. H. Jordan; published by The Macmillan Company of Canada, Toronto, 1908; 450 pages, illustrated. Price, $1.75.

This is a simple, logical treatment of the feeding of farm animals, written for the layman and so simple that any boy can understand the problems dealt with.

Scientific Feeding of Farm Animals. By O. J. Kellner; published by The Macmillan Company of Canada, Toronto, 1913; 404 pages. Price, $1.90.

This book goes into the subject more fully than the preceding book. Part I deals with composition, digestion and utilization of feeding stuffs, their properties, conservation, preparation and applicability. Part III discusses the feeding of domestic animals under conditions usually found in practice.

Feeds and Feeding. By Henry & Morrison; published by W. A. Henry, Madison, Wis., 1911; 657 pages. Price, $2.25.

An up-to-date publication, dealing with feeding problems relating to all kinds of live stock; very readable and appeals to all practical stockmen.

Feeding of Crops and Stock. By A. D. Hall; published by Messrs. E. P. Dutton & Company, New York, 1911; 298 pages, illustrated. Price, $1.50.

This book includes a fuller treatment of the work of the various parts of the plant, as for instance the special work of the leaf and root, changes of composition within the plant, how the soil is brought into solution to supply these wants and what constituents within the soil are essential to the growth of the plant. In connection with the feeding of stock, the nature and composition of foods, how the various constituents of a food are utilized by the animal and what is required by a growing and fattening animal. These and many problems in connection with fertilizers for soils and foods for animals are discussed in this book.

BREEDING AND JUDGING FARM ANIMALS.

Types and Market Classes of Live Stock. By H. W. Vaughan; published by Messrs. R. G. Adams & Company, Columbus, Ohio, 1915; 448 pages, illustrated. Price, $2.00.

Deals with judging, and gives a thorough outline of the development of the large market centres of America, together with classifications of the various kinds of live stock.

Types and Breeds of Farm Animals. By C. S. Plumb; published by Messrs. Ginn & Company, Boston, 1911; 563 pages. Price, $2.00.

A general treatise of the history, development, and characteristics of our common breeds of horses, cattle, sheep and swine.

Breeding Farm Animals. By F. R. Marshall; published by The Sanders Publishing Company, Chicago, 1911; 287 pages, illustrated. Price, $1.50.

Somewhat scientific, but practical, and of special interest to the student of principles of breeding and pedigrees.

Judging Farm Animals. By C. S. Plumb; published by The Orange Judd Company, New York, 1917; 608 pages, illustrated. Price, $2.25.

Different sections of the book are devoted to judging horses, cattle, sheep and swine. Very clearly written, and of special value to the student or teacher of judging.

Judging Live Stock. By J. Craig; published by the Kenyon Company, Des Moines, Ia., 1914; 193 pages, illustrated. Price, $2.00.

Very concise, dealing particularly with breed type; an excellent book for a beginner.

Live Stock Judging and Selection. By R. S. Curtis; published by Messrs. Lea & Febiger, New York, 1915; 455 pages, illustrated. Price, $2.00.

Deals with many points considered in judging the classes of live stock.

DISEASES OF FARM ANIMALS.

Common Diseases of Farm Animals. By R. A. Craig; published by the J. B. Lippincott Company, Philadelphia, 1914; 334 pages, illustrated. Price, $2.00.

A handy reference book, well illustrated.

The Farmer's Veterinarian. By C. W. Burkett; published by The Orange Judd Company, New York, 1909; 275 pages. Price, $1.50.

This book treats of the diseases of the different classes of stock, in language practically void of technicality.

DAIRYING.

Canadian Dairying. By H. H. Dean; published by Wm. Briggs, Toronto, 1914; 307 pages, illustrated. Price, $1.00.

A practical, clearly-written book. Part I deals with farm dairying, and includes chapters on dairy stables, care of dairy cows, milk and cream production, butter and cheese making. Part II treats of co-operative dairying, and deals with butter-making and cheese-making in creameries and cheeseries.

First Lessons in Dairying. By H. E. Van Norman; published by The Orange Judd Company, New York, 1908; 95 pages, illustrated. Price, 50c.

This book aims to set forth the principles of dairying for the beginner, and is intended to meet the needs both of the farm butter-maker and of the farmer who sends milk to the factory or shipping station.

Farm Dairying. By Mrs. L. R. Stephen; published by Messrs. A. C. McClurg & Company, Chicago, 1911; 298 pages, illustrated. Price, $1.25.

Covers the whole field of dairying, care of dairy cattle, feeding, milking, care of milk and cream, butter-making, uses of dairy products and many other subjects.

Productive Dairying. By R. M. Washburn; published by the J. B. Lippincott Company, Philadelphia, 1917; 425 pages, illustrated. Price, $1.75.

Treats of dairy breeds of cattle, care and management of cows, clean milk production, farm dairying, and the marketing of milk.

Testing Milk and Its Products. By Farrington & Woll; published by The Mendota Book Company, Madison, Wisconsin, 1914; 297 pages. Price, $1.25.

This book deals with the composition of milk. Describes Babcock test, shows how to test milk and cream for acidity and purity, and how to calculate the yields of milk and returns from it.

Dairy Technology. By Larsen & White; published by Messrs. Wiley & Sons, New York, 1912; 298 pages, illustrated. Price, $1.50.

Contains a very complete treatment of the uses of milk under the following main headings: Milk as a food, the city milk supply, ice-cream making, and by-products of the creamery and cheese factory.

Creamery Butter-Making. By J. Michels; published by J. Michels, Lansing, Michigan, 1909; 271 pages. Price, $1.50.

This book covers the whole field of creamery butter-making, discusses the location and construction of buildings, describes the mechanics of the creamery, and deals with methods of testing, ripening and churning, and with the care of milk and cream.

Cheesemaking. By J. W. Decker; published by J. W. Decker, Columbus, Ohio, 1905; 192 pages. Price, $1.75.

This book deals with the composition of milk, sources of contamination, milk testing, action of rennet, steps in making cheese, methods of curing, storing and shipping, and how to judge cheese.

THE GARDEN AND THE ORCHARD.

GENERAL HORTICULTURE.

Manual of Gardening. By L. H. Bailey; published by The Macmillan Company of Canada, Toronto, 1910; 539 pages, illustrated. Price, $2.00.

A useful, practical book on all features of Horticulture, including Floriculture.

Plant Breeding. By Bailey & Gilbert; published by The Macmillan Company of Canada, Toronto, 1915; 474 pages, illustrated. Price, $2.00.

The best general guide to plant improvement in agricultural and horticultural plants. This is Bailey's "Plant Breeding," thoroughly revised and rewritten.

Productive Plant Husbandry. By K. C. Davis; published by the J. B. Lippincott Company, Philadelphia, 1917; 462 pages, illustrated. Price, $1.75.

Covers practically the whole field of plant life and growth, including soils, fruits, vegetables, field crops and forestry, weeds, insects and plant diseases.

VEGETABLES.

Garden Farming. By L. C. Corbett; published by Messrs. Ginn & Company, Boston, 1913; 473 pages, illustrated. Price, $2.00.

Commercial methods for market gardeners and truck growers.

Vegetable Gardening. By S. B. Green; published by The Webb Publishing Company, St. Paul, Minn., 1914; 335 pages, illustrated. Price, cloth, $1.00; paper, 50c.

For the amateur as well as the commercial grower. An excellent companion volume to the preceding.

How to Grow Vegetables. By A. French; published by The Macmillan Company of Canada, Toronto, 1913; 312 pages, illustrated. Price, $1.75.

An excellent practical guide for the amateur. Covers the full range of plants grown as vegetables and herbs.

The Gardenette. By B. F. Albaugh; published by The Stewart and Kidd Company, Cincinnati, 1917; 138 pages, illustrated. Price, $1.25.

This is a suggestive book for the amateur gardener. It contains practical directions for growing vegetables, small fruits, and flowers, so as to produce results that make the most out of the soil.

FRUIT.

The Principles of Fruit Growing. By L. H. Bailey; published by The Macmillan Company of Canada, Toronto, 1915; 432 pages, illustrated. Price, $1.75.

One of the best and sanest books for a beginner. An excellent guide to fruit-growing, theory and practice.

The Pruning Manual. By L. H. Bailey; published by The Macmillan Company of Canada, Toronto, 1916; 407 pages, illustrated. Price, $2.00.

The old "Pruning Book," splendidly revised. The best guide to the subject.

The Nursery Book. By L. H. Bailey; published by The Macmillan Company of Canada, Toronto, 1915; 365 pages, illustrated. Price, $1.50.

A reliable guide to the propagation of horticultural plants. Special attention given to general nursery practices.

Bush Fruits. By F. W. Card; published by The Macmillan Company of Canada, Toronto, 1917; 409 pages, illustrated. Price, $1.50.

A standard work on this subject, and thoroughly reliable.

Strawberry Growing. By S. W. Fletcher; published by The Macmillan Company of Canada, Toronto, 1917; 325 pages, illustrated. Price, $1.75.

A new work by the most competent authority in America.

Popular Fruit Growing. By S. B. Green; published by The Webb Publishing Company, St. Paul, Minn., 1912; 328 pages, illustrated. Price, $1.10.

An excellent guide to fruit-growing practices for the colder parts of Ontario.

Productive Orcharding. By F. C. Sears; published by the J. B. Lippincott Company, Philadelphia, 1914; 315 pages, illustrated. Price, $1.50.

An excellent guide to commercial fruit-growing methods. Written for the Eastern States, but very largely applicable to Ontario.

The Apples of New York.
The Grapes of New York.
The Plums of New York.
The Cherries of New York.
The Peaches of New York.

This wonderful set is being published at great expense by the New York State Experiment Station. The volumes are purchasable only through book dealers, and not from the Station. Prices vary according to available supplies. We can recommend John H. Skinner, bookman, Albany, New York, and Jos. McDonough, bookman, also of Albany. All of the volumes are beautifully illustrated by reproductions from actual colour photographs. These valuable works cover practically all varieties known at present in Ontario, and will certainly stand for many years as the highest authority in variety, identification and description.

FLOWERS.

Home Floriculture. By Eben E. Rexford; published by The Orange Judd Company, New York, 1904; 300 pages, illustrated. Price, $1.00.

A splendid book for amateur flower growers.

LANDSCAPE GARDENING.

The Natural Style in Landscape Gardening. By F. A. Waugh; published by Richard G. Badger, Boston, 1917; 151 pages, illustrated. Price, $2.50.

A notable book in American horticulture —the most complete definition we have had of the aims and methods of ornamental planting for America.

Landscape Gardening. By F. A. Waugh; published by The Orange Judd Company, New York, 1899; 152 pages, illustrated. Price, $1.75.

Concisely this book outlines the work in laying out grounds from the standpoint of art, whether a formal or a natural effect is desired.

Landscape Gardening as Applied to Home Decoration. By S. T. Maynard; published by Messrs. John Wiley & Sons, New York, 1899; 338 pages, illustrated. Price, $1.50.

In this book special attention is given to the planning of home grounds from a decorative point of view. Suitable trees and shrubs are mentioned, with the necessary treatment desired for each variety.

POULTRY.

Poultry Production. By W. A. Lippincott; published by Messrs. Lea & Febiger, Philadelphia, 1916; 517 pages, illustrated. Price, $2.00.

A comprehensive and convenient statement of the factors and principles of poultry production. Deals with breeding and rearing of poultry for food purposes and for the market. One of the best books on the subject.

Principles and Practice of Poultry Culture. By John H. Robinson; published by Messrs. Ginn & Company, Boston, 1912; 611 pages, illustrated. Price, $3.00; school edition, $2.50.

The first division of this book deals with the poultry industry; the second, with production, including housing, feeding and incubation; the third, with reproduction, including varieties and breeding; and the last division, with exhibiting and judging poultry.

Poultry Breeding and Management. By James Dryden; published by The Orange Judd Company, New York, 1917; 402 pages, illustrated. Price, $1.60.

An up-to-date book dealing with the housing, feeding and rearing of poultry.

Productive Poultry Husbandry. By H. R. Lewis; published by the J. B. Lippincott Company, Philadelphia, 1913; 536 pages, illustrated. Price, $2.00.

Covers the entire subject of poultry production very thoroughly from both a scientific and a practical standpoint.

Diseases of Poultry. By Raymond Pearl, and others; published by The Macmillan Company of Canada, Toronto, 1916; 342 pages, illustrated. Price, $1.60.

Contains information which is intended to help the farmer or poultryman to avoid diseases by proper hygiene, and to treat them intelligently when they do occur.

BEES.

First Lessons in Bee-keeping. By C. P. Dadant; published by Messrs. Dadant & Sons, Hamilton, Illinois, 1917; 189 pages, illustrated. Price, $1.00.

An excellent book for beginners, containing the direct practical information that they need.

Bee-keeping. By E. F. Phillips; published by The Macmillan Company of Canada, Toronto, 1915; 457 pages, illustrated. Price, $2.00.

A thorough and accurate text. It treats of the various phases of bee-keeping, the bee as a living animal, first steps in bee-keeping, manipulation of bees, production of honey, marketing the crop, care of bees in winter, and other subjects.

Productive Bee-keeping. By F. C. Pellett; published by the J. B. Lippincott Company, Philadelphia, 1916; 302 pages, illustrated. Price, $1.50.

An attractive book. It deals with the production of honey under general headings, such as: Making a start with bees, the occupants of the hive, feeding, wintering, marketing the crop, and diseases and enemies of bees.

Langstroth on the Honey Bee. By C. P. Dadant; published by Messrs. Dadant & Sons, Hamilton, Illinois, 1908; 575 pages, illustrated. Price, $1.25.

A text-book containing extensive information on all matters relating to bee-keeping.

The A B C and X Y Z of Bee Culture. By A. I. Root and B. E. Root; published by A. I. Root Company, Medina, Ohio, 1917; 830 pages, illustrated. Price, $2.50.

A very complete encyclopedia of bee-keeping knowledge.

A Thousand Answers to Bee-keeping Questions. By C. C. Miller; published by "The American Bee Journal," Hamilton, Illinois, 1917; 275 pages, Price, $1.25.

This is a collection of queries and answers that have appeared in the "American Bee Journal," and should prove of value to the practical bee-keeper.

Wilderness Honey. By F. L. Pollock; published by The Century Company, New York, 1917; 325 pages, illustrated. Price, $1.25.

This is an interesting story, intended for boys, but it contains reliable information as to the care of bees; and the bee-keeper will find it not only an interesting, but a profitable book to read.

INSECTS.

Insect Pests of Farm, Garden and Orchard. By Sanderson & Jackson; published by Messrs. Wiley & Sons, New York, 1912; 684 pages, illustrated. Price, $3.00.

An excellent book of reference, containing accounts of the life histories and habits, with illustrations, of the destructive insects that we have to contend with, and suggesting the best methods of control.

Elementary Entomology. By Sanderson & Jackson; published by Messrs. Ginn & Company, Boston, 1912; 372 pages, illustrated. Price, $2.00.

This is a very satisfactory manual for the use of those who wish to learn something about the classification of insects. By the aid of its descriptions and illustrations, most of our common insects may be identified.

Insects Injurious to the Household. By G. W. Herrick; published by The Macmillan Company of Canada, Toronto, 1914; 470 pages, illustrated. Price, $1.75.

A convenient handbook for the housekeeper and people in general. Descriptions and figures of the habits of all our domestic pests are given and methods of control are furnished. The chapters on house flies. mosquitoes, bed bugs, clothes moths and carpet beetles, and many other more or less familiar insects, are full of most useful matter and are free from technical language that would not be intelligible to the ordinary reader.

School Entomology. By Sanderson & Peairs; published by Messrs. Wiley & Sons, New York, 1917; 356 pages, fully illustrated. Price, $1.50.

An excellent manual.

WEEDS.

Farm Weeds. By The Department of Agriculture; published by The Government Press, Ottawa, 1909; 192 pages, illustrated. Price, $1.00.

This book contains coloured plates and descriptions of the common farm weeds of Canada, and gives instructions in regard to their control.

Weeds of the Farm and Garden. By L. H. Pammel; published by The Orange Judd Company, New York, 1911; 281 pages, illustrated. Price, $1.50.

This is a handy manual for the identification of common weeds.

FRUIT AND PLANT DISEASES.

Manual of Fruit Diseases. By Hesler & Whetzel; published by The Macmillan Company of Canada, Toronto, 1917; 462 pages. Price, $2.00.

This book contains a very complete, though somewhat technical account of fruit diseases. The methods of controlling the various diseases are given in a clear, concise, easily understood way, so that the book should be of great value to every fruit grower.

Diseases of Economic Plants. By Stevens & Hall; published by The Macmillan Company of Canada, Toronto, 1910; 513 pages, illustrated. Price, $2.00.

This book contains a simple and non-technical account of the more common diseases of the field, garden and orchard.

BACTERIOLOGY.

Agricultural Bacteriology. By H. W. Conn; published by Messrs. Blakiston & Son, Philadelphia, 1909; 412 pages, illustrated. Price, $2.00.

A good, non-technical, readable volume for the farmer. It treats of bacteria in the soil; the relation of bacteria to dairy products; and bacterial diseases affecting farm animals.

Agricultural Bacteriology. By Russell & Hastings; published by H. L. Russell, Madison, Wis., 1915; 303 pages, illustrated. Price, $1.25.

This book is similar in character to the preceding one. It deals with soil bacteriology; the relation of bacteria to foods; and transmissible diseases of a bacterial nature.

BUSINESS METHODS.

Farm Management. By G. F. Warren; published by The Macmillan Company of Canada, Toronto, 1917; 590 pages, illustrated. Price, $1.75.

A study of business principles and business methods in Agriculture. A real "guide" to profitable farming.

The Marketing of Farm Products. By L. D. H. Weld; published by The Macmillan Company of Canada, Toronto, 1916; 483 pages. Price, $1.60.

Deals with principles of marketing as applied to marketing at country points, the wholesale produce trade, cold storage, transportation, prices, co-operative marketing, and other subjects.

Principles of Rural Economics. By T. N. Carver; published by Messrs. Ginn & Company, Boston, 1911; 386 pages. Price, $1.30.

Deals with some of the most important features of the so-called "rural problems"—land, labour, capital, investment, equipment, wages, profits, social life in rural communities, and other subjects.

FARM EQUIPMENT.

The Farmstead. By I. P. Roberts; published by The Macmillan Company of Canada, Toronto, 1907; 350 pages, illustrated. Price, $1.50.

This book deals with the building, furnishing and sanitation of the farmhouse, the construction of barns and out-buildings, and the general "lay-out" of the farm.

Home Water-works. By J. Lynde; published by Messrs. Sturgis & Walton, New York, 1912; 270 pages, illustrated. Price, 75c.

This book contains a clear and practical treatment of the problems relating to the water supply on the farm. It deals with such matters as sources of water, wells and pumps, systems of water supply, methods of pumping, plumbing and sewage, etc. At the end of the book there is a list of firms who manufacture equipment necessary for the installing of home water-works.

The Gasoline Engine on the Farm. By X. W. Putman; published by The N. W. Henley Publishing Company, New York, 1913; 527 pages, illustrated. Price, $2.00.

This book first explains the principle of the gasoline engine, both the two-cycle and the four-cycle. It then deals with the construction of the engine and gives full directions as to how to regulate and operate it and how to apply it to the work of the farm, in the feed room, the workshop, the orchard, the laundry, etc.

Farm Machinery and Farm Motors. By J. B. Davidson and L. W. Chase; published by The Orange Judd Company, New York, 1908; 513 pages, illustrated. Price, $2.00.

It deals with machinery for tillage, seeding, haying and harvesting, manure spreaders, wagons, buggies, feed mills, etc.; engines—steam, traction and gasoline; windmills, etc.

Electricity for the Farm. By F. I. Anderson; published by The Macmillan Company of Canada, Toronto; 265 pages, illustrated. Price, $1.50.

The volume gives practical working knowledge of electricity for use as light, heat and power. It tells the farmer how to instal his own plant without the aid and expense of an expert. It treats of water power, gasoline engine, batteries, etc.

Modern Farm Buildings. By A. Hopkins; published by Messrs. Robert M. McBride & Co., New York, Messrs. J. M. Dent & Sons, Toronto, 1916; 206 pages, illustrated. Price, $2.50.

Every phase of modern, scientific stable building is treated—planning, materials and construction details of cow barns, horse stables, silos, dairies, chicken houses, root cellars, ice houses, etc.

The Modern Gas Tractor. By Victor W. Page, M.S.A.E.; published by the Norman W. Henley Publishing Company, 2-4-6 West 45th St., New York; 500 pages, illustrated. Price, $2.00.

This is a book recently issued dealing with the construction, utility, operation and repair of gas tractors. It deals with every phase of the gas tractor in a very up-to-date manner. With the increased use of machines of this nature books of this kind are sure to be in great demand and serve an important purpose.

FARM MECHANICS.

Problems in Farm Woodwork. By S. A. Blackburn; published by The Manual Arts Press, Peoria, Illinois, 1915; 128 pages, illustrated. Price, $1.00.

This book contains many practical problems and working directions with regard to them. Shop problems, poultry problems, yard problems, garden problems, stock problems, concrete forms and other problems.

Concrete on the Farm and in the Shop. By H. C. Campbell; published by The Henley Publishing Company, New York, 1916; 149 pages, illustrated. Linen. Price, 75c.

A practical treatise on the common uses of concrete. Of special value to the inexperienced.

Handy Farm Devices and How to Make Them. By R. Cobleigh; published by The Orange Judd Company, New York, 1910; 288 pages, illustrated. Price, $1.60.

Contains directions for making gates, fences, appliances for the garden, orchard, barns, etc., and for the care of farm animals, including poultry and bees.

The A B C of the Steel Square and Its Practical Uses. By F. T. Hodgson; published by F. J. Drake, Michigan Ave., Chicago, 1908; 136 pages, illustrated. Price, 50c.

Describes the various kinds of squares, their markings, their uses, and application in the solution of simple problems—the cuts, bevels and lengths of all sorts of rafters for roofs of every description.

Knots, Splices and Rope Work. By A. H. Verrill; published by The Norman W. Henley Publishing Company, New York, 1912; 102 pages, illustrated. Price, 75c.

Gives directions for making all kinds of knots in common use. Adapted for the use of persons having to handle ropes of any kind.

Agricultural Woodworking. By L. M. Roehl; published by The Bruce Publishing Company, Milwaukee, Wis., 1916; 137 pages, fully illustrated. Price, $1.00.

A collection of problems for rural schools and the farm shop. It includes working drawings, stock bills, and brief, comprehensive directions for making many articles that have been tested for usefulness and economy.

Forge Shop Practice. By J. D. Littlefield; published by The Taylor Holden Company, Springfield, Mass., 1910; 68 pages, illustrated. Price, $1.05.

General description of forge and tools. Gives instruction in simple forge work—binding, twisting, pointing, welding and upsetting. The making of simple objects—hooks, bolts, rings, links, etc.

CYCLOPEDIAS OF AGRICULTURE.

Farm Economy. By Thirteen Writers; published by The Imperial Publishing Company, Toronto, 1916; 1,247 pages. illustrated. Price, $7.50.

Aims to present in concise form the results of scientific research in agriculture. Each of the chapters in the book is written by an expert. The subjects treated of are seed selection, soils, the garden and orchard, concrete construction, drainage, farm buildings, weeds, insects, farm mechanics, the business side of farming, and labour-saving devices for the housewife. An up-to-date, reliable book of reference.

The Standard Cyclopedia of Horticulture. By L. H. Bailey; published by The Macmillan Company of Canada, Toronto, 1915; 6 volumes. Price, $36.00.

Replaces "The Cyclopedia of American Horticulture," published in 1900. Will be the standard work of reference for many years. The quality of its many special articles is quite in keeping with the breadth of scope of the whole work.

Cyclopedia of American Agriculture. By L. H. Bailey; published by The Macmillan Company of Canada, Toronto, 1917; 4 volumes. Price, $20.00.

Aims to bring together the most complete information and most reliable opinions on agricultural subjects. The four volumes deal respectively with: Farms, Crops, Animals, and Farm and Community.

AGRICULTURAL PERIODICALS

The Canadian Countryman, Toronto; weekly; $1.00 per year.

The Canadian Farm, Toronto; weekly; $1.00 per year.

The Farmer's Advocate, London; weekly; $1.50 per year.

The Farmer's Magazine, Toronto; semi-monthly; $1.00 per year.

The Farmer's Sun, Toronto; weekly; $1.00 per year.

The Ottawa Farm Journal, Ottawa; semi-weekly; $1.00 per year.

Rural Canada, Toronto; monthly; $1.00 per year.

The Farm and Dairy, and Rural Home, Peterboro; weekly; $1.00 per year.

The Canadian Horticulturist, Peterboro; published monthly in three editions; Fruit Edition, 50c. per year; Floral Edition, 50c. per year; Agricultural Edition (known as The Canadian Horticulturist and Beekeeper), $1.00 per year.

The Canadian Poultry News, Grimsby; monthly; 50c. per year.

The Canadian Poultry Review, Toronto; monthly; 75c. per year.

The Poultry, Garden, and Home Advocate, Toronto; 50c. per year.

BOOKS ON HOUSEHOLD SCIENCE

HOUSEKEEPING.

The Furnishing of a Modest Home. By F. H. Daniels; published by The Davis Press, Worcester, Mass., 1908; 114 pages, illustrated. Price, $1.10, postpaid.

A helpful book to the average house-owner. The author gives definite rules for the choice of furniture and colouring, and clear reasons for his opinions.

Home Economics. By Maria Parloa; published by the Century Company, New York, 1915; 380 pages, illustrated; Price, $1.50.

Deals with house-furnishing, water supply, marketing, food, table service, care of furniture, floors, utensils, lighting and fuel, insect pests, and other subjects relating to the home. The information is reliable, and is given from the standpoint of an experienced housekeeper.

1,000 Shorter Ways Around the House. By Mae S. Croy; published by Messrs. G. P. Putnam's Sons, New York, 1916; 335 pages. Price, $1.50 net.

Contains suggestions in brief form as to building and furnishing the house, cooking, sewing, cleaning, the sick room, the care of children, and other subjects pertaining to the work of the household.

Laundering. By L. Ray Balderston; published by L. R. Balderston, Philadelphia, 1914; 210 pages, illustrated. Price, $1.25 postpaid.

Deals fully with the process of washing white and coloured clothes, woollens, silks, laces, etc., and with the process of dry-cleaning. Contains complete instructions for the removal of stains.

Housekeeper's Handbook of Cleaning. By Sarah J. McLeod; Messrs. Harper & Brothers, New York, 1915; 259 pages, illustrated. Price, $1.25 net.

Deals with the cleaning of clothing, woodwork, floors, carpets, furniture, utensils, and with the destruction of household pests. A large section of the book is devoted to laundering. A simply written, practical book.

The Healthful Farmhouse. By Helen Dodd; published by Messrs. Whitcomb & Barrows, Boston, 1906; 69 pages, illustrated. Price, 60c.

Full of suggestions as to convenient and sanitary arrangements and as to economical methods of work in the farm house.

The New Housekeeping. By Christine Frederick; published by The Musson Book Co., Toronto, 1913; 266 pages, illustrated. Price, $1.00.

Deals with methods of securing greater efficiency in the work of the home. A very readable and practical book.

Adventures in Thrift. By Anna S. Richardson; published by George J. McLeod, Ltd., Toronto, 1916; 229 pages. Price, $1.25.

The story of one woman who undertook to find out how to keep house economically.

Family Expense Account. By T. A. Brookman; published by Messrs. D. C. Heath & Company, Boston, 1914; 84 pages. Price, 64c.

A system of keeping household accounts. Especially valuable as showing a simple and satisfactory method of comparing one year's accounts with another.

COOKING.

Boston Cooking School Book. By Fannie M. Farmer; published by Messrs. Little, Brown & Company, Boston, 1918 (14th edition); 648 pages, fully illustrated. Price, $2.00 net.

One of the best known standard cook books.

Practical Cooking and Serving. By Janet M. Hill; published by Messrs. Doubleday, Page & Co., Garden City, New York, 1916; 679 pages, fully illustrated. Price, $1.80.

A complete manual of how to select, prepare, and serve food. The chemical composition of the various foods is given at the head of the respective chapters into which the recipes are divided.

Lessons in Cooking Through the Preparation of Meals. By Robinson and Hammel; published by the American School of Home Economics, Chicago, 1915; 468 pages, illustrated. Price, $2.00.

A systematic course in the cooking of meals, with detailed directions, not only for cooking the separate dishes, but also for preparing and serving each meal as a whole. The book is divided into twelve parts, each containing the recipes of a week's menu suitable for one month of the year. An excellent book for the beginner in cooking.

Cooking for Two. By Janet M. Hill; published by Messrs. Little, Brown & Co., Boston, 1915; 407 pages, fully illustrated. Price, $1.50.

Gives in simple and concise style directions for the selection and cooking of food, in reasonable variety, for a family of two.

Meatless Cookery. By Maria M. Gilmore; published by Messrs. E. P. Dutton & Company, New York, 1914; 344 pages, illustrated by charts. Price, $2.00 net.

An assortment of attractive recipes intended to provide food which will not cause auto-intoxication with its attendant evils.

Wheatless and Meatless Days. By Partridge and Conklin; published by Messrs. D. Appleton & Company, New York, 1918; 225 pages. Price, $1.25 net.

Simple detailed recipes for inexpensive nourishing dishes which can be made without the use of wheat or meat.

How to Cook Fish. By Olive Green; published by Messrs. G. P. Putnam's Sons, New York, 1908; 522 pages. Price, $1.00 net.

A compact manual setting forth in simple concise form the various ways of cooking all kinds of fish.

Canning, Preserving, and Jelly-Making. By Janet M. Hill; published by Messrs. Little, Brown & Co., Boston, 1917; 189 pages, illustrated. Price, $1.00.

This book presents the latest ideas in canning, preserving, and jelly-making.

Everywoman's Canning Book. By Mary B. Hughes; published by Messrs. Whitcomb & Barrows, Boston, 1918; 96 pages. Price, 75c.

"The A B C of Safe Home Canning and Preserving." Answers questions on all doubtful points. The material in this book is admirably arranged.

Table Service. By Lucy G. Allen; published by Messrs. Little, Brown & Co., Boston, 1915; 128 pages, illustrated. Price, $1.25.

Deals chiefly with the care of the dining-room, setting tables, etc. Also devotes attention to both formal and informal service.

Food and Cookery for the Sick and Convalescent. By Fannie M. Farmer; published by Messrs. Little, Brown & Co., Boston, 1912; 289 pages, illustrated. Price, $1.75.

Covers the whole range of the subject of cookery for the sick and convalescent. Includes chapters on infant feeding and on diet in special diseases.

A Cook Book for Nurses. By Sarah C. Hill; published by Messrs. Whitcomb & Barrows, Boston, 1911; 76 pages, illustrated. Price, 75c.

In this book recipes identical in method of cooking but differing in one or two ingredients, are grouped together, and all recipes are presented in condensed, easily read form. An excellent collection of recipes in small compass for ready reference.

Feeding the Family. By Mary S. Rose; published by The Macmillan Co. of Canada, Ltd., Toronto, 1917; 449 pages, illustrated. Price, $2.10.

A guide-book to good nutrition. Separate chapters are devoted to the special food needs of babies, growing children, adults, aged persons, and the sick. The book contains tables which are useful to any one interested in the proper feeding of the family.

Principles of Human Nutrition. By W. H. Jordan; published by The Macmillan Co. of Canada, Ltd., Toronto, 1917; 450 pages, illustrated. Price, $1.75.

A study in practical dietetics. A more technical book than the preceding.

The Fundamental Basis of Nutrition. By Graham Lusk, Ph.D.; published by the Yale University Press, New Haven, Conn., 1914; 51 pages. Price, 50c.

A clear exposition of food values and their relation to the cost of living. The aim of the book is to enable the family of small income to select the foods highest in nutriment at the lowest expense.

SEWING.

Clothing for Women. By Laura I. Baldt; published by The J. B. Lippincott Company, Philadelphia, 1916; 454 pages, illustrated. Price, $2.00.

Deals with fabrics, clothing design, colour, drafts of shirtwaists, skirts and undergarments, and methods of finish and decoration. A good book for sewing teachers as well as for the home.

Shelter and Clothing. By Kinne & Cooley; published by The Macmillan Co. of Canada, Ltd., Toronto, 1915; 377 pages, illustrated. Price, $1.25.

The division of the book dealing with Shelter treats of house building, furnishing and decorating; the division dealing with Clothing treats of raw materials and fabrics, pattern-making and alteration, cutting of garments, care of garments, simple garment drafts, costume design and millinery.

The Dressmaker. Published by the Butterick Publishing Co., New York, 1916; 138 pages, illustrated. Price, $1.00.

A very complete book on all matters relating to sewing and dressmaking. It describes both practical and ornamental stitches and deals with cutting, making, altering, mending and caring for clothes.

The Sewing Book. By Anne L. Jessup; published by the Butterick Publishing Co., New York, 1913; 120 pages, illustrated. Price, 50c.

Deals mainly with stitch construction and the making and finishing of simple clothing, such as could be made by children.

A Manual of Dressmaking. By Jane Fales; published by Messrs. Charles Scribner's Sons, New York, 1917; 485 pages, illustrated. Price, $1.50.

This book contains three sections: Part I, the history of costume; Part II, fabrics—manufacture, methods of testing; Part III, dressmaking—drafting and pattern-making, designing, draping, finishing, and embroidering.

HEALTH AND SANITATION.

Personal Hygiene and Physical Training for Women. By Anna M. Galbraith, M.D.; published by The W. B. Saunders Co., Philadelphia, 1917 (Canadian representatives, The J. F. Hartz Company, Toronto); 393 pages, fully illustrated. Price, $2.25.

An up-to-date book which gives detailed directions for the care of the body.

Emergencies. By Charlotte V. Gulick; published by Messrs. Ginn & Company, New York, 1909; 173 pages, illustrated. Price, 48c.

Gives in clear, concise form directions as to what to do in cases of drowning, poisoning, stings, burns, cuts, sprains, and in other accidents likely to happen in the average family. An excellent book for ready reference.

Rural Hygiene. By Henry N. Ogden; published by The Macmillan Co. of Canada, Ltd., Toronto, 1916; 434 pages, illustrated. Price, $1.50.

A systematic treatment of subjects relating not only to personal hygiene but to the health of the community at large. Contains chapters on the construction of houses, ventilation, water supply, plumbing, disposal of sewage, care of foods, and treatment of common diseases.

The Mothercraft Manual. By Mary L. Read; published by Messrs. Little, Brown & Co., Boston, 1916; 440 pages, illustrated. Price, $1.50.

A practical book on preparing for the baby, and its feeding, care and training. An excellent manual, full of information of value to mothers.

School Sanitation and Decoration. By Burrage and Bailey; published by Messrs. D. C. Heath & Company, Boston, 1899; 224 pages, fully illustrated. Price, $1.60.

Deals with the proper ventilation, heating, lighting, furnishing, and decoration of schoolrooms.

Games for the Playground, Home, School, and Gymnasium. By Jessie H. Bancroft; published by The Macmillan Co. of Canada, Ltd., Toronto, 1917; 463 pages, illustrated. Price, $1.50.

The best known collection of games, with full directions for each. This book should be in every school library.

The Prevention of Disease. By Kenelm Winslow, M.D.; published by The W. B. Saunders Co., Philadelphia, 1916 (Canadian representatives, The J. F. Hartz Company, Toronto); 348 pages. Price, $1.75.

Gives in simple language the causes of the most common diseases and shows how to avoid them.

Home Nurse's Handbook of Practical Nursing. By Charlotte A. Aikens; published by the W. B. Saunders Co., Philadelphia, 1917 (Canadian representatives, The J. F. Hartz Company, Toronto); 303 pages, fully illustrated. Price, $1.50.

A book full of suggestions for the care of the sick in the home.

LIST OF BULLETINS

Published by the Ontario Department of Agriculture, Toronto,
Available at Date of Issue of Latest Bulletin.

Serial No.	Date.		Title.
135	June	1904	......The Cream-gathering Creamery.
137	Aug.	1904	......A Bacterial Disease of Cauliflower and Allied Plants.
138	Feb.	1905	......The Composition of Ontario Feeding Stuffs.
141	April	1905	......Gas-producing Bacteria and Their Effect on Milk and its Products.
156	May	1907	......Tillage and Rotation.
164	March	1908	......Legume Bacteria.
167	Oct.	1908	......Mitchell-Walker Moisture Test.
170	March	1909	......Mitchell-Walker Test Bottle.
174	Dec.	1909	......Farm Underdrainage: Does It Pay?
175	Dec.	1909	......Farm Drainage Operations.
184	Nov.	1910	......Uses of Vegetables, Fruits and Honey.
187	Jan.	1911	......The Codling Moth.
188	April	1911	......Weeds of Ontario (No. 128, revised).
195	Jan.	1912	......Insecticides and Fungicides (No. 154, revised).
198	Feb.	1912	......Lime-Sulphur Wash.
205	Sept.	1912	......Dairy School Bulletin (No. 172 revised).
			..Part I. Cheese-making and Butter-making in Factories.
207	Dec.	1912	......Ice Cold Storage on the Farm
209	March	1913	......Farm Forestry (No. 155, revised).
211	March	1913	......Fruits Recommended for Ontario Planters.
213	April	1913	......Bee Diseases in Ontario.
216	Oct.	1913	......Box Packing of Apples.
218	Dec.	1913	......Birds of Ontario (No. 173, revised).
219	Jan.	1914	......The San José and Oyster-Shell Scales.
220	March	1914	......Lightning Rods.
221	April	1914	......Food Value of Milk and its Products.
222	April	1914	......Currants and Gooseberries.
223	May	1914	......Fertilizers.
224	Sept.	1914	......Greenhouse Construction.
225	Dec.	1914	......Swine.
226	Dec.	1914	......Plum Culture in Ontario.
227	Jan.	1915	......Cherry Fruit-Flies.
229	Feb.	1915	......Smuts and Rusts of Grain Crops.
230	March	1915	......The Cherry in Ontario.
231	April	1915	......Vegetable Growing.
232	April	1915	......Field Beans.
237	March	1916	......The Grape in Ontario.
238	May	1916	......Lime and its Use in Agriculture.
239	May	1916	......Potatoes.
240	June	1916	......Bacterial Diseases of Vegetables.
241	July	1916	......Peach Growing in Ontario.
242	Dec.	1916	......Diseased Mouths a Cause of Ill-health.
243	Dec.	1916	......Nature Study, or Stories in Agriculture.
244	Dec.	1916	......Hints for Settlers in Northern Ontario.
245	Dec.	1916	......Food Values.
246	Jan.	1917	......Suggestions on Feeding Stock.
247	April	1917	......Farm Poultry (No. 217, revised).
248	April	1917	......Pruning.
249	May	1917	......The Pear in Ontario.
250	July	1917	......Insects Attacking Fruit Trees.
251	July	1917	......Insects Attacking Vegetables.
252	July	1917	......The Preservation of Food: Home Canning.
253	Aug.	1917	......Dairy Cattle.
254	Aug.	1917	......War Breads.
255	Oct.	1917	......Tuberculosis of Poultry in Ontario.
256	Oct.	1917	......Wintering Bees in Ontario.
257	Dec.	1917	......Diseases of Fruit Trees.
258	Jan.	1918	......Diseases of Vegetables.
259	Feb.	1918	......Books on Agriculture and Household Science.

BULLETIN 260] [FEBRUARY, 1918

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

Results of Co-Operative Experiments with Farm Crops, Sources of Seed and Production of Food Materials

C. A. Zavitz, W. J. Squirrell and A. W. Mason.

INTRODUCTION.

The farm at the Ontario Agricultural College, Guelph, consists of seven hundred and seventeen acres. Of this area, seventy-five acres are used for experiments in Field Husbandry. This is divided into about 2,500 plots, from which definite yields are determined. In addition to these plots, certain areas are devoted to plant breeding work, where thousands of plants are studied individually. Experiments are being conducted with varieties of grain, root, tuber, grass, clover, fodder, silage and other crops, with artificial, green, and barnyard manures; with methods of cultivation, selection of seed, dates of seeding, mixtures of grains, pasture grasses, etc. All experiments are conducted under as near average farm conditions as possible, in regard to rotation of crops, manuring, etc., and are repeated for at least five years before they are dropped, and many of them are continued for a much longer period of time.

Based on the work of the field experiments at the Ontario Agricultural College, a system of co-operative experiments has been inaugurated throughout Ontario. This work has been carried out through the medium of the Ontario Agricultural and Experimental Union. Thirty-nine years ago the Experimental Union was organized by the students, ex-students and officers of the Ontario Agricultural College. From that time to the present, a meeting has been held each year, for the discussion of the questions which come before the Association. Very shortly after the Union was established, co-operative experiments were started in a small way. In 1886, however, the co-operative work was started under the present plan, but with only twelve experimenters the first year. From that small beginning, it has gradually developed, until it has become one of the most influential forces in the organized agriculture of Ontario. Many of the farm crops, which are now the most extensively grown throughout the Province, were introduced to the public through the medium of the Experimental Union. The work has included not only those who have been directly associated with the Agricultural College, but thousands of other practical farmers located throughout the Province.

The increase in the number of experimenters in agriculture can be seen from the following figures, which show the average yearly number actually engaged in the work in each of four eight-year periods:

Periods.	Years.	Average number of Experimenters per Annum.
1886–1893	8	315
1894–1901	8	2,608
1902–1909	8	3,882
1910–1917	8	4,282

The total number of distinct tests made throughout the Province, in agriculture alone, during the past thirty-two years has been 88,604. The number of experimenters in the past year was 4,299. Even though labor is exceptionally scarce at the present time, the number of experimenters in the past year was greater than that of the previous year. The farmers seem particularly anxious to secure pure seed of the best varieties of farm crops as foundation material, and to keep in touch with the most improved methods of crop production.

Since our last meeting, co-operative experiments have been conducted throughout Ontario with varieties of farm crops, quantities of seed per acre, mixed grains for grain production and for fodder, the application of commercial fertilizers, the eradication of weeds, the testing of cattle for tuberculosis, the re-foresting of waste places, etc.

The past three years have been abnormal for crop production in Ontario. There was an exceptionally large amount of rainfall in July and August, 1915, May and June, 1916, and June and July, 1917; in fact, in June and July of the past year there was no less than 13.94 inches of rain on the level, which is a larger amount than that of any two consecutive months in the last eighteen years, according to the records made in the Department of Agricultural Physics at the College.

The farmers of Ontario, to the number of over four thousand, who conducted co-operative experiments upon their own farms in the past year, not only did work of real service for themselves, but also furnished most valuable object lessons and practical results of special importance to the other farmers of the Province. We believe that the influence of this Association will be even greater in the future than it has been in the past. With the present urgent demands of the agriculture of the Province, the Experimental Union will fill an important place. New lines of enquiry are sure to develop, and will undoubtedly receive the close attention of the various committees appointed to carry forward the active work of the Association in the months and the years which are to follow.

This bulletin contains the report for the past year of the co-operative experiments in agriculture, including certain references to results of experiments conducted at the Ontario Agricultural College, and also of co-operative experiments carried out in former years. It also includes information on Sources of Farm Seed Supply for Ontario, and Practical Suggestions in the Production of Food Materials for the Coming Year, the greater part of which was presented at the annual meeting of the Experimental Union, held at the Agricultural College in January, 1918. This information is issued at an early date, that it might be in time to be of real service to the farmers for the coming season's cropping. The Annual Report of the Experimental Union cannot be printed until a later date.

RESULTS OF CO-OPERATIVE EXPERIMENTS IN AGRICULTURE.

DR. C. A. ZAVITZ, PROFESSOR OF FIELD HUSBANDRY, O.A.C., GUELPH.

Although co-operative experiments in agriculture have been conducted through the medium of the Experimental Union in each of the past thirty-two years, there was probably never a time when there was a greater interest taken in the work than at present. Even in spite of the fact that labor is exceptionally scarce at the present time, there was fully one thousand more experimenters in 1917 than in the year previous. The farmers of Ontario are very deeply interested in their work, and are endeavoring to do their utmost in increasing essential food materials. They realize, more than ever before, that for increased crop production, one of the first essentials is the use of seed of the highest quality. It is now generally recognized that the Experimental Union uses nothing but pure seed of high quality of a few of the very best varieties. The co-operative work with farm crops is exerting an increasing influence on the agriculture of the Province as time advances.

The committee appointed last year to look after the co-operative work in agriculture for 1917 was as follows: C. A. Zavitz (Director), W. J. Squirrell, A. W. Mason, C. R. Klinck, and A. E. Whiteside. As Director of this branch of the work, it rests with me to present the report of the co-operative experiments with field crops, as conducted throughout the Province during the past year. We had in all thirty-seven distinct and separate tests, six being with autumn and thirty-one with spring-sown crops. To furnish definite information and an outline of the work, a copy of the list of experiments, which was forwarded to ex-students and other farmers, is here presented.

WINTER CROPS, 1916-1917.

Material for any one of the six experiments here mentioned will be sent, free, to any Ontario farmer applying for it, if he will conduct an experiment with great care and report the results after harvest next year. The seed will be sent out in the order in which applications are received, as long as the supply lasts.

	Plots.
1. Testing three leading varieties of Winter Wheat	3
2. Testing one leading variety of Winter Rye and one of Winter Wheat	2
3. Testing Spring Applications of five Fertilizers with Winter Wheat	6
4. Testing Autumn and Spring Applications of Nitrate of Soda and Common Salt with Winter Wheat	5
5. Testing Winter Emmer and Winter Barley	2
6. Testing Hairy Vetches and Winter Rye as Fodder Crops	2

The exact size of each plot is to be one rod wide by two rods long. The material for Experiment Nos. 1, 2, 3, 5 and 6 will be forwarded by mail, and for the other one by express. Each person wishing to conduct one of these experiments should apply as soon as possible, mentioning which test he desires, and the material, with instructions for testing and the blank form on which to report, will be furnished, free of cost, until the supply of experimental material is exhausted.

SPRING CROPS, 1917.

The members of the Ontario Agricultural and Experimental Union are pleased to state that for 1917 they are prepared to distribute into every Township of Ontario, material for experiments with fodder crops, roots, grains, grasses, clovers and fertilizers. Fully 2,500 varieties of farm crops have been tested in the Experimental Department of the Ontario Agricultural College, Guelph, for at least five years. These consist of nearly all the Canadian sorts, and several hundred new varieties and new strains, a few of which have done exceedingly well in the carefully conducted experiments at the College, and will be used for the co-operative experiments throughout Ontario in 1917.

Each person in Ontario who wishes to join in the work may choose any one of the experiments for 1917, fill out the accompanying form of application, and return the same to the Director of the Co-operative Experiments in Agriculture, at as early a date as possible. The material will be furnished in the order in which the applications are received, until the supply is exhausted. A sheet containing the instructions for conducting the chosen experiment, and the blank form on which to report the results of the work, will be sent to each experimenter at the time the fertilizers or seeds are forwarded. All material will be furnished entirely free of charge to each applicant, and the produce of the plots will, of course, become the property of the person who conducts the experiment. In return, the Committee on Agricultural Experiments desires to ask that each experimenter will sow all the plots belonging to the particular experiment which he has chosen for 1917, and that he will be very careful and accurate in his work, and forward to the Director a complete report of the results obtained from the test, as soon as possible after the plots are harvested.

All seeds and fertilizers will be sent in good time for spring seeding, providing the applications are received at an early date. The supply of material being limited, those who apply first will be surest of obtaining the desired outfit. Each applicant should make a second choice, for fear the first could not be granted. The Experiment selected should be indicated by using its number as given in the left hand column in the list of Experiments. Further information is given on the application form which is attached.

LIST OF EXPERIMENTS FOR 1917.

Grain Crops.

		Plots.
1.	Testing two varieties of Oats	2
2a.	Testing O. A. C. No. 21 Barley and Emmer	2
2b.	Testing two varieties of Two-rowed Barley	2
3.	Testing two varieties of Hulless Barley	2
4.	Testing two varieties of Spring Wheat	2
5.	Testing two varieties of Buckwheat	2
6.	Testing three varieties of Field Peas	3
7.	Testing two varieties of Spring Rye	2
8.	Testing three varieties of Soy, Soja, or Japanese Beans	3
9.	Testing seven varieties of Husking Corn	7

Root Crops.

10.	Testing three varieties of Mangels	3
11.	Testing two varieties of Sugar Beets for feeding purposes	2
12.	Testing three varieties of Swedish Turnips	3
13.	Testing two varieties of Fall Turnips	2
14.	Testing two varieties of Carrots	2

Forage, Fodder, Silage and Hay Crops.

15.	Testing the planting of Corn at six distances in the row	6
16.	Testing three varieties of Millet	3
17.	Testing two varieties of Sorghum	2
18.	Testing Grass Peas and two varieties of Vetches	3
19.	Testing Rape, Kale and Field Cabbage	3
20.	Testing three varieties of Clover	3
21.	Testing two varieties of Alfalfa	2
22.	Testing four varieties of Grasses	4

Culinary Crops.

23. Testing three varieties of Field Beans 3
24. Testing two varieties of Sweet Corn 2

Fertilizer Experiments.

25. Testing Barley on potato plots fertilized in 1916 6
26. Testing fertilizers with Mangels 10
27. Testing fertilizers with Rape 5

Miscellaneous Experiments.

28. Testing two varieties of Potatoes 2
29. Testing three grain mixtures for Grain production 3
30. Testing three grain mixtures for Fodder production 3

The size of each plot in each of the first twenty-seven experiments and in Nos. 29 and 30 is to be two rods long by one rod wide; in No. 28 one rod square.

If you wish to conduct one of the thirty agricultural experiments named on the accompanying circular, kindly fill out this blank form and return it as soon as possible.

The distribution will be confined to the choice varieties included in the various experiments. In filling out the blank form, therefore, it is neither necessary, nor advisable, to mention any particular variety or varieties.

Materials for experiments numbered 26 and 27 will be sent by express, and that for each of the others by mail.

Application for Material for an Experiment.

I would like to conduct experiment number ......, but if all the material for that experiment has been applied for before my application is received I select experiment number ...... as my second choice. If the material for one of these experiments is forwarded to me, I will endeavor to

1. Carry on the test according to the instructions received with the seed.
2. Exercise care and accuracy in the work, and
3. Report the result of the experiment as soon as possible after harvest, whether successful or not.

The past three years have been abnormal for crop production in Ontario. The following information has been secured from the Department of Agricultural Physics, and gives the amount of rainfall for each month from April to September for each of the past three years, and for the average of the past eighteen years:

Months.	1915.	1916.	1917.	Average 18 years.
April	2.23	3.53	3.36	2.36
May	2.24	4.41	3.29	2.83
June	2.27	4.46	6.40	2.72
July	5.87	1.21	7.54	3.66
August	6.16	1.68	3.28	2.90
September	3.92	1.83	1.41	2.32
Total, 6 months	22.69	17.12	25.28	16.79

At the Ontario Agricultural College, within the past eighteen years, the total amount of rainfall for the six growing months did not surpass 20 inches, except in 1915, when there were 22.69, and in 1917, when there were 25.28 inches. It will, therefore, be seen that out of the past three years, we have had two exceptionally wet seasons. The tabulated results here presented show that the rainfall was exceptionally heavy in July and August, 1915, May and June, 1916, and June and

July, 1917. The total amount of rainfall in June and July of the past year was greater than that of any two consecutive months in the eighteen-year period. The average total amount of rainfall for the six growing months, from April to September, inclusive, as determined at ten different localities throughout the Province, amounted to 18.56 inches in 1917, and 17.34 inches in 1916. The amount of rainfall between Fort William and Manitoba was exceptionally light during the past year. The results of experiments in 1917 have peculiar interest, but care is necessary in order to avoid drawing wrong conclusions from any single abnormal year.

The co-operative work of the Experimental Union is entirely voluntary, and this is probably one of the greatest reasons for its development and for its success. The various experimenters conduct the tests, according to instructions which are furnished them, and report the results of their individual experiments on blank forms, which are sent at the same time as the seed.

The reports of the co-operative experiments for 1917, which were received at the College, were submitted as usual to a very critical examination. For the summary report, which is presented at this time, only those reports which showed carefulness and reliability throughout were used. All reports, whether successful or not, are here on the platform for the inspection of any member who wishes to examine them. Many of these reports have been furnished by men who have had a large amount of practical experience on the farm, have had the advantage of a good education, and have had a careful training in experimental work, as they have conducted successful tests on their own farms in each of a number of years. It should be clearly understood that, while only the good reports of carefully conducted experiments have been used for publication, many of those not included in the summary report show that the individual experimenters must have obtained a considerable amount of valuable information from their work and, in each of a number of cases, a start with choice seed of varieties particularly suited to their own local conditions. It occasionally happens that, owing to some accident, an experiment may have been injured so that the results could not be used in the summary report, but the experiment may have given useful lessons to the farmer conducting the test, and sometimes to other farmers in the vicinity. It is certainly true that experimenters obtain much more information from the experiments which they conduct in addition to that included in the summary report such as the one here submitted.

Every experimenter who received instructions for conducting the co-operative work was asked to give his decision on the relative standing of the different varieties, mixtures, quantities of seed, fertilizers, manures, etc., after everything had been taken into consideration. The report here presented includes a summary of the answers to this enquiry, and is presented in the tabulated results, under the heading of "Comparative Value."

Varieties of Farm Crops.

The number of varieties distributed for co-operative work is very small, as only those are used which have been thoroughly tested for a series of years in the trial grounds at the Ontario Agricultural College, and which have made high records. There are too many varieties of nearly all classes of farm crops grown in Ontario. Many of these are brought into the country by agents, and are frequently purchased by farmers who are attracted by means of beautiful illustrations and the extravagant claims made by the travelling salesmen, who go from house to house, selling small amounts of seed at high prices. Some of these are old varieties under new names, and some are new varieties which are not as good as those which are already grown in general cultivation. It is the aim of the Experimental Union to furnish the highest quality of seed of a few of the best varieties, in order that the farmers may increase crop production in the most economical way and at the same time glean valuable information through the medium of their experimental work.

The Experimental Union is actively engaged with those crops which are now used on fully ninety per cent. of the cultivated land of the province. Some of the varieties which are now being extensively used in cultivation are those which were introduced by or originated at the College, and, after proving worthy, were distributed and used for the co-operative experimental work on different farms throughout the province. Some varieties do particularly well over nearly the whole of Ontario, while others do the best on certain soils or in special localities. The barley crop is now confined almost entirely to either the Mandscheuri or the O.A.C. No. 21 varieties. The last-named barley has increased so substantially that it is the only kind grown in many of the localities throughout the province. Other varieties are also increasing very rapidly, such as the O.A.C. No. 72 oats and the Marquis spring wheat. These are becoming great favorites pretty generally throughout the province.

We are pleased to submit the tabulated returns of the different varieties of grain crops tested throughout Ontario in 1917, and, even though the tests were made in an abnormal year, the results, if studied with good judgment, should prove of special service.

Experiments.	Varieties.	Comparative Value.	Yield per Acre.		
			Straw (tons).	Grain (bus.).	Grain (lbs.).
Oats (53 tests).	O. A. C. No. 72	100	1.74	45.86	1,559
	O. A. C. No. 3	69	1.37	41.20	1,401
Six-rowed Barley and Emmer (20 tests).	O. A. C. No. 21	100	1.34	37.38	1,794
	Common Emmer	73	1.68	42.63	1,705
Hulless Barley (11 tests).	Black Hulless	98	1.28	23.88	1,433
	Guy Mayle	100	1.20	23.45	1,407
Spring Wheat (24 tests).	Wild Goose	100	1.53	20.80	1,248
	Marquis	91	1.46	20.09	1,206
Winter Wheat (25 tests).	O. A. C. No. 104	100	1.78	23.69	1,421
	Improved Imperial Amber	94	1.78	22.91	1,375
	Improved Dawson's Golden Chaff.	94	1.41	21.47	1,288
	Kharkov	48	1.72	19.34	1,160
	Yaroslaf	55	1.79	17.57	1,054
Spring Rye (5 tests).	O. A. C. No. 61	100	2.17	22.50	1,260
	Common	56	2.05	20.36	1,140
Winter Rye and Winter Wheat (12 tests).	Petkus Winter Rye	100	1.11	27.89	1,562
	American Banner Winter Wheat.	81	1.02	21.62	1,297
Field Peas (53 tests).	Early Britain	89	1.20	21.84	1,310
	Potter	96	1.32	21.36	1,281
	Canadian Beauty	100	1.49	21.24	1,274
Field Beans (27 tests).	Pearce's Improved Tree	90	.86	18.75	1,125
	Elliott's Pea	100	.65	17.83	1,070
	O. A. C. No. 81 Soy Bean	51	.93	14.81	889

In the tabulated results of the grain crops here given, attention is called to the fact that the figures in the third column under "Comparative Value" are made up from the answers received from the experimenters after the farmers, who conducted the experiments, had taken everything into consideration. In the fourth column the yield of straw per acre represents the total crop, less the amount of grain and, therefore, includes the chaff with the straw. The yield of grain is given in pounds as well as in bushels per acre, in order that the results may be very clearly understood and that certain comparisons may be made between the different classes of crops as well as between the varieties of each class in a season such as we have had in 1917. Definite determinations can be made between the varieties of each class of farm crops, as they were grown on the same farms and under similar conditions. Caution should be exercised, however, in comparing one class of farm crops with another, as it should be understood that these have been grown on different farms. In cases where there are a considerable number of tests of each class, however, certain comparisons might be made regarding the yields of different classes. Owing to the great variation in the weight per measured bushel in different crops, it is easier to compare the results in pounds than in bushels per acre. In working out the number of bushels per acre, the standard weights per measured bushel have been used for each class of crop.

Varieties of Oats.—The market value of the oat crop in Ontario is about equal to the combined values of the winter wheat, spring wheat, barley, rye and buckwheat. It is about one-quarter of the value of all the field crops grown in the Province, about one-half of the value of the horses, cattle, sheep, lambs, swine and poultry of all classes which are sold or slaughtered annually, and practically double the value of the cheese and butter manufactured in the factories and in the creameries of Ontario each year.

About three hundred varieties of oats have been carefully tested under uniform conditions in the experimental grounds at the College. These include the different varieties obtained in Ontario as well as a large number of the leading kinds which have been imported from other countries which possess climatic conditions somewhat similar to those of this Province. Efforts have been made to improve the best varieties by means of plant selection and by cross-fertilization. One of the great difficulties in oat production in Ontario is the fact that too many varieties are grown, and there are so many kinds under cultivation that it is practically impossible to get large shipments of any one variety grown in the same locality. It has been the aim of the Agricultural College and of the Experimental Union to eliminate as many of the varieties as possible and to concentrate on a few of the very best. With this object in view, much attention has been given to the improvement of a few of the very best varieties. Two varieties started at the College have made excellent records, both in our own trial grounds and in the co-operative experiments throughout the Province. It is believed that the O.A.C. No. 72 variety of oats, which requires the same length of time to mature as the Banner, will soon supplant practically all of the varieties of late oats in the Province.

The O.A.C. No. 72 variety of oats was started from a single seed in 1903, and the O.A.C. No. 3 variety from a single seed in 1904. These two varieties have been carefully tested at the College with other varieties of oats in each of the past eleven years. In ten out of eleven years the O.A.C. No. 72 surpassed the Banner, and in nine out of eleven years the O.A.C. No. 3 surpassed the Daubeney in yield of grain per acre, the average annual yield of increase being about sixteen bushels for the former and seven bushels for the latter.

In the year 1911, the O.A.C. No. 72 variety of oats was first distributed for co-operative experiments throughout Ontario. One pound lots were sent in that year to three hundred Ontario farmers who applied for the co-operative experiments with oats, through the medium of the Experimental Union. The one pound lots of the O.A.C. No. 72 oats were compared with equal quantities of two or three other leading varieties on plots one rod wide by two rods long. The new variety did so well in the first year that a large number of farmers saved their seed very carefully and sowed it on larger plots in 1912.

In 1913, one farmer had sufficient seed of the O.A.C. No. 72 oats to enter in the Field Crop Competition, in which he received first prize. From that time forward the number of first prizes for this new variety has been rapidly increasing as is seen by the following table, which gives the first prizes in the Ontario Field Crop Competitions for both Banner and O.A.C. No. 72 oats, according to the reports which have been issued:

Year.	O. A. C. No. 72.	Banner.
1913	1	41
1914	20	34
1915	48	33
1916	76	26

In connection with the Provincial Winter Fair, held annually at Guelph, the O.A.C. No. 72 oats had six per cent. of the entries in 1913, twenty-eight per cent. in 1914, forty-three per cent. in 1915, and fifty-two per cent. in each of the past two years.

The O.A.C. No. 72 and the O.A.C. No. 3 varieties of oats have been tested over Ontario in each of the past five years, the average in bushels of grain per acre being 50.1 for the former and 45.7 for the latter. In each of the five years the O.A.C. No. 72 surpassed the O.A.C. No. 3 in yield of grain. The latter named variety, however, is thinner in the hull and is usually about ten days earlier in maturing than the former. In 1917, according to the co-operative experimenters, the O.A.C. No. 3 matured on an average twelve days earlier than the O.A.C. No. 72. The former is exceptionally well adapted for mixing with barley when it is desired to grow the two in combination. The yield of straw per acre of the O.A.C. No. 72 usually surpasses the O.A.C. No. 3 by an average of about two-fifths of a ton. In 1917, both varieties were exceptionally free from smut and from rust, there being scarcely a trace of either in the early variety.

O.A.C. No. 21 Barley and Common Emmer. In each of five years we have distributed throughout Ontario, for co-operative experiments, the O.A.C. No. 21 barley and the Common emmer, in order that these might be tested under uniform conditions for crop production. We had previously found that the emmer was a close rival of barley in yield of grain per acre. In the co-operative experiments, however, the Common emmer has been surpassed in yield per acre by the O.A.C. No. 21 barley in each of the five years, the average for 1917 being 89 pounds of grain per acre.

The O.A.C. No. 21 variety of barley was started in the Field Husbandry Department at our College from a single seed in 1903. This barley possesses a good length of straw which is particularly strong in comparison with most other varieties. The heads possess six rows of grain and are bearded. The grain is white on the outside, but is of a bluish color immediately under the hull. So far the crop has been comparatively free from rust. The weight of the grain per measured bushel has been somewhat over the standard and the yield per acre has been heavy. According to the experimenters in 1917, the O.A.C. No. 21 barley matured on the average eleven days earlier than the Common emmer.

For ten years in succession, the O.A.C. No. 21 barley has been distributed throughout Ontario for co-operative experiments. In each of four years in which it was compared with the Mandscheuri in the co-operative experiments throughout the Province, it surpassed the latter in yield of grain per acre, in freedom from rust, and in both length and strength of straw. From the one-pound lots of the O.A.C. No. 21 barley, which have been distributed through the medium of the Experimental Union, this variety has increased very rapidly over the Province. It has been increasing so rapidly that it has practically supplanted all other varieties in Ontario. At the Provincial Winter Fair, in each of the past three years, there has been no other entry of a named barley than the O.A.C. No. 21 except in 1917, when there was one entry of the Mandscheuri.

From an enquiry made in 1917, of practical farmers throughout Ontario, as to the most extensively grown barley in their respective counties, sixty-five per cent. of the farmers mentioned O.A.C. No. 21, thirty per cent. Mandscheuri, and five per cent. Common Six-rowed.

Hulless Barley.—Even though the Bureau of Industries report gives no special record of the production of Hulless barley in Ontario, it is known that it is grown to a limited extent. In some sections of the Province there is much more interest taken in this crop than in others. At the College we have had under experiment some fifteen different varieties of Hulless barley. The most of them, however, have not proven very satisfactory over Ontario. In each of the past fourteen years we have distributed the Guy Mayle and the Black Hulless varieties for co-operative tests. In the average of the whole period of thirteen years previous to 1917, in which there were 168 separate tests, we find that the Guy Mayle gave 24.1 and the Black Hulless 23.1 bushels per acre. In 1917, it will be seen that the Black Hulless gave 23.9 and the Guy Mayle 23.5 bushels per acre. The Guy Mayle, on the whole, has been superior to the Black Hulless, both in yield per acre and in popularity.

Spring Wheat.—In each of the past three years increased interest has been aroused in spring wheat production owing to the high price of wheat brought about through the European war and through the partial failure of the winter wheat crop in some of the countries. It is interesting to note that in the Province of Ontario the number of acres of spring wheat amounted to 144,305 in 1916, and 182,957 in 1917. As the acreage sown to fall wheat was not large in the autumn of 1917, and as there is a big demand for wheat to supply the world's market, it is very probable that the acreage of spring wheat, which will be sown next spring, will be unusually high, providing the weather conditions are at all favorable.

In each of five years, the Marquis and the Wild Goose varieties have been distributed over Ontario for co-operative experiments. In four of these years the Wild Goose surpassed the Marquis in yield per acre, the average for the five years being 20.2 bushels for the Wild Goose and 19 bushels for the Marquis. The Marquis spring wheat is of excellent quality for bread production, and was originated at the Central Experimental Farm, Ottawa. There is probably no other spring wheat which will meet the present demand so well as the Marquis.

Winter Wheat.—Five varieties of winter wheat were again distributed in the fall of 1916. The results of this experiment, as well as those of other autumn sown crops, were prepared for publication in August of the present year, and were sent to about four hundred of the newspapers and agricultural journals of Ontario. This enabled the farmers to learn the results of the tests conducted both at the College and throughout Ontario with the autumn sown crops before the time for seeding in the latter part of August and in early September. As the season was very late, however, a full report could not be prepared until more recently.

In each of three years the same varieties of winter wheats were distributed for co-operative experiments, and the one which gave the highest average yield per acre was Imperial Amber. In 1917, the five varieties used for the co-operative experiments were the O.A.C. No. 104, Improved Imperial Amber, Improved Dawson's Golden Chaff, Kharkov and Yaroslaf. The first and the third are white and the other three are red wheats. The last two named varieties are exceedingly hard and are of superior quality for bread production. It will be seen that in the average of twenty-five experiments the O.A.C. No. 104 came at the top of the list in yield of grain per acre and in popularity. The O.A.C. No. 104 was a cross made at our College between the Dawson's Golden Chaff and the Bulgarian. This cross has furnished a new variety which, in the experiments at the College during the last five years, has surpassed both its parents in average yield per acre and is about equal to the Bulgarian in bread production. This variety was distributed over Ontario through the medium of the Experimental Union in the autumn of 1916, for the first time. Its record, so far, is very encouraging.

Buckwheat.—Two varieties of buckwheat were distributed in the spring of 1917 for co-operative experiments, but owing to the abnormal weather conditions, there were not enough reports received for including the yields in the tabulated statement. The two or three reports which were received showed a higher yield per acre for the Rye buckwheat than for the Silver Hull in each instance. In the average of seven years' results, which we previously reported, the Rye buckwheat gave 25.3 and the Silver Hull 20.5 bushels per acre per annum. The latter-named variety is the most extensively grown in Ontario, and the former variety in Nova Scotia.

Spring Rye.—For seven years in succession two varieties of spring rye have been distributed over Ontario for co-operative experiments. The average yield in bushels of grain per acre for 1917, and for the average of the seven-year period are, respectively: O.A.C. No. 61, 22.5, 24.7; and Common, 20.4, 21.6. It is interesting to note that in each of the seven years the O.A.C. No. 61 surpassed the Common variety in yield per acre. In the experiments at the College, the O.A.C. No. 61 variety has made the highest record. This variety of spring rye was originated at the College.

Winter Rye and Winter Wheat.—In the autumn of 1914, and again in 1915, the Petkus winter rye and the Imperial Amber winter wheat were distributed for co-operative tests. The average results show that the Petkus rye surpassed the Imperial Amber winter wheat by an average of 380 pounds per acre in 1915 and by 344 pounds in 1916. In the average of twelve co-operative tests made in 1917, the Petkus winter rye surpassed the American Banner winter wheat by an average of 265 pounds per acre. The Petkus variety has surpassed all other kinds of winter rye in the average results of the experiments conducted at the College during the past six years.

Field Peas.—In each of the past three years there has been an unusual demand for the experiment with field peas. This was brought about, undoubtedly, by the high price of peas, the demand for concentrated food for home use and for export, and by the encouragement given to the growth of field peas in Ontario. According to the annual report of the Bureau of Industries for 1916, the average market value per acre of the pea crop of Ontario was $27.41, while that of oats was $17.50, and that of barley was $23.91.

In each of the past two years three varieties, viz., the Canadian Beauty, a large white smooth pea; the Early Britain, a brown dented variety; and the Potter, a smooth pea of large size, were used for the co-operative experiments. The results in bushels of grain per acre, for 1917, are shown in the table, and those for the last two years combined, including eighty-two separate tests, are as follows: Potter, 21.9; Canadian Beauty, 21.8; and Early Britain, 21.3. In sixteen years, in which the Canadian Beauty and the Early Britain have been grown in competition throughout Ontario, the former took the lead in ten, and the latter in six separate years, but in average yield of grain per acre per annum they produced an equal number of bushels, viz., 23.9. Both the Canadian Beauty and the Potter were quite popular with the experimenters throughout Ontario in the past season. These are both choice varieties.

Field Beans.—The demand for field beans for co-operative experiments has also been large in each of the past three years. The average price paid for beans in Ontario for the thirty-two years previous to 1914 was $1.25 per bushel, and for the average of the years 1911, 1912 and 1913 it was $1.84 per bushel. In January, 1915, the Government of Ontario paid approximately $2.50 per bushel for several car loads of beans for shipment to the Belgians. In March, 1915, the Commercial beans of Ontario were selling for about $3.00 per bushel. In the latter part of 1916, the price of beans advanced to upwards of $6 per bushel, and in the latter part of 1917 to about $7.50 per bushel in the trade of the Province. In the spring of 1917, good seed beans were exceedingly scarce, and sold readily from $9 to $12 per bushel.

In the spring of 1917, two varieties of field beans and one variety of soy beans were distributed for co-operative experiments. This was the first time that the soy beans were tested in this way. The interest in the soy beans has been quite keen recently owing to the scarcity of concentrated materials for domestic purposes and as feed for farm stock. It will be seen, from the tabulated results, that the Pearce's Improved Tree bean gave the highest yield per acre, viz., 18.75 bushels, which was followed by the Elliott's pea bean with 17.83 bushels and the O.A.C. No. 81 soy bean with 14.81 bushels. The Pearce's Improved Tree bean has been used in the co-operative experiments in each of the past five years. In comparison with the pea bean for the four years previous to 1917, the former gave 25.4 and the latter 23.5 bushels per acre. In the average of the co-operative experiments over Ontario for three years, the Pearce's Improved Tree gave 26.6 bushels and the Marrowfat, for the same period, an average of 24.5 bushels per acre. In 1917, the Pearce's Improved Tree bean was sent out in comparison with the Elliott pea bean, the latter being a special strain of this commercial bean grown for a number of years in the southern part of Wellington county. In the average of twenty-seven separate tests, it was surpassed by the Pearce's Improved Tree bean by nearly one bushel per acre.

A bulletin on "Field Beans" was published in the spring of 1915, and copies can be obtained from the Department of Agriculture, Parliament Buildings, Toronto.

In this bulletin the results are given of each of ten varieties of field beans for a period of ten years which show that the Pearce's Improved Tree bean stands at the head of the list with 23.4 bushels per acre, being 5.3 bushels per acre per annum higher than the yield of any other variety. The Pearce's Improved Tree is a white bean of excellent quality, medium to large in size, but it requires a fairly long season to ripen, and for this reason was not quite so popular with the experimenters in 1917 as the pea bean which was slightly earlier.

Winter Emmer and Winter Barley.—In the co-operative experiments over Ontario in the past year, Black winter emmer surpassed winter barley in yield of grain per acre by 493 pounds in the average of six tests. The difference in favor of the emmer in 1916 was 360 pounds per acre. The winter emmer at the College has given an average of about 2,500 pounds of grain per acre in the results of the past ten years. Winter barley usually gives a large yield per acre when it survives the winter, but it is somewhat more tender than winter wheat. We have not yet secured a winter barley which can be relied on for general cultivation in many parts of Ontario, although there are some sections in which winter barley might be used with a good deal of satisfaction.

Soy Beans.—The past two seasons have been particularly unfavorable for the production of soy beans in Ontario. Two varieties were distributed for co-operative experiments each year, but owing to the abnormal weather conditions, few complete reports were received. In both years the results were slightly in favor of the Brown variety which is the earliest kind of soy beans tested at the College. In normal seasons the O.A.C. No. 81 has surpassed the Brown soy bean in the College tests.

Corn for Grain Production.—The seven varieties of corn which are specially recommended by the Ontario Corn Growers' Association were distributed in the spring of 1917 for co-operative experiments. The season being very abnormal, we have only the complete results of three carefully conducted experiments with the seven varieties of corn for the past season. One of these was conducted in York, one in Norfolk and one in Huron county. The highest yields of grain per acre were obtained by the Golden Glow in York county, by the Wisconsin No. 7 in Norfolk county, and by the Longfellow in Huron county. The following gives the average yield in bushels of grain per acre as shown by the experiments conducted in the three counties: Golden Glow, 48.6 bushels; Longfellow, 46.2; White Cap Yellow Dent and Wisconsin No. 7, each 41.4; Compton's Early and Salzer's North Dakota, each 39.0; and Bailey, 33.3. In the average yields per acre for the past two years of the seven varieties of corn under test the number of bushels for each is as follows: White Cap Yellow Dent, 53.2; Golden Glow, 51.6; Wisconsin No. 7, 51.1; Longfellow, 44.9; Compton's Early, 43.1; Bailey, 42.6; and Salzer's North Dakota, 39.7. In amount of stover per acre, the Golden Glow came the highest in 1917 with 7.4 tons, the Wisconsin No. 7 second with 7 tons, and the Longfellow lowest with 5.3 tons.

GRAINS GROWN IN COMBINATION FOR GRAIN PRODUCTION.

Experimental work has been conducted in a systematic way at the Ontario Agricultural College for a number of years in succession in testing various combinations of grain for green fodder, for hay and for grain production. The results of these experiments have been both interesting and important, and have been reported from time to time in the College publications. It was found that the combination of varieties of the same class of grain gave no appreciable advantage in increase in yield per acre. It was also found that certain combinations of different classes of grain gave practically no advantage, while others furnished considerable increase. One of the most important results obtained was from the combination of oats and barley grown in the proper proportions of the right varieties which gave a yield of slightly over two hundred pounds of grain per acre over either grain grown separately in the tests which were carefully conducted over a series of years.

From information gleaned in the experimental work at the College, co-operative tests were arranged for having different combinations tested throughout the Province. In an experiment which was conducted for five years, and which was completed in 1909, different varieties of oats, barley and spring wheat were grown in combinations of two and three kinds of grain together. The average results of the five years' co-operative experiment show that one bushel of the Daubeney oats and one bushel of the Mandscheuri barley gave a higher yield of grain per acre than any of the other mixtures used in the experiment. In 1910, a co-operative experiment was started for the testing of three different proportions of oats and barley in order to find out which ones would give the highest yields on the average and on the different soils throughout the Province. In 1910, the varieties used were the Daubeney oats and the Mandscheuri barley; in 1911, the Alaska oats and the O.A.C. No. 21 barley; in 1912, in 1913 and in 1914, the Daubeney oats and the O.A.C. No. 21 barley; in 1915, in 1916 and in 1917, the O.A.C. No. 3 oats and the O.A.C. No. 21 barley.

The experiment has been conducted for eight years, but in 1912 the reports were not of sufficient value to be tabulated. The average results of the experiment for each of the seven years and for the whole period during which this experiment has been satisfactorily conducted are as follows:

Pounds of Seed per acre in combination.	Yield per Acre.															
	Tons of Straw.								Pounds of Grain.							
	1910	1911	1913	1914	1915	1916	1917	Ave.	1910	1911	1913	1914	1915	1916	1917	Ave.
Oats 17......... Barley 24.......	1.32	.75	.97	.68	1.28	.77	1.12	.98	1528	1420	1260	1136	1880	900	1377	1357
Oats 34 .... Barley 48	1.47	.93	1.25	.68	1.72	1.08	1.34	1.21	2104	1820	1510	1296	2270	1320	1514	1691
Oats 51 .... Barley 72	1.61	1.29	1.63	.65	1.86	1.26	1.35	1.38	2096	1594	1700	1488	1980	1320	1477	1665

In yield of threshed grain per acre, one bushel of oats and one bushel of barley, making a combination of two bushels per acre, gave on the average a greater yield per acre than either the lighter or the heavier seeding. In the seven years' test, the light seeding did not give the highest yield in any one year, and the heavy seeding gave the highest returns in only two years. In the production of straw, however, the heaviest seeding gave the highest yield in each of six out of the seven years. In the average of the whole period, the medium seeding gave 26 pounds of grain per acre more and 340 pounds of straw per acre less than the heavier seeding. It can be seen that the heaviest seeding required 41 pounds of grain per acre more than the medium seeding. It will, therefore, be seen that the results of this experiment throughout Ontario have shown that one bushel of oats and one bushel of barley by weight, when mixed together, gives more satisfactory returns than either one-half bushel of each or one and one-half bushels of each when sown in combination.

In the results of more extensive experiments carried on at the College, extending over a period of more than a dozen years, a combination of one bushel of oats and one bushel of barley by weight has produced the largest yield of grain per acre.

FIELD ROOTS, FODDER CROPS, GRASSES, CLOVERS AND ALFALFA.

In 1917, co-operative experiments were conducted throughout Ontario with mangels, sugar mangels, swede turnips, fall turnips, field carrots, fodder corn, millet, grass peas, vetches, rape, kale, field cabbage, mixed grains, grasses, clovers and alfalfa. We never have as many applications for this class of farm crops as we do for the cereals. Owing to the abnormal season, experimenters found it exceedingly difficult to carry on satisfactory tests with such crops as corn, sorghum and millet in the past year. We always find it difficult to get full and satisfactory reports of grasses, clovers and alfalfa in a manner suitable for presentation in tabulated form. These different crops are not ready for cutting at the same time, and the weather conditions frequently make it very difficult, indeed, to secure uniformity in the weights of either the green crop or the hay. Some of the crops produce one, some two and some even three cuttings in the one season, hence the difficulty in presenting definite information. In some of the crops belonging to this class, however, we have received satisfactory reports of carefully conducted experiments, a summary of which is here presented:

Experiments.	Varieties.	Comparative Value.	Yield per Acre (tons).
Mangels (10 tests)	Yellow Leviathan (Ferry)	100	24.86
	Sutton's Mammoth Long Red	85	24.78
	Ideal (Ontario Seed Company)	91	24.16
Sugar Mangels (8 tests)	Bruce's Giant White Feeding	100	20.72
	Carter's Improved White Sugar	71	16.80
Swede Turnips (4 tests)	Garton's Model	85	20.09
	Steele Briggs' Good Luck	100	19.89
	American Purple Top	85	19.06
Carrots (4 tests)	Bruce's Mammoth Intermediate Smooth White	100	15.32
	Rennie's Mammoth Short White	100	14.18
Rape, Kale and Cabbage (2 tests)	Sutton's Earliest Drumhead Cabbage	100	11.76
	Thousand Headed Kale	93	8.17
	Dwarf Essex Rape	90	7.11

Varieties of Mangels.—Mangel cultivation in Ontario includes four distinct types of roots, viz., long, intermediate, globe and tankard, but very few of the globe varieties, however, are now used for field work. Varieties of each of the four classes have been tested over a series of years at the Ontario Agricultural College. It has been the general opinion in past years that the long red type of mangel was the most prolific in root production. More recently, however, the majority of experiments at the College and throughout Ontario have shown that the highest yields have been obtained from some of the intermediate and the tankard types.

In 1917, three varieties of mangels were distributed for co-operative experiments throughout the Province. The long red type was represented by Sutton's Mammoth Long Red, the intermediate by the Yellow Leviathan, and the tankard by the Ideal. In the average of the co-operative tests conducted on ten farms, the Yellow Leviathan came at the top of the list both in popularity and in yield per acre. It will be noticed, however, that the average yields of the three varieties were not very different. The least popular of the three varieties of mangels was the Sutton's Mammoth Long Red. These three varieties have been included in the co-operative tests in each of the past eight years. The average results for the eight-year period, in which there were sixty-seven distinct tests, show the following yields in tons per acre per annum: Yellow Leviathan, 27.4; Ideal, 26.8; and Sutton's Mammoth Long Red, 26.7. The seed of the Yellow Leviathan was first obtained by the Ontario Agricultural College from D. M. Ferry and Company, Windsor, Ontario, in the spring of 1893. The name "Yellow Leviathan" was entered in the catalogues of some of our Ontario seedsmen as follows: Steele, Briggs' Seed Company, Toronto, in 1896; Jas. Hewer, Guelph, in 1908; The Wm. Rennie Seed Company, Toronto, J. A. Simmers, Toronto, and Jno. A. Bruce, Hamilton, in 1909; and Geo. Keith, Toronto, in 1910. We have found that the seed under the name of Yellow Leviathan, obtained from different seedsmen in Ontario, has varied considerably in germinating power of the seed and in shape, size and color of the roots in 1917, as well as in other years. We realize, however, that under the abnormal conditions, it is almost impossible for the seedsmen to get a sufficient supply of good seed of true stalks of some of the best varieties of mangels at the present time.

Sugar Mangels.—This class of roots is frequently called sugar beets, but they are usually varieties which are not grown for sugar production but as food for farm stock. They are sometimes called sugar beets for feeding purposes, but a less confusing name is sugar mangels. They occupy an intermediate place between sugar beets and mangels in the percentage of sugar which they contain. As a rule they grow more out of the ground than the sugar beets, and are more easily harvested, but do not yield quite as much as the leading varieties of mangels.

A large number of varieties of sugar mangels have been grown at the Ontario Agricultural College and, from these, two varieties have been selected for co-operative experiments. Previous to 1917, the same two varieties have been grown for nine years, viz.: Bruce's Giant White Feeding and Rennie's Tankard Cream, and the former gave an average annual increase over the latter of four-fifths of a ton per acre. In the spring of 1917, the Bruce's Giant White Feeding was again distributed, and Carter's Improved White Sugar was used instead of the Rennie's Tankard Cream. In the average results of eight experiments, the Bruce's Giant White Feeding gave practically four tons per acre more than the Carter's Improved White Sugar. It will also be seen that the Bruce's Giant White Feeding was much more popular with the experimenters than the Carter's Improved White Sugar variety.

Swede Turnips.—Much interest has been taken in the production of swede turnips during the past couple of years, owing to the fact that swede turnips sold at high prices, frequently bringing fifty cents per bushel, the standard for which is fifty pounds. The swede turnips are still used quite extensively in Ontario for stock feed, and to a limited extent for table use. Although certain sections of Ontario have for years exported to the United States many car loads of turnips, the demand was quite large and high prices paid in 1916. The price dropped somewhat, however, in the past year. In each of the past three years the same three varieties of swede turnips were used for the co-operative experiments. The following gives the yields in tons per acre for 1917, and for the average of the three years: Steele, Briggs' Good Luck, 19.9 and 27.0; American Purple Top, 19.1 and 25.8; and Garton's Model, 20.1 and 25.7. The roots of each of these varieties are of good shape and of good quality.

Fall Turnips.—But little interest has been taken in the cultivation of fall turnips in Ontario. The roots of this class usually yield well, but do not keep late into the winter. The two varieties which have given comparatively good results at Guelph and in the co-operative experiments are the Purple Top Mammoth and the Red Top White Globe. No satisfactory reports were received from the co-operative experimenters with the fall turnips in the past year.

Field Carrots.—Within the past few years the Intermediate White field carrots have been used almost exclusively throughout Ontario. Several of the seedsmen sell seed of this type which produce carrots which are very similar in characteristics. The following gives the yield in tons of roots per acre for 1917 and for the average of the past two years of the varieties used in the co-operative experiments: Bruce's Mammoth Intermediate Smooth White, 15.2 and 15.7; and Rennie's Mammoth Short White, 14.2 and 14.9.

Rape, Kale and Field Cabbage.—Experiments have been conducted at Guelph for a number of years in testing different varieties of rape, kale, field cabbage, etc., for the production of crops which can be used for soiling purposes or for pasture. In the experiments at Guelph, particularly good results have been obtained from some of the varieties of field cabbage when sown the same as rape by using one and one-half pounds of seed per acre and by leaving the crop unthinned. The following gives the yields in tons per acre of green crop of each of the varieties included in this co-operative experiment for 1917, and for the average of five years: Sutton's Earliest Drumhead cabbage, 11.8 and 16.3; Thousand Headed Kale, 8.2 and 12.8; and Dwarf Essex Rape, 7.1 and 11.9. These results are very interesting and show the possibilities in the use of field cabbage as a fall pasture in Ontario.

Millet.—In each of the past four years O.A.C. No. 71, Japanese Panicle and Hungarian varieties of millet have been distributed for co-operative experiments. No satisfactory reports, however, were obtained in 1915 or in 1917. The average yields in tons of green crop of millet per acre of the different varieties for 1914 and 1916 were as follows: Japanese Panicle, 9.8; O.A.C. No. 71, 8.5; and Hungarian Grass, 7.3.

Sorghum.—About thirty varieties of sorghum, including sugar canes, broom corns, kaffir corns, milo maize and Jerusalem corn have been under experiment at the Ontario Agricultural College. Only two of these, viz., the Early Amber Sugar Cane and the Early Minnesota have been included in the co-operative experiments during the past few years. Owing to the abnormal weather conditions of 1917, no satisfactory reports were received. Each of these varieties may be used for fodder purposes, for the production of seed or for the production of sorghum molasses. The Early Amber Sugar Cane is used to a limited extent for pasture purposes, and is included in a mixture which is as follows: Thirty pounds of sugar cane, fifty-one pounds of oats and seven pounds of red clover seed per acre. If this mixture is sown in the first week in May it is usually ready for pasturing about the 20th of June, and forms a natural rotation of pasture throughout the season. Cattle of all kinds do particularly well on this pasture. As a rule there is an excellent catch of clover, and when desired the clover can be left over the winter for cropping in the year following.

Grass Peas and Vetches.—For nineteen years in succession experiments have been conducted throughout Ontario in the testing of grass peas, hairy vetches and common vetches. The hairy vetches in particular have been highly recommended in Ontario, and they are used perhaps rather more extensively as a cover crop in orchards than as a fodder crop on the farms. The grass peas have been grown as a farm crop in some sections of the Province, and the common vetches for mixing with oats as a green fodder. In the average of sixteen years the following yields in tons per acre have been obtained throughout the Province: Hairy vetches, 8.5; grass peas, 6.9; common vetches, 6.3. No complete reports, however, were obtained in 1917.

Hairy Vetches and Winte Rye.—Hairy vetches are sown either in the winter or in the spring. Experiments at the College have shown that the best results are obtained from the autumn sowing. In the co-operative tests over Ontario, in comparing hairy vetches and winter rye, the reports have been very few and the results are not of sufficient value for placing in tabulated form. Both have given fairly good satisfaction for fodder purposes. The hairy vetches were a little higher in yield in 1915 and the winter rye in 1917.

Fodder Corn.—In 1917, fodder or silage corn was grown on 511,329 acres in Ontario. The area devoted to this crop has been increasing quite rapidly in recent years. This increase is likely to continue as the corn furnishes such a large amount of valuable stock food and is pre-eminently the silage crop of Ontario. Corn serves the purpose not only of furnishing a large amount of food, but, with thorough cultivation, cleans the land and fills in an important place in the rotation.

In each of the past two years the seven varieties of corn specially recommended by the Ontario Corn Growers' Association were used in the co-operative experiments for fodder production. There were five full reports received in 1916 and fifteen in 1917. The average results for the two years, in tons of fodder and also in freshly husked ears, are as follows:

Variety.	Tons Freshly Husked Ears per Acre.	Tons Whole Crop per Acre.
Wisconsin No. 7	3.4	13.0
Compton's Early	3.4	12.5
Golden Glow	3.3	12.2
Longfellow	3.2	11.8
White Cap Yellow Dent	3.1	11.7
Bailey	2.8	11.1
Salzer's North Dakota	3.2	10.7

It must be remembered that the last two years have been very abnormal, also that these results are from different soils and from various parts of the province; as for instance, in 1917 the experiment was conducted in fourteen separate counties. This test will likely be repeated for several years when more detailed information will be secured regarding the value of the different corns for the separate localities.

Grasses, Clovers and Alfalfa.—It is difficult to obtain full and accurate information of the experiments with different varieties of grasses and of clovers, as the different varieties produce a varying number of crops which are ready for cutting at different dates. Although no tabulated results are available, some most interesting and valuable co-operative experimental work is being carried on throughout the Province, especially with alfalfa. This relates to the testing of the hardiness of different varieties, the suitability of the row method for seed production, the value of the application of lime, the influence of innoculation, the different amounts of seed, the best method of handling the crop for seed production, etc. It might be mentioned that it has been found to be an excellent practice, in a number of instances, to sow a very hardy variety of alfalfa, such as the Grimm or the Ontario Variegated, in rows thirty inches apart, by using only three pounds of seed per acre. The crop can be cultivated occasionally, and so far this method of sowing has usually withstood the winter well, and has furnished a very good supply of seed in normal years. An acre of alfalfa, sown in this way, makes an excellent source of home-grown seed of a hardy strain, which can be kept comparatively free of weeds and of weed seeds.

VARIETIES OF SWEET CORN FOR TABLE USE.

Sweet corn is grown in Ontario for table use at home, for supplying the canning factories, and for use as a green or dry fodder for farm stock. It is scarcely ever used for making silage. For home use it is important to secure those varieties which are ready for use at different dates and which produce corn of the highest quality. Some people prefer using one variety of sweet corn and planting at different dates, so as to prolong the season in which the corn is in the best condition for domestic purposes. As a fodder crop, it is important to grow varieties which produce a large amount of stalks and of ears which are most suitable for feeding in the autumn to farm stock.

The main object in the co-operative experiments with sweet corn has been to secure the variety for table use at home that will furnish the green ears which are sweet, juicy and tender, which are comparatively small, and have but few rows, eight being the most desirable number.

No less than fifty varieties of sweet corn have been under test at the Ontario Agricultural College. These different varieties have all been studied in the field, and many of them have been tested for table use. In the co-operative experiments, the varieties which have been used most extensively have been the Golden Bantam, the Mammoth White Cory and the Malakhoff. Of these varieties, the Golden Bantam has proven the best, the Mammoth White Cory the second best, and the Malakhoff came lowest in the list. In each of the past five years only two varieties were selected for distribution, one being the kind which has proven most desirable and the other being a standard late variety. The two kinds used were the Golden Bantam of the early, and the Stowell's Evergreen of the late varieties. The following table gives the average results of twenty successfully conducted tests of these two varieties, under similar conditions, in the past year:

Experiment.	Varieties.	Comparative Value.	Number of Ears.	Number of days until ready for table use.	Table quality.	
					Flavor.	Juiciness.
Sweet Corn (20 tests.)	Golden Bantam....	100	123	94	100	100
	Stowell's Evergreen......	67	103	104	74	88

In each of the past five years the Golden Bantam was the most popular with the experimenters, the comparative value being represented by one hundred (100), while that of the Stowell's Evergreen was represented by seventy-three (73) in 1913, eighty-three (83) in 1914, seventy-seven (77) in 1915, sixty-nine (69) in 1916, and sixty-seven (67) in 1917. In comparative number of ears, the Golden Bantam was the highest throughout, and was ready for table use about two weeks earlier than the Stowell's Evergreen. In both flavor and juiciness, the Golden Bantam surpassed the Evergreen in each year of the comparative tests. It is evident that there is no sweet corn throughout Ontario which is as popular for table use as the Golden Bantam variety, which is increasing very rapidly in the farm homes throughout the Province.

VARIETIES OF POTATOES.

Within the past twenty-five years a large amount of experimental work with the potato crop has been conducted at the Ontario Agricultural College. The results of these experiments were embodied in Bulletin No. 239, under the title of "Potatoes," and copies can be secured by writing to the Department of Agriculture, Parliament Buildings, Toronto. The bulletin comprises eighty-five pages and gives the results of upwards of fifty definite experiments, practically all of which were conducted in each of five years or more.

The average annual yield of potatoes per acre in 1912, 1913 and 1914, was the highest, and in 1915, 1916 and 1917, the lowest, in Ontario, of any period of three consecutive seasons in the last thirty-five years. You are all aware that the past three years have been abnormal seasons. These abnormal conditions have placed the seed potato problem in a perplexing position in Ontario. Much work has been done during the past year in investigating potato problems, with the idea of formulating definite plans for potato improvement in this Province.

Most of the soils of Ontario are very well adapted to potato production, providing they are properly underdrained, either naturally or artificially. Some sections of the Province are particularly well suited to potato growing on a large commercial basis. Experimental evidence, however, goes to show that particularly high yields are likely to result from the use, in southern Ontario, of seed potatoes obtained from the northern sections of the Province. In each of five years an experiment has been conducted at the College in testing, under uniform conditions, potatoes obtained from different sources, including New Brunswick, Northern Ontario, and Southern Ontario. Without an exception, the highest returns were secured from the seed obtained in a northerly part of this Province, about 150 miles north of Toronto, in the Muskoka district. In the past year seed was obtained from Thunder Bay district, near Fort William, and the returns were very satisfactory.

As the result of experimental work conducted at Guelph over a series of years, immature seed potatoes gave higher returns than those which were allowed to mature before they were dug. The fact that the northern grown seed potatoes have been produced in a comparatively cool climate, and without a severe drought, and that the vines have been immature at the time of digging, seems to give an explanation of the value of northern grown seed.

In 1917, an enquiry was made from hundreds of experimenters with potatoes regarding the most extensively grown varieties in the separate counties of Ontario. In all sixty varieties were mentioned, one or more times, as being the most extensively grown. As the result of a similar enquiry, fifty-seven varieties were mentioned in 1916, thirty-nine in 1915, fifty-one in 1914, fifty-seven in 1913, and fifty-eight in 1912. The following gives the names and the order of the varieties which were mentioned the greatest number of times in 1917: Irish Cobbler, 114; Delaware, 47; Green Mountain, 42; Carman, 40; Rural New Yorker No. 2, 28; Extra Early Eureka, 23; Empire State, 19; Beauty of Hebron, 15; Dooley, 14; Carman No. 1 and Early Ohio, each 13; Early Rose and American Wonder, each 12; Davies' Warrior, 8; White Elephant and Gold Coin, each 7; Sir Walter Raleigh, 5; and Carman No. 3, 3. Each of twelve other varieties were mentioned twice, and the remaining thirty kinds only once. In the last five years the varieties mentioned the greatest number of times as being the most extensively grown in the different counties of Ontario, are as follows:

Varieties.	Average Five Years, 1913—1917.	Varieties.	Average Five Years, 1913—1917.
Irish Cobbler	48	Early Rose	12
Delaware	31	Carman No. 1	9
Rural New Yorker No. 2	27	American Wonder	8
Carman	25	Dooley	8
Green Mountain	21	Beauty of Hebron	8
Empire State	14	Early Ohio	7
Extra Early Eureka	12	White Elephant	7

As some reports mention Carman, others Carman No. 1, and still others Carman No. 3, they have been classified exactly as reported. As the Delaware and the Green Mountain are frequently sold as one of the same variety, it will be seen that these two taken together would, along with the Irish Cobbler, form the two varieties mentioned the greatest number of times.

In the co-operative experiments conducted previous to 1913, it was found that the Davies' Warrior had made the highest record of the late potatoes, and the Extra Early Eureka of the early varieties. It might be mentioned that the Extra Early Eureka and the Irish Cobbler are both early potatoes which resemble each other closely, but in the experiments, extending over a series of years at the College, the Extra Early Eureka has somewhat surpassed the Irish Cobbler in both yield and quality. It was decided, in the spring of 1913, to use only the Davies' Warrior and the Extra Early Eureka for the co-operative tests. The same two varieties have now been used in each of the past five years, and in 1917 the Irish Cobbler was also included. The following table gives the average results of the co-operative experiments with two varieties of potatoes, successfully tested on 263 farms in 1917:

Experiment.	Varieties.	Comparative Value.	Per Cent, of Small Tubers.	Mealiness When Cooked.	Bushels of Whole Crop per Acre.
Potatoes	Extra Early Eureka....	100	11	100	167.8
(263 tests)	Davies' Warrior.........	91	9	98	147.8

In addition to the varieties here reported, there were ninety-three carefully conducted tests in which the Irish Cobbler was used. The seed potatoes of the Irish Cobbler variety came from New Brunswick, and were secured through two different sources. The average yield in bushels per acre of the three varieties, when brought to the same basis, would be as follows: Extra Early Eureka, 165.1; Irish Cobbler, 158.5; and Davies' Warrior, 145.5. The percentage of small potatoes was exactly 11 in both the Extra Early Eureka and the Irish Cobbler varieties.

A conference was called by the Commissioner of Agriculture, and held in the Parliament Buildings at Toronto on the 30th and 31st of October last, to discuss the best methods for improving the potato industry of the Province. A committee, of which the speaker was chairman, was appointed to make recommendations regarding the varieties of potatoes most suitable for growing for commercial purposes throughout Ontario. The Association finally adopted the following recommendation:

"That the Irish Cobbler be recommended as a standard early variety for commercial purposes, and the Early Ohio as an extra-early variety for market gardeners to meet the requirements of special markets. The Green Mountain was recommended as a standard late variety, with certain other late varieties as Carman No. 1, Dooley, Rural New Yorker No. 2, etc., recognized as standard varieties, and be recommended for those districts where conditions are peculiarly favorable to their growth. Where a variety was found especially suited to the conditions, farmers were advised to confine their attention to such variety."

The Extra Early Eureka is very similar to the Irish Cobbler, and if these two varieties were shipped in the same car for commercial purposes no serious results would follow. The same could be said in regard to the Davies' Warrior and the Green Mountain varieties. It will be seen from the earlier part of this report that both the Irish Cobbler and the Green Mountain varieties are well established in Ontario, and in many localities it is believed that either one or the other of these varieties might be grown to the exclusion of other varieties. By so doing more satisfactory results could be obtained from potato production in Ontario.

FERTILIZERS AND MANURES WITH FARM CROPS.

Interesting and valuable experiments with fertilizers and manures have been conducted throughout Ontario with farm crops during the past twenty-six years. In the beginning of this work the experiments were made as simple as possible in order that the people conducting them could furnish complete reports. As experience has been obtained the work has gradually become more complicated and is improving in value from year to year. The results which have been obtained are of general value. A number of the experimenters in connection with the Experimental

Union have been carrying on tests successfully for a number of years, and are now in a position to conduct fertilizer work with a large amount of satisfaction. We believe that the Experimental Union is carrying on co-operative experiments with fertilizers at the present time which are more comprehensive than those conducted at any other place. Information is being obtained that could not possibly be obtained in any other way. It is true the work is subject to criticism, but such is the case with any experiments with fertilizers which have been conducted at any time and at any place. The results of experiments conducted through the medium of the Experimental Union for a period of twenty-four years may be secured in printed form by writing to the Experimental Union Secretary, Agricultural College, Guelph.

In 1917, co-operative experiments with fertilizers and manures were conducted throughout Ontario with potatoes, mangels, rape and winter wheat. Owing to the abnormal weather conditions, no summary tabulated report has been issued except for the experiment in testing fertilizers with mangels.

Nitrate of Soda and Common Salt with Mangels.

An experiment was conducted throughout Ontario for five years in succession in the testing of different fertilizers with mangels. The results were very interesting and showed that an application of 160 pounds of nitrate of soda per acre, applied to the land when the mangels were about three inches in height, increased the yield of roots per acre by fully six tons, according to the average of forty-one separate tests conducted within the five years.

In the spring of 1911 another experiment was started with fertilizers and mangels. For this experiment nitrate of soda was applied to the mangels at the rate of 100, 160 and 200 pounds per acre at the same time as the seed was sown and also on separate plots when the mangel plants were about three inches in height. In comparison with the six plots with nitrate of soda, common salt was applied at the rate of 200 pounds and 400 pounds per acre at the time of sowing the mangel seed. Two plots were left unfertilized in each experiment. In 1911 and in 1916 no really satisfactory reports were obtained which could be used in a tabulated form. In 1912 four, in 1913 two, in 1914 three, in 1915 two and in 1917 four complete reports were obtained.

Fertilizers.			Yield of Mangels per Acre (tons.)	
When Applied.	Kinds.	Quantity per Acre (lbs.)	*Approximate Cost per Acre.	Average Five Years. (15 tests)
			$ c.	
When Plants were three inches tall.	1. Nothing	....	....	24.08
	2. Nitrate of Soda	100	3.00	27.14
	3. " " "	160	4.80	28.36
	4. " " "	200	6.00	30.29
At the time Seed was sown.	5. Nitrate of Soda	100	3.00	27.19
	6. " " "	160	4.80	28.57
	7. " " "	200	6.00	30.15
	8. Common Salt	200	....	27.39
	9. " "	400	....	27.03

*The prices here given for the nitrate of soda were approximately correct in the earlier years of this experiment and under normal conditions.

In the former experiment, which was conducted throughout Ontario for a period of five years, and of which we obtained forty-one good reports, it will be remembered that the mangel crop was increased six tons per acre by an application of 160 pounds of nitrate of soda. In the results here presented it will be seen that 160 pounds of nitrate of soda, applied when the plants were three inches tall, increased the yield of mangels 4.3 tons per acre, and that the same quantity of nitrate of soda, applied at the time the seed was sown, increased the yield of mangels 4.5 tons per acre. The results presented in tabulated form furnish information regarding the increases from the other applications of nitrate of soda which are worthy of careful study. The yield of mangels per acre has been increased or decreased, according to the amount of nitrate of soda which has been applied. The highest average yield of roots per acre in the past five years was produced from 200 pounds of nitrate of soda per acre, applied when the plants were about three inches in height. This was an increase of 6.2 tons per acre over the unfertilized land.

SOURCES OF FARM SEED SUPPLY FOR THE PROVINCE OF ONTARIO.

Experimental Union—Prof. W. J. Squirrell.

If any justification is required for including the Experimental Union on this programme as a source of good seed, it will be found in its past record in this regard. For thirty-two years this organization has been supplying farmers with good seed of the best varieties, and during this period of time 88,604 farmers, situated in every township and every county of Ontario, have received material.

The seed, distributed through the medium of the Experimental Union, was nearly all grown in the Experimental field at the College. This seed was carefully tested for a period of five years or more and must have shown some special merit to warrant its distribution. Some of these varieties distributed have been the product of importations from foreign countries, others of systematic selection, and still others of artificial cross-fertilization. The Experimental Union has realized, and realizes to-day, that one of the chief weaknesses in crop production in the province is the presence of too many varieties in the different classes of crops. Its aim, therefore, has been and is to send out a comparatively few varieties, and those only of the very best.

This organization has given to the farmers of Ontario such varieties as the Mandscheuri barley and the O.A.C. No. 21 barley, the latter now being practically the only barley grown; the O.A.C. No. 72 oats, one of the most grown oats in Ontario; the O.A.C. No. 3 oats, the Dawson's Golden Chaff and the O.A.C. No. 104 winter wheats, and several other varieties whose records speak for themselves.

It has provided the basis of seed supply for much of the work of the Canadian Seed Growers' Association, the Field Crop Competitions, School Fairs, and other organizations.

A large share of the prizes obtained by exhibitors in the past few years at the Provincial Winter Fair at Guelph, at the Eastern Winter Fair at Ottawa, and at the Canadian National Exhibition at Toronto, have gone to varieties which were first distributed by the Experimental Union.

Some of the largest seed houses in Canada have considered varieties of seed, which had their source in the work of the Experimental Union, of sufficient importance to feature them in their seed catalogues.

It is true that the Experimental Union deals only in small quantities, and it is also true that occasionally we have complaints from farmers because we do not send more seed. These men say, "We can't be bothered with these small quantities, but send us a bushel or two and we shall be glad to grow them." If it were possible for us to send these larger amounts—which it is not—we would be defeating the chief purpose for which the Experimental Union exists, that of enabling the farmer to find out for himself, and under his own conditions, which methods or varieties are best suited to his farm. The average farmer, I think, much overestimates the time it requires for these small quantities to increase to large amounts. It is possible for one seed of oats to increase to one hundred bushels in three years, and we have had experimenters who, from the third year's crop from seed supplied by the Experimental Union, have sold hundreds of dollars' worth of seed.

Sufficient seed is sent to each experimenter to sow 1-80th of an acre, excepting in the case of potatoes, when the amount is only enough to plant 1-160th of an acre. In addition to these amounts, it is possible for paid members of the Union to get one "Member's Special," which consists, generally, of five pounds of seed.

The farmer who obtains Experimental Union seed, though the quantity may not be large, is sure of getting, free of charge, seed of varieties true to name; the best seed of these varieties, as the seed is all handpicked, and material free from any fungus disease, where it is possible to make it so.

The Department of Field Husbandry keeps a list of men who have good seed for sale, and farmers who wish to obtain seed of those varieties which have been distributed for some time by the Experimental Union, in larger quantities than is regularly supplied for experiment, may do so by writing to the Director of Co-operative Experiments in Field Crops.

Perhaps the chief causes of the success, other than the supplying of good seed in the distribution work of the Experimental Union, lies in the fact that it is able to reach every farmer, even those the most remote from the chief seed centres, and that its method of operation is competitive.

The obtaining of the best seed of the best varieties cannot be too strongly emphasized when we consider, if we take the case of alfalfa alone, that it is possible to get seed of this crop which will vary in production from nothing to nearly five tons of hay per acre. No farmer could have better insurance on his crops than is provided by the sowing of the best seed.

Ontario Seed Trade—Walter Steele.

The source of many varieties of seed and seed grain is visible to anyone travelling through Ontario during the summer and early fall, and it is only necessary to mention them briefly:

Practically all seed grain used in this Province is produced locally or secured in the Canadian West. Every indication points to a large demand for good, clean seed oats and Red Fyfe seed wheat, but, unfortunately, supplies of both are short. There is a good stock of Marquis seed wheat available, also a fair supply of barley, buckwheat and Canadian field peas.

The Ontario crop of red clover is short, and it will be necessary to import considerable quantities from the North-western States, which we find gives better results than seed produced farther south or from European countries. A limited quantity will be available from New Ontario.

Alsike is a full average crop, both in quality and quantity, and there will be ample stocks of good quality for home requirements.

The Ontario crop of alfalfa is again very short, and no European seed is available.

Timothy was a good crop in Ontario, and during the past two or three years considerable quantities of choice seed have been produced in Southern Alberta, which have given good results in Ontario and Eastern Canada. Unfortunately, Canada does not yet produce sufficient for requirements of the trade, and large quantities are imported each season from the United States.

We will also have to depend largely the present season on the country to the south for seed corn, as the Ontario yield is very short, though in favorable seasons considerable quantities of Flints and Early Dents are produced in the South-western Counties.

There is a large market each season for choice stocks of seed grain, and a greater number of farmers should specialize in producing pure stocks suitable for seed purposes, which can be disposed of at a premium over ordinary market prices, and would give a much larger financial return for their labor.

I would also like to emphasize the importance of removing weeds from growing crops of clover intended for seed purposes, as many varieties cannot be removed by milling, and it will pay the producer many times over for the labor expended.

The sources of vegetable and field root seeds are not so well known as those previously mentioned. I have frequently been asked if we grow all our seeds on our farm at Oakville.

The chief object in maintaining these grounds is to have a suitable place to test all the stocks we handle. Each season we make a field test of every variety of vegetable and root seed received, growing similar varieties received from various growers side by side, and including tests from new sources of supply offered. An accurate record has been kept in this manner by our company for many years.

For some years past there has been considerable agitation on the part of the Seed Branch at Ottawa to produce seeds in Ontario, or at least in Canada, and I am pleased to state that this is a matter that was looked into very carefully by our company. Many years ago our Mr. Briggs conceived the idea that we could supply more reliable and uniform strains if we selected our own plants and roots and produced our own seed stock, afterward sending it to more favored countries, where a crop would be more certain. Unfortunately, though the experiment was tried with both annuals and biennials, it was found impracticable, and our present method adopted. Each season we make from 900 to 1,200 comparative tests. Careful records are made and every variety is maintained at the highest possible standard of quality. In this manner a constant process of selection is maintained at a minimum expense.

I suppose the majority of those present believe that carefully selected, fully ripened seed, produced in a given locality, will produce a better crop in that locality than imported stocks, but this is far from being a universal rule.

To give a few illustrations: The United States, with possibly the most varied soil and climate in the world, cannot produce swede turnip or mangel seed to compare in results with importations from England and France. The same applies to garden beets and many other vegetables. California can produce a fair strain of certain varieties of celery, but to be dependable the seed stock must be imported from France, as, even with the most careful selection, locally grown seed rapidly deteriorates. Exactly the same conditions apply to the finer varieties of table carrot.

You have been assured that Ontario can successfully grow root crop seed in commercial quantities because conditions were so similar to the growing sections of Germany. Yet, our firm discontinued growing mangel seed in Central Europe some years ago, as we found the quality compared unfavorably with English and French-grown stocks. Germany never was a factor in producing swede turnips.

Danish supplies of mangel were also heralded as being superior for Canadian use, and our firm secured supplies at considerably higher prices than from other sources for some years, until we found that the dangerously low vitality was a usual condition, when several large shipments were returned and importations discontinued.

To sum up the results of our experience, we have found, in common with seed merchants in every other country, that certain portions of the earth are especially adapted for growing certain crops, and that the results obtained from seed produced in these sections will be more uniform and generally satisfactory than from seed produced at home or in any other present known section. Some of these localities are in California, the Central and Eastern States, the British Isles, France, and Holland.

At the present time, when the world is crying for supplies that can be produced in Canada to better advantage than any other country in the world, it does not appear a wise diversion to experiment extensively in seed producing, particularly in Ontario, where the growers of practically the only garden seeds produced in Canada, viz., peas and beans, find it impossible to place contracts, even at prices previously unheard of.

The greatest service the Seed Branch has given to the people of Canada is in their educational work in convincing planters that it pays to sow the best seeds obtainable, and there is still an ample field for their efforts in this direction.

As a result, we presume, of the inducements offered to produce seed locally, we receive letters from time to time advising that a sample of seed is being forwarded; for example, turnip seed, and requesting our highest quotation. Variety names are rarely mentioned, and conditions under which it has been grown and source of seed stock—never.

We have also received lists of Canadian-grown supplies the past few seasons, with the information opposite a number of entries that they are possibly cross-fertilized. Instead of these supplies being offered to the public, they should be destroyed by the inspectors, unless facilities are provided for carrying the stock until a careful field test can be made.

The present season, if expected deliveries are received safely, there should be sufficient supplies for Canadian demands, though prices, in sympathy with all other agricultural products, will be much higher than usual. Any shortages will be due more to the extremely unfavorable season in Europe and the United States, than to conditions caused by the war. The season of 1919 will be more critical, owing to reduced surplus stocks, but every effort is being made to place contracts through the best available sources of supply, and much will depend on the season and export restrictions.

It is commonly believed by many, who have learned the prices paid to growers, that the seed merchant makes an exorbitant profit. Unfortunately, the spread between buying and selling price is largely absorbed by unavoidable expenses.

The first expense is for freight and insurance, both of which items the past three years, particularly, have been a heavy tax. On arrival, each bag is opened and inspected to see if it has arrived in good condition to be placed in storage, and a sample removed, part of which is used for germination test at once, and balance laid aside for a field test during the summer, which entails still further labor in planting, cultivating, and recording. When orders are received, the original shipment is measured or weighed up in smaller lots as required, and packed for transportation. In addition to heavy charges for labor, the season is very short, and it is only possible to turn over your investment in stock once each year, at most, and a permanent lockup of a considerable sum is necessary for buildings and machinery. In addition to general cost of conducting business, an attractive catalogue is necessary, which still further reduces the gross profit.

It is doubtful if any enterprise in Canada during the past generation has demanded such close attention to meet the demands of a critical public, and yielded such small financial returns.

District Representatives—R. S. Duncan.

In view of the conditions that prevailed one year ago and the difficulty some farmers had in obtaining seed, a seed campaign was inaugurated by the Department of Agriculture, and carried out through their District Representatives. This scheme resulted in a great deal of pure seed being distributed to the farmers in the various counties. The campaign was carried on through the newspapers, inviting farmers to send samples of seed, together with the quantity they had for sale and the price, to the district representative, and these samples of seed were displayed in their office in small boxes, or placed in glass jars. Farmers coming into the office would inspect this seed, and in this way the district representative acted as a medium of exchange. The representative would suggest that the farmer write direct to the farmer who had seed for sale and make his own bargain; in other words, the district representative's office was simply used as a clearing house for good seed.

To give some idea of what was accomplished, I will give two concrete examples. In York County, 150 farmers received this information from the district representative's office, and were put in touch with farmers having this good seed, and we know from the records that 150 farmers actually got seed from farmers in the district who had it.

In Glengarry County over 2,000 bushels of good seed were actually distributed through this means to farmers who hadn't good seed from the 1916 crop.

We have been receiving crop reports, during the past year or so, each week from the district representatives, and there is a special paragraph set aside for products required by farmers or products offered for sale. Farmers in certain counties may, perhaps, have beans or good, pure seed potatoes; or alfalfa seed or clover seed; or good barley or oat seed, and the representative would simply list these in the weekly crop report. There is another paragraph devoted to the wants of the farmers in that district. Schedules would be prepared and sent to the district representative, and in turn to the various farmers' clubs. In this way a great deal of seed was exchanged between farmers, and it put the farmers in touch with good seed. That has been carried out through the district representatives during the past few years, in connection with their farmers' clubs and other agricultural organizations in their counties.

It would be possible for the district representatives to display samples of seed from the winning fields in the Field Crop Competitions, in their offices, and in this way a number of farmers can be put in touch with a source of good seed. This might also be true with the seed which won prizes at Guelph Winter Fair, and which will win prizes at the Kemptville Seed Fair, which will be held this month.

The district representatives in their travels during the season have been urged to keep their eyes open and look out for good fields of seed. In this way, they will be able to put farmers in touch with the actual conditions as they existed during the growing season, and, understanding these conditions, would be able to impart that information to the farmers. Of course, the district representative would co-operate with all other organizations, Experimental Union, seed houses, etc., in getting an equitable distribution of pure seed.

The corn situation this year is a very acute one, and as a consequence I doubt very much whether the district representatives will be able to assist in the distribution of this seed, any more than perhaps to put farmers in touch with sources of good seed.

During the past few years, the district representatives have been conducting a variety test in corn, with certain standard varieties. The object of these variety tests is simply to find out what variety of corn will do best in a certain district, and, after they find out this information, they will advise the corn growers in the south-western peninsula to grow these special varieties for the farmers.

During last year there was an acute shortage in potato seed; forty cars of potatoes from New Brunswick and the Western Province were distributed through the medium of the district representatives; farmers' clubs would handle them, or some local merchants in the town. In some instances, the municipal council would handle the carload of potatoes. Very satisfactory results have been achieved in connection with the distribution of these carloads of potatoes, and particularly is this true with the potatoes from New Brunswick. Fairly satisfactory reports have been received of the potatoes which were planted and obtained from the Western Provinces.

In connection with the Field Crop Competitions, which have been conducted over the Province during the past few years, every contestant has secured good seed, and we are making an endeavor to get that seed as pure as we possibly can. This holds true in the case of potatoes, oats and barley, and in some cases, of wheat. The representatives are in touch with all these men, whose fields have been inspected in their counties. This forms a source of good seed, for which arrangements have been made for distribution.

Then, in a number of seed centres, there are organizations operating under the rules of the Canadian Seed Growers' Association, in various counties—in oats, wheat, barley, and potatoes. These organizations in the seed centres have been practically all organized through the district representatives. And, while some are producing registered seed, others again have only improved the seed, and that is a source of good seed. In two counties in Eastern Ontario, i.e., Carleton and Russell, we have boys' and girls' potato-growing contests. I have just forgotten the number of boys who have competed in these contests, but each boy has to put in one-tenth of an acre, and he naturally secures the best seed in his district. Certain varieties are grown in certain districts. The Green Mountain variety has been grown most extensively. The yield has varied from 200 to 400 and 450 bushels per acre—on the 1-10th acre basis. In many cases farmers are going to the young boys for their seed for the coming year.

In connection with the Rural School Fair, methods have been organized for the last seven or eight years. In 1917, 3,072 individual plots of barley were grown in the Province of Ontario; 4,392 individual plots of oats; 1,380 individual plots of wheat, and 14,532 individual plots of potatoes. Barley, oats and wheat were given out in one-pound lots, and the potatoes in five-pound lots. Altogether, these totalled 23,676 individual plots of oats, barley, wheat, and potatoes.

Practically all this seed was of the following varieties: Barley, O.A.C. No. 21; oats, O.A.C. No. 72, and, in some cases, Banner; wheat, Marquis; and potatoes, I am sorry to say, there may have been 10 or 15 different varieties distributed last year. Last year the potato situation was unfavorable, but this year, I may say, that all the potatoes for distribution in connection with the School Fair methods have been purchased from Northern Ontario, and the varieties that will be grown are Green Mountain and Irish Cobbler.

What effect will the distribution of these seeds have in connection with the source of supply of good seed? I can give instance after instance of where the farmer is growing a variety that was originally distributed to the pupils some few years ago, and he has nothing but that one variety on his farm to-day. That holds true in oats and barley. I know one district where the boys' potato contest was conducted, where 90 per cent. of the boys received Green Mountain potatoes. There are very few other varieties grown there but that one.

District representatives are at the command of the farmers, and they will only be too glad to co-operate with organized bodies and assist in the distribution of the seed supply we have for the Province of Ontario for 1918.

Field Crop Competitions—J. Lockie Wilson.

I am very glad to have the opportunity of going over very briefly some things that have happened in the last ten years with regard to the Standing Field Crop Competitions. The competitions have been a success, and it is due very largely to the foundation laid by you gentlemen who are here to-day. The Experimental Union in the past thirty years has done a splendid work in improving the field crops of this country. In addition to this, I may say that the successful prosecution of the work of the field crop competitions is very largely due to the splendid assistance given us by the officials of the Guelph Agricultural College and the Ottawa Experimental Farm. The farm journals have also assisted splendidly in advertising the work over all the Province.

In 1907, we got the first grant of $1,000 from the Hon. Nelson Monteith, to start the work. Beginning with ten societies and 325 farmers in 1907, we had this past year 185 societies, 7,000 entries, and 7,000 fields were judged. The grant given by the Government then was $1,000, while the grant to-day is $25,500, including the spring Seed Fairs. Twenty thousand dollars was utilized for the work of the Standing Field Crop Competitions in 1917. From this you can form some idea of the opinion the Ontario Government has of the work in hand, and also the opinion of the farmers of this country in respect to the Standing Field Crop Competitions.

I don't believe there ever was a grant paid out by the Federal or the Provincial Governments that has proved of more value to the agriculturists of Ontario than has this amount of money paid out for Standing Field Crop Competitions. The first difficulty even the ten societies had, was to get competent field crop judges. The Federal Government kindly loaned men, and, with the help of some expert grain growers, the work was accomplished the first year. It developed fast. To have uniformity in judging, we established short courses for Department Field Crop Judges, and this has been of vital importance to all men who attended these classes. There has never been a farmer who has attended the short courses to fit himself as a judge of grain, but said he was well repaid for his time, in so far as he was personally concerned, and so far as the work was concerned on his own farm. We had 150 judges employed last year on the Standing Field Crop Competitions.

I hope suggestions will come from this Convention regarding important rules and regulations. You are after all bound to be, in the coming years as in the past, the real book-keepers along this line. I believe it is for you to assist in every possible way, by making suggestions for the future, towards this splendid agricultural and educational work.

Score cards were prepared, short courses for judges were held, and the judges were sent out and the work has been well done. Last year over one hundred societies took up two crops, and eighty-five, one crop. Every agricultural society can conduct either one or two field crop competitions. Agricultural men must be members of an agricultural society to compete. We have had as many as forty and fifty men in these competitions in one society. So the work is progressing.

We have found that many good farmers wanted to know where to find good seed. How were they going to get it? We added an appendix to the report of the Agricultural Societies, and in that appendix the names and addresses of every farmer that entered the competition, the name of the variety of crop, the exact score taken in the field crop competition, the names of the members winning, and the names of the different men who did the judging, were entered. Thousands of copies of this appendix are issued every year, and the one for 1918 is now in the hands of the printer, and the farmers will have an opportunity of finding out the men who have been most successful in the Standing Field Crop Competitions. They will also know by this report which weeds, if any, have been in every field in the 70,000 acres judged this year, so I say, so far as the appendix is concerned, it will be of value to the farmers when it is issued, and it has been of value in the past.

The farmers are not the only ones who profit by the Standing Field Crop Competitions. The Ontario Vegetable Growers' Association has taken it up. For the past few years they have been offering prizes for the best kept market gardens or vegetable gardens entered by members of the Ontario Vegetable Growers' Association. Their crop competitions are on the same lines as the Standing Field Crop Competitions. So much has the country profited that the larger exhibitions are writing and asking that they have an opportunity of offering larger prizes. The Canadian National Exhibition, shortly after we started, realized that there was a forward movement in it, and offered $100 in prizes for the members winning in the Standing Field Crop Competitions. Only prize-winners are allowed to compete at the large exhibitions. At the Provincial Winter Fair, Guelph; the Eastern Ontario Winter Fair, Ottawa; and the Canadian National Exhibition, Toronto, prizes are given to further the educational work that is being carried on.

Canadian Seed Growers' Association—L. H. Newman.

The Canadian Seed Growers' Association has, scattered throughout Canada, over 1,500 farmers doing more or less work in producing seed of various kinds. Five hundred and eighty-three of this number are located in Ontario, and of these only a comparatively small percentage have any considerable quantity for sale. Up to the present date we have listed 45,040 bushels of oats, 2,220 bushels barley, 2,744 bushels potatoes, 30,420 bushels wheat, and 170 bushels of corn. In Ontario alone we have listed 1,450 bushels of wheat, 6,345 bushels oats, 1,390 bushels barley, 170 bushels corn, and 400 bushels potatoes. Many growers have not listed their offerings in view of the fact that these have found ready sale locally. A good deal of the seed that is being offered is quite suitable for foundation stock, and has been picked up readily at good prices. In fact, all seed which is suitable for registration is finding a ready market. The North Gower Banner Oat Centre, for instance, has an offer for its entire supply of Registered Banner oats at $1.25 per bushel.

In years like this the value of Seed Centres, as a source of supply of good seed, is particularly apparent, and it is earnestly hoped that a greater number of these will be organized and put on a good basis as soon as possible. In average years seed oats, particularly, have been brought into Ontario in considerable quantities from other provinces. This year, however, other provinces, notably Quebec, and to some extent the Maritime Provinces, are looking to Ontario for their supply.

The value of good seed is gradually impressing itself upon the minds of the farmers throughout the Province, as a result of which an increasing number are taking up systematic work under the direction of the Association on their own farms, while the demands for good seed on the part of others is likewise increasing. Unfortunately the present labor conditions mitigate against any *rapid* increase in membership, and therefore in the production of the class of seed that is wanted. What is clearly needed in the Province at the present time is a systematic effort to encourage a greater number of farmers to sow only pure seed and to operate so that when they harvest a crop of grain good enough for seed, they may offer this to the trade as such. In order to assist farmers in carrying this into effect, the C.S.G.A. was organized, and all who contemplate doing something along this line should at once apply for membership.

The Western Ontario Seed Growers' Association—A. McKenney.

An Association incorporated under the Agricultural Association's Act, and known as the Western Ontario Seed Growers' Association, was formed in December, 1914.

The object of the Association is to encourage a general and constant improvement in the production and dissemination of all high-class field, root and vegetable seeds, including cereals, clovers, grasses, roots and vegetables.

1. By co-operating with the Department of Agriculture.
2. By holding meetings to discuss matters of importance to the seed-growing industry in the Province.
3. By co-operating with Exhibition and Seed Associations and Societies, firms or individuals, to advance the interests of the seed-growing industry generally.
4. By holding, and assisting to hold, competitive exhibitions and educational meetings.

All bona-fide seed growers and persons professionally interested in seed growing, who are willing to comply with the Constitution and By-laws of this Association, are eligible for membership in this Association upon payment of a membership fee of $1.00.

All seed for sale by members of this Association must be described accurately as to variety, germination and purity and guaranteed as described.

Purity in this case shall mean the number and kind of all weed and other seed content.

Purchasers of seed must notify the Association of all complaints within ten days after receipt of seed. The Association may at any time in its discretion take action against any member should complaint arise.

It is the aim of this Association to encourage its members to greater production by means of—

(*a*) More thorough and efficient methods of cultivation.
(*b*) By careful application of suitable fertilizers,
(*c*) By proper rotation of crops,
(*d*) Using the best seed obtainable.

The members are expected, so far as possible, to secure their stock seed from the growers of registered seed and from the Dominion and Provincial Experiment Stations. This method is to be adopted for the purpose of securing not only the highest production, but an available quantity of first-class seed, which may be sold at a reasonable price. This seed would be only a few generations removed from the registered seed produced by the Canadian Seed Growers' Association, or from the seed sent out by the Experiment Stations.

This Association has a representation on the Executive Committee of the Ontario Provincial Winter Fair, and now all exhibitors in the general class of the Seed Exhibition in connection with this fair are members of this Association.

Each director of the Association is expected to keep the secretary advised, during the season, as to the probable production of crops in his locality.

Ontario Corn Growers' Association—P. L. Fancher.

The corn crop for Ontario has been rapidly increasing, both in the number of acres grown in the older corn-growing areas and in the newer areas. This increased acreage has demanded a large seed supply. At no time has Ontario ever met this demand with Ontario-grown seed. In fact, the majority of the seed sown for ensilage purposes has been imported, while that grown for husking has been of Ontario varieties. Ontario has never had such a shortage of her own varieties fit for seed as she has at the present time. This is true for the United States as well, but to a lesser extent. The past season was so cold that corn did not come to maturity early in the fall; and the fall was so wet and cold that what got fairly well matured did not have a chance to get thoroughly dry before frost came. To put it briefly, Ontario has not enough good seed corn of her own varieties to reseed the seed-producing section of Ontario. The ensilage grower will have to be content this year with seed from the United States.

As to the supply of seed in the United States, much may be said, but it is sufficient to *emphasize* here the fact that the United States has met similar results as Ontario in seasonal reverses, and *we must not put too much faith in the United States corn for seed purposes.*

The latest reports show that the average germination test for good United States shell corn this year, and even much ear corn, does not run 70 per cent., much of it around 50 per cent. *Good seed corn is hard to obtain in the United States,* and where it is found in any quantity it is being picked up fast. Nearly all of *this corn is in the south, where frosts did not come before the corn got dried.* So the ensilage growers will have to be satisfied with southern-grown dent corn if they wish good strong germination.

Let me say here that there is some good seed corn *in the ear,* testing 90 per cent. and above. Every effort is being made to get this good corn into Ontario.

I cannot emphasize too much the great importance of farmers demanding germination tests from those selling seed corn.

One thing more, do not take anyone else's test as absolute. Test the seed you buy for yourself. I know that there is much corn that *seems* to be good seed that *is not.*

Test the seed for yourself before planting.

Dominion Seed Branch—W. J. W. Lennox.

The members of the Canadian Seed Growers' Association, whose organization receives a grant from the Federal Department of Agriculture, are in a position to multiply the superior strains of seed bred and selected by Federal and Provincial Department Experiment Stations. From these the members of the Western Ontario Seed Growers' Association and successful competitors in Field Crop Competitions commonly obtain the required amount of seed. The product of these fields should materially help to create a supply of seed in every county. The Seed Branch provides $50,000 a year to support Field Crop Competitions, Seed Fairs and Provincial Seed Exhibitions, more than $14,000 of which come into the Province of Ontario. Considering the prospective shortage of field, root and garden vegetable seeds, as indicated by the unusually high prices, competitions in these crops should now be restricted to seed crops. It seems desirable that the number of varieties for which competitions may be held be reduced to a few approved, as has already been done with potatoes.

Should a further allotment of money by the Federal Department in support of competitions be considered advisable, the Seed Branch contemplates an advanced step in connection with these competitions, and may suggest that prizes be restricted to crops grown from registered seed.

In Ontario at the present time, it is impossible to secure from many districts a sufficient quantity of oats of any given variety to fill one car. It might be correct to suggest that a competition be held for one particular variety. In localities where this is practised, a large supply of uniform product would be available for shipment in car lots. If this latter state of affairs existed in Ontario at the present time, a large quantity could be used to ship east to supply the needs of localities requiring seed oats.

In *The Agricultural Gazette* of Canada for November, 1917, is printed a report of our Seed Purchasing Commission, as follows:

"The rapid increase in areas under cereal crop in the Prairie Provinces has not been followed with an equivalent development of business organizations of capacity sufficient to meet the full requirements of good seed grain in years of partial crop failure covering considerable areas. The Immigration Branch of the Department of Interior has for many years provided seed grain to homesteaders on the basis of deferred payments, and on occasions have extended that distribution to all farmers who have been in need.

"The condition of the wheat crop in southern Manitoba and south-eastern Saskatchewan, which had been severely attacked by rust during the summer of 1916, made it clear as early as the first of September that large quantities of seed wheat would have to be shipped into that area from the Province of Alberta, and a month later the Seed Purchasing Commission of the Seed Branch was established and at work in each of the three Prairie Provinces. The new plan for handling this difficult seed situation was authorized by the Honourable Arthur Meighen, then acting Minister of Agriculture, based on the recommendations of the Seed Commissioner. This arrangement provided that all farmers who were in need of financial support to procure their supplies of seed grain, should establish their claim to such support before the local governing body in the municipality where they lived, which governing body would be expected to assume the responsibility of financing their purchases, either directly or with the co-operation of their provincial governments. The Seed Purchasing Commission, with headquarters at Regina, Sask., proceeded in early October with the purchase of seed wheat, for which they were authorized to pay a premium over current market prices amounting to not more than five cents per bushel. All of the seed purchased by the Commission was subject to inspection on delivery at the Canadian Government interior terminal elevators at Saskatoon, Moose Jaw, or Calgary, in which all of the seed purchased was stored and cleaned for shipment. Standards of quality for seed wheat, seed oats and seed barley were fixed by Order in Council and administered by the Seed Inspection Division of the Seed Branch staff, which had two experienced inspectors at each elevator. All of the seed grain purchased was bought subject to being graded seed by these men over whom the Seed Purchasing Commission had no direct control. In addition to inspecting the seed grain purchased by the Seed Purchasing Commission, these seed inspectors issued certificates and caused to be separately binned all grain admitted to these elevators that was sufficiently clean and good to pass the seed grades. The Seed Purchasing Commission did not have a monopoly of the purchase and sale of grain for which seed certificates were issued at these interior terminal elevators. The Commission did, however, handle a sufficient quantity of seed grain to ensure an abundant supply at fair prices.

"The Commission purchased six hundred and twenty-nine thousand bushels of seed wheat, four hundred and eight thousand bushels of seed oats, and a small quantity of seed barley. This seed, which was selected because of being clean and free from wild oats and other noxious impurities, was carefully recleaned and sold at a price sufficient to cover the net cost of the recleaned seed. Special freight rates and arrangements for handling were provided by the railway companies. The Provincial Departments of Agriculture for Manitoba and Sasketchewan extended their hearty co-operation by providing the municipal governing bodies with financial assistance to enable them to purchase seed for needy farmers. Seed grain in any quantity was shipped either in sacks or in bulk to fill orders received from individual farmers, farmers' organizations, municipal governing bodies or seed merchants, in any part of Canada. One hundred and fifty-four thousand bushels of seed oats and a small quantity of seed wheat were shipped on orders from points in Ontario, Quebec and New Brunswick.

"All orders were filled subject to cash payment by bank draft and the moneys as collected were deposited to the credit of the Receiver-General. A total of one million four hundred thousand dollars was placed to the joint credit of the Chief Commissioner and the Accountant in Regina in installments of one hundred thousand dollars as required. The total amount returned to the Receiver-General up to the 30th of September, 1917, was one million four hundred and twenty-two thousand dollars, in addition to which there is in the Canadian Government elevator at Moose Jaw about twenty-four thousand bushels of seed oats, which were held in reserve and will be needed in Saskatchewan for next spring's seeding.

"The volume of the work entailed in handling seed grain of this amount, which has to be procured by picking out special cars of superior quality can be fully appreciated only by men who have had wide experience in this kind of business. All of this work, however, was managed throughout by the members of the Seed Branch staff who served on the Commission and who had had several years' experience in the work of seed inspection. That the seed sold and distributed was generally satisfactory would seem evident from the fact that no serious complaints and many letters of commendation have been received. The Commission is now purchasing seed oats in quantity for next year's supplies to meet the needs of northern areas in Saskatchewan, Manitoba, Ontario, Quebec and New Brunswick. In addition they will procure sufficient supplies of high quality Marquis seed wheat, grown from registered seed, to meet the needs of those farmers who may desire to procure a supply of fresh seed of superior quality. All orders for seed grain desired from this Commission should be addressed to Seed Purchasing Commission, Post Office Building, Regina, Sask."

The Seed Purchasing Commission has continued its operations again this year and is in a position to supply seed wheat, oats or barley from Government terminal elevators at Calgary, Moose Jaw, Saskatoon and the Harbour Elevator at Quebec. The Seed Purchasing Commission is not pushing the seed grain business, but has been pressed into taking care of a seed situation that resulted from extraordinary prices and a highly speculative condition of seed business that rendered it exceedingly risky for seed grain merchants to perform their normal functions. In consequence, the purpose of the Seed Purchasing Commission has been simply to provide large reserve supplies of good, sound grain that may safely be used for seeding, and to have this seed grain in storage in Canadian Government elevators at points convenient for distribution to meet any emergency that might arise. The business of the seed merchant or seed grower in the matter of production and distribution of named varieties of superior quality of seed grain does not form a part of the work of the Seed Purchasing Commission.

For information as to prices, applicants should communicate directly with the Seed Purchasing Commission, Post Office Building, Regina, Saskatchewan, or Quebec City. Supplies of seed oats are now being purchased in the Province of Ontario. It may here be announced that special arrangements have been made with private companies to guard against probable shortage of seed peas and seed beans.

ROOT SEED GROWING IN CANADA.

Dr. M. O. Malte.

As you are aware, there was very little root seed grown in Canada before the war. Some swede turnip seed was grown in the Maritime Provinces, especially in Nova Scotia, and some mangel and beet seed was raised in Ontario, but the total amount produced in the Dominion was altogether too small to cut any figure in the supply required by the country as a whole. As a result, the bulk of the field root seed required yearly by Canadian farmers had to be imported.

Small quantities were imported to Canada from the United States, but the vast bulk came from European countries, principally the United Kingdom, France, Holland, Germany and Russia. It would be unnecessary, I think, in this connection, to give any detail figures on the imports for the years before the war, but, just to give some idea of the quantities of root seed that came to Canada from some of the European countries now at war. I may say that in the year 1913-14, Canada imported 350,000 pounds of turnip seed from Holland and France only, about 900,000 pounds of mangel and beet seed, principally from France and Germany, and about 33,000 pounds of carrot seed from France.

There are several reasons why Canadian farmers were content to use imported European seed in preference to Canadian-grown before the war. In the first place, labor was cheaper and more plentiful in Europe than on this side of the Atlantic. As a consequence, the European grower could bring on the market seed crops at a much lower price than could the Canadian or American farmer. The fact that the rural districts of most European countries are comparatively thickly populated, has long ago brought home to the farmers of Europe the necessity of farming on an intensive scale that is unknown to this country. The necessity of utilizing every foot of tillable ground to the greatest possible advantage and with the smallest possible outlay of money, has resulted in more general employment in farm work of all the members of the family able to work, and as a result the cost of production of any kind of farm products was being kept as low as possible. Furthermore, as the cost of living was much lower than on this continent, the European farmer could afford to be satisfied with much smaller profits than the farmer in this country. As a result of such conditions, the European farmer could, before the war, supply Canada with root seed at very low prices.

Another reason why Canada, before the war, imported her supply of root seed, was due to a rather wide-spread, but surely false conception of the value, from a crop-producing standpoint, of European-grown seed in comparison with seed grown in Canada. It is quite generally supposed, both in Canada and in the United States, that European-grown seed of field roots, especially sugar beets, is of much greater value than any root seed grown in America, because it is thought capable of producing larger crops of better quality. The reason for such a supposition which, as I will show presently, is entirely without foundation, is vaguely attributed to certain climatic and soil conditions in the seed-producing countries of Europe, by which the quality of the root seed is supposed to be influenced. Under the circumstances, it is no wonder that the Canadian farmer has, so to speak, been brought up on the idea that it was good business to secure whatever seed he needed from Europe.

Root Seed Supply and the War.—As long as conditions in Europe remained normal, there was no danger of Canadian farmers not being abundantly supplied with seed of at least average quality, but with the outbreak of war conditions became different.

During the first year of the war there was really no actual danger of Canada suffering from seed shortage in the immediate future, because the Canadian seed houses were well stocked with all principal varieties; they also had contracts for the delivery of varieties actually available in allied European countries. But as time went by, with no signs pointing to an early peace, the danger of a seed shortage in Canada gradually increased. The danger began to be pronounced when it became known that the European seed-exporting countries, from which Canada still might hope to secure an adequate supply, *i.e.*, the United Kingdom, France and Holland, had restricted the export of seed for the duration of the war. The danger became intensified when it began to be realized, on this side of the Atlantic, that the warring nations in Europe gradually were being forced to concentrate, if not all, at least most of their activity in agriculture on production of food for the armies. Later still, the danger became extremely grave when, to the difficulty of buying the seed in Europe, was being added the difficulty of securing ocean transportation, and, if such could be secured, to bring the seed in safety across the Atlantic.

To sum up, the war has created a situation with regard to Canada's root seed supply that must be called extremely serious. I am sorry that I have to make such a statement, but there is no use to try to deceive ourselves when we have the actual facts staring us in the face.

As it is, something must be done to bring relief, and to bring it as quickly as possible. I shall briefly sketch what has been done by the Dominion Experimental Farms to relieve the root seed situation.

Dominion Experimental Farms Take Action.—Before I tell you what the Experimental Farms are doing now, I beg to call your attention to the fact that, from the very beginning of the war, the Experimental Farms have been warning the farmers of Canada repeatedly against the possibilities of a serious curtailment in the root seed supply, and have tried, I think, their best to prevent the creation of a situation such as exists at present.

The Central Experimental Farm, in Ottawa, realized, right from the beginning of the war that, on account of a very probable disorganization in the seed-exporting business of Europe, there was a certain danger of Canada's supply of seed being partially, or even wholly, cut off, should the war last any length of time. For this reason a bulletin was issued early in the spring of 1915, *i.e.* approximately half a year after the outbreak of the war. This bulletin, which is entitled "Growing Field Root, Vegetable and Flower Seeds in Canada," strongly urges the Canadian farmer to take up field root seed growing for the purpose of meeting a threatening shortage in the supply.

A year later, *i.e.* in March, 1916, the "Seasonable Hints," a publication issued by the Central Experimental Farm three times a year, and distributed to nearly 400,000 farmers, had an article on the root seed situation, saying in part:

"Reports from Europe indicate that *the growing of field-root seed in the countries at war has been neglected during the past season. As a result, the export of all kinds of seed from France and Germany, the chief root-seed producing countries of Europe, has been restricted for the duration of the war.*

"In view of this it is evident that, even should the war be brought to an end in the nearest future, there is still a grave danger of Canada not being able to secure from Europe, for years to come, the quantity of root-seed necessary to fill its needs. You are, therefore, urged seriously to consider the situation and to help to lessen the danger of a possible shortage of a class of seed without which farming would suffer very materially.

"*Grow at least as much seed as you require for your own needs.*"

And in July the same year, 1916, the "Seasonable Hints" again dealt with the subject and said:

"At the present moment the outlook is far from bright with regard to the importation from Europe of root-seed sufficient for the needs of the Dominion. As a matter of fact, *there are several varieties which even now cannot be obtained at all, and others that are available only in small quantities.* As a result, it is very likely, not only that prices for root-seed will be comparatively high the next few years, but also that much of the seed finding its way to Canada will be of inferior quality. You are, therefore, sincerely advised to make arrangements to raise your own seed next year."

I could quote much more along the same line from other issues of the "Seasonable Hints" and from press articles, but what I have quoted will, I hope, be sufficient to convince you that the Experimental Farms, through the Division of Forage Plants, have made a determined effort to make the farmers of Canada realize that there existed, right from the beginning of the war, a grave danger of the root seed supply becoming seriously affected, and that the Experimental Farms have not failed to impress upon the individual farmer the necessity of producing on the farm what quantities of seed may be needed for home use.

Just the same, when the seed situation was being more closely looked into in the early summer of last year, it was found that quick action of quite a drastic nature had to be taken by the Government in order to provide for an adequate seed supply for the next few years. The Dominion Experimental Farms were called upon to try to meet the emergency and act accordingly.

Quite a large acreage was secured last July and seeded to turnips, mangels, carrots and rape, with a view of producing stecklinge to be used for seed production in 1918. How many acres will be employed in seed growing in 1918 is almost impossible to tell at present. The last season was a very unfavorable one, the harvesting conditions, in Eastern Canada at least, were about as unfavorable as could be imagined, and the winter has so far not proven very suitable for storing of roots, the more, as practically all of the seed roots harvested had to be pitted outside. However, if conditions during the rest of the winter and the early spring prove to be reasonably normal, the Experimental Farms expect to have a total of about 350 acres of roots for seed planted by next spring. Granting this, and assuming that a fair crop is realized, the Farms expect to be able to bring on the market a considerable quantity of seed next fall, and hope thus to be able to bring relief to a situation that, without prompt assistance, threatens to be anything short of disastrous.

You will understand that the seed-growing undertaken by the Dominion Experimental Farms is purely an emergency measure made necessary by the war. It is a Government intervention for the purpose of securing a supply of a class of seed that, without such intervention, would be available, it is feared, in altogether too small quantities to meet even the most moderate demand from the farmers.

Comparative Value of Canadian-grown and Imported Seed.—I said, a few minutes ago, that it is a wide-spread idea, in Canada as well as in the United States, that European countries are better suited, on account of soil and climatic conditions, to produce high-classed seeds, and that such a conception has been one of the obstacles preventing this continent from developing a root seed-growing industry of any importance to speak of. When I say that European countries have been considered able to produce more high-classed seed than Canada, I mean, that the prevalent idea has been that seed produced in Canada could not compete with European-grown seed because it would not be capable of producing root crops of such a good quality as the European-grown seed was supposed to produce.

I may say, as I have said before, that there is no foundation whatsoever for such a supposition. Canada can grow root seed of just as good quality, if not better, than Europe, and, if the quality of the seed is being judged from the quality and quantity of the root crops that it produces, I may say that there is no reason whatever why this country should rely on Europe for its seed supply, at least for the duration of the war and years thereafter.

I beg to lay before you some facts, results of experiments, in support of this statement.

As far back as 1891, the Bureau of Chemistry of the United States Department of Agriculture started some systematically planned experiments in Sugar Beet seed raising in Nebraska. The experiments were carried on for a few years, and the results were that when Nebraska seed was grown in comparison with imported seed, it was found to possess a higher vitality, and, what is of more importance, it was found that the sugar beets produced from the Nebraska-grown seed possessed a higher sugar content and gave a heavier yield than any of the imported varieties tested.

For a number of years, the United States Department of Agriculture also conducted experiments in sugar-beet seed growing in the State of Washington, the results obtained showing that the American-grown seed in all respects could compete successfully with imported seed.

As far as Canada is concerned, I must confess that we have not much data on the value of Canadian-grown sugar-beet seed as compared with imported seed, but the little data we have indicates that Canadian-grown sugar-beet seed is in all respects at least as good as imported seed. The year before last the Central Experimental Farm received, through the kindness of Mr. Henry Stokes, of the Dominion Sugar Company, some Ontario-grown sugar-beet seed. This was tested on most of our Experimental Farms and Stations, and, I am glad to say, it compared very favorably with imported seed tested in comparison with it.

With regard to mangels, I am in a position definitely to state that mangel seed can be produced in Canada that is at least as good as mangel seed produced in Europe. Canadian-grown mangel seed is capable of producing at least as large root crops as imported seed and crops that, to say the least, do not fall behind in feeding value or quality in general.

In support of this statement, I beg to refer briefly to some experiments with home-grown and imported seed, which were conducted by the Experimental Farms in 1916. The home-grown seed used in these experiments was raised in Canada in 1915. The varieties used were Mammoth Long Red, Yellow Intermediate, and Danish Sludstrup. Three lots of Mammoth Long Red seed were tested: one lot of seed produced at the Central Experimental Farm, Ottawa, another lot produced at the Experimental Station, Charlottetown, P.E.I., and the third at the Experimental Station at Kentville, N.S. Two lots of Yellow Intermediate seed were used in the experiment, viz., one originated at the Central Farm at Ottawa and the other at the Experimental Station at Charlottetown, P.E.I. Of three lots of home-grown Danish Sludstrup seed that also were tested, one came from Charlottetown, P.E.I., another from Kentville, N.S., and the third from the Experimental Farm at Agassiz, B.C.

The Canadian-grown seed of these varieties was tested in comparison with imported seed of the same varieties on Experimental Farms and Stations in Eastern Canada and British Columbia, and in no single case did the Canadian-grown seed produce smaller yields than the imported seed of the same variety tested alongside with it. The Canadian-grown seed, on the contrary, gave higher yields than the imported seed.

I shall not trouble you with many detail figures, but would like to say that the Yellow Intermediate mangel seed from Ottawa yielded—it was tested at 7 Experimental Stations—on the average 3 tons 750 pounds to the acre more than the imported seed of the same variety. If the Ottawa seed had been brought on the market it would, I may add, from its very appearance have commanded much higher price than the imported one. It was plumper, of better color, more uniform and of a much stronger vitality. It germinated quicker and more evenly, and as a result the crop raised from it had a better start and was more vigorous from the beginning than the crop produced by the imported seed.

I would also like to say a few words about the experiment with Ottawa-grown seed of Mammoth Long Red mangel in comparison with commercial seed of the same variety.

The Ottawa-grown seed was raised from roots taken from the ordinary farm crop at Ottawa. The roots that produced the seed were taken practically without any selection at all; only such roots were culled that were too badly malformed or too prongy. The roots used were therefore far from ideal. In fact, if our object had been to raise seed of a high standard, we would have discarded at least fifty per cent. of the roots as unfit for seed raising. Under the circumstances you understand that the seed that we obtained from the Ottawa-grown roots could, under no circumstances, be considered to be of high quality from a selection standpoint. We could, therefore, hardly expect that it should produce as good a crop as seed of the same variety raised from well-selected roots. And yet, it did. And it did even better; it gave higher yields than imported seed of the same variety, which presumably was of a better-bred stock.

The Ottawa-grown and the imported seed were tested side by side at nine Experimental Farms and Stations and, on the average, the Ottawa-grown seed produced nearly 3 tons more roots to the acre than imported seed of the same variety. The seed was also tested at some fifty private farms in Eastern Canada with the result that, as an average, the Ottawa-grown seed produced about 10 per cent. heavier yield of roots than the imported seed.

In 1916, an experiment was also conducted with swede turnip seed raised at Fredericton, N.B., in comparison with imported seed. The variety used was Kangaroo. The New Brunswick-grown seed was tested in comparison with commercial Kangaroo seed at five Experimental Stations in Eastern Canada and yielded on the average about two and three-quarters tons more to the acre than the imported seed.

I think I am justified, from the experience we have so far on the subject of the comparative value of home-grown and imported seed, to conclude that from a crop-producing standpoint Canadian-grown root seed is at least equal to imported seed, *i.e.* European seed. And I beg to repeat what I said a few minutes ago: There is no foundation whatsoever for the conception that European-grown seed, because it is grown in Europe, is superior to Canadian-grown. On the contrary, what data we have on the subject furnishes a very strong argument in favor of Canadian-grown seed being used in preference to imported seed, providing of course that the Canadian seed is being raised from reasonably well-selected roots.

Where and How to Grow Root Seed.—I have used the rather vague term, "Canadian-grown seed," in the discussion on the value of imported seed, in comparison with seed grown in Canada, and possibly some of you may be inclined to infer that when I have referred to "Canadian-grown seed," I was trying to convey the impression that seed of first-class quality of mangels, turnips and carrots can be grown to advantage anywhere in agricultural Canada. To convey such an impression on you is far from what I desire to do.

I regret very much that I am in a position to give you only very meagre and incomplete information as to what districts of Canada are suitable for the different varieties of field roots. From our experience I may say, however, that so far the best results with turnip seed growing have been obtained in Quebec and the Maritime Provinces, especially in Nova Scotia, and that success in mangel seed raising has been repeatedly reported from Eastern Ontario, British Columbia, and maybe to a lesser degree, from the Maritime Provinces and southern parts of Ontario. Carrot seed has been grown the last few years very successfully in Eastern Ontario, and, judging from what I saw last summer in British Columbia, the dry belts of the interior of British Columbia, and the Victoria district of Vancouver Island, seem to be admirably well adapted to carrot seed raising.

But remember that root seed growing is still in its infancy in Canada. It will take years before we are able definitely to say that such and such a province or such and such a district of a province is best suited to such and such a variety of roots for seed raising. We will, no doubt, find that while a certain part of, for instance Ontario, may be classed as very well suited for mangel seed raising, another part may be classed as either doubtful or altogether unsuitable. We need data on these matters, and before we have it I think it would be wise to be conservative in our expectations as to what Provinces or districts of Provinces can do with regard to production of the various classes of root seeds.

Climatic conditions no doubt determine, in combination with soil and fertility conditions, to a large extent what success will be had in root seed raising. But on the other hand, much depends on the methods of planting, culture, and handling of the seed crop, especially if the seed is raised on a commercial scale.

I am not going to take up your time with a discussion on what methods are liable to bring the best results, simply because it is not possible to lay down any hard and fast rules for a country of such a diversified nature as Canada. It would be impossible, indeed, even to prescribe definite methods for Ontario, or even for Ontario west of Toronto, because the methods to be employed depend on so many things, for instance nature of soil, fertility, nature of season, labor conditions, etc.

Before I close, I would once more most earnestly impress upon you that there is an acute shortage of root seed in Canada at present. I would most sincerely advise everybody to grow some root seed this year, the more the better. Every farmer who grows what seed he needs for his own farm, is protecting himself from want, and every farmer who grows more than he can use for himself is doing a service to his country.

HENRY STOKES.

Agricultural conditions in Ontario have been much disturbed by the war. Before the outbreak of hostilities, practically all of our supplies of root seed were procured in Europe. These supplies have been gradually cut down until we are forced to turn our attention to the production in Ontario of seed to meet our own requirements.

Seed growers will find that the shortage of labor is one of the real problems to meet. We are now facing the worst labor crisis which has ever confronted us. In the years 1912 and 1913, our labor was costing us $1.50 per day for ten hours, while in 1917 we were compelled to pay from $2.75 to $3.00 per day. Compare these conditions with those of Europe for 1912, and we find that in Russia, Italy and Germany the average wage was 50 cents per day of twelve hours.

Planting usually starts about the 25th of April, and continues until the end of May. If the weather is warm the stecklinge will soon spoil, so planting must proceed as quickly as possible. If we are planting on clay land, and have heavy downpours of rain, such as we had last spring, then we are doubly handicapped. The cultivation of the crops must be done early in the season, before the plants are large enough to suffer from breaking down by the passing of the horse and cultivator in the rows.

From a sugar beet standpoint, we require 450,000 pounds of seed each year, to plant the acreage which is necessary to keep our three large factories running. In 1917, we grew one hundred acres of seed, which supplies only about one-fifth of our requirements. We expect to grow two hundred acres of seed this year, which, with favorable conditions, should produce 150,000 pounds, or about one-third of the total amount required. In 1919, or in 1920, we hope to be able to grow five hundred acres, which should produce all we need. We realize that if we are to have seed, we must produce it ourselves.

This year high prices are being paid in Canada for vegetable seeds. These prices will tend to encourage men to specialize in this work. From my six years' experience, I am satisfied that seed can be produced in Canada on a commercial basis. It would cost about fifty dollars per acre to produce stecklinge in the pit. An acre planted with stecklinge, including cost of planting, etc., would amount to from twenty to thirty-five dollars. The total cost, therefore, of producing an acre of seed would amount, approximately, from eighty to one hundred dollars.

A difficult part of the work is to produce proper storage for the stecklinge. This is especially so during the early part of the season, when planting is going on. I have had much difficulty and loss occur, while planting on a clay soil, during a rainy season. The rains caused delay in the planting, while the moisture and warmth started a growth of the stecklinge in the pit. To retard this growth, I aired the roots, and, although I was successful in stopping the growth, I greatly lessened their productive power.

Seed growing, in a commercial way, should not be attempted by every farmer. It should be carried on in localities where the soil and climatic conditions are favorable. The counties of Kent, Essex and Lambton produce good corn; Kent and Elgin, along the lake shore, good tomatoes; while Waterloo and Wellington can produce seed of mangels, sugar beets and turnips, yet other districts may prove by experiments to be suitable for this work as well.

As it is very easy to allow the stock to degenerate, the work must be undertaken by men of keen observation and foresight, and supervised by men of good technical ability. In growing beet seed, we test the mother roots for sugar content, and plant only those which have a high sugar content. By following this practice, we have increased the sugar content of our factory beets by about one-half per cent., while a common test for mangels and turnips is a specific gravity one.

The past two years have not been ideal for this work, because of the periods of excessive rainfalls and drouths. For two years now, I have had poor luck with my mangel seed, but this was my own fault, as I planted the stecklinge too late. We have ten farmers growing seed for us, but under my supervision. We are also going to attempt turnip seed production, three of us having purchased fifteen hundred bushels of roots for planting in the spring of this year.

I have received much valuable assistance in this work from Mr. George H. Clark, the Dominion Seed Commissioner, and his staff, Messrs. Lennox and McMeans; as well as from Dr. Malte and Mr. Brown, of the Central Experimental Farm; and also from the Ontario Agricultural College.

Dr. C. A. Zavitz.

I wish to supplement very briefly what has already been stated. We are greatly indebted to Dr. Malte, for telling us what is being done throughout the Dominion in the endeavor to produce root seed in the different Provinces, and to overcome the crisis in regard to the scarcity of root seed in this country. We are also very grateful to Mr. Stokes for the information which he has given in regard to the production of sugar beet seed in this Province. Mr. Stokes has probably had more experience in the actual production of root seed in Canada than any other person.

We have been carrying on experimental work at the Agricultural College at Guelph during the past ten years in growing mangel, turnip and carrot seed, to obtain information as to the success of seed production of these classes of roots in this Province. Our results have not been very satisfactory in the production of turnip seed, but our success has been fair in the production of carrot seed. I am pleased to state that so far, with only two exceptions, we have had very decided success in the production of mangel seed at the College. Five years ago the mangel seed germinated only twenty-seven per cent. from the clusters. This was probably owing to the fact that we had a frost in the early part of September and the mangel seed was not harvested until the latter part of the month. In 1916 mangel seed production was a failure in this Province. The seed produced at the College only germinated about ten per cent. We had one acre of mangel seed which looked promising, but when the plants were in bloom we had an exceptionally hot, dry spell, which seemed to seriously affect the plants. At harvest time many of the clusters had a good appearance, but they contained no vital seed. Not only was this true in our mangel seed at the College, but the conditions were very similar throughout the Province. This was a great disappointment to us. We had been working on a special strain of the Yellow Leviathan mangel, which we had carefully selected. In July, 1915, we planted seed of this special strain, and produced about fifty thousand stecklinge. In the spring of the following year, not only did we plant about six thousand of these stecklinge ourselves, but we distributed about forty thousand to about twenty-five progressive farmers throughout Ontario. Had the season been favorable, we would probably have had from six to ten tons of seed of this special strain of the Yellow Leviathan mangel, which would have been of great service in using for the production of more stecklinge in 1917, but, as I stated before, mangel seed production was a failure throughout the Province in that year. In 1917 we planted at the College a little less than an acre of stecklinge of another selected strain of the Yellow Leviathan mangel.

This area gave us about sixteen hundred pounds of first-class mangel seed, which is giving a germination of about 213 per cent. from the mangel clusters. We expect to use this seed entirely in 1918 as foundation stock for producing steck-linge, to be re-planted in 1919 for seed production.

Generally speaking, we have had excellent results from home-grown mangel seed, and I think the outlook is very good, indeed, for the production of mangel seed in this country. In the average results for nine years at our College, very careful field tests show that our home-grown seed gave an average percentage of germination from the clusters of 113 per cent., while, in the average of the same nine years, imported seed, obtained through three of the leading Ontario seed houses, gave 78, 75 and 72 per cent. We have not obtained imported seed from any source which has given us as high a percentage of germination over a series of years as we have secured from the seed produced at Guelph.

I would also emphasize what Dr. Creelman suggested this morning, and what Dr. Malte mentioned this afternoon, that is the great importance of individual farmers throughout Ontario helping along in this movement. If farmers who have some good mangels stored in their root cellars would, in the spring when vegetation is starting to grow, plant these in a piece of well-tilled land, they would be able to grow seed for home use. The mangels might be placed about thirty inches apart each way. We have occasionally obtained as high as a pound of seed per plant, but this is very exceptional, and it would not be wise to count on more than from three to eight ounces of seed per plant on the average. By transplanting from fifty to one hundred plants in the spring, a nice quantity of seed could be obtained. This would greatly help out the situation in furnishing home-grown seed, and in showing what could be done in seed production in different localities throughout the whole Province. I would be pleased to receive word of the success of any farmers who will undertake to produce a small quantity of mangel seed in the coming year. In former years our mangel seed was nearly all imported from Europe, and, if we are going to avoid serious results from lack of seed, in the next few years, especially, we should do what we can to produce seed of our own, which might lead eventually to the development of a new industry in this country.

PRACTICAL SUGGESTIONS IN THE PRODUCTION OF FOOD MATERIALS FOR THE COMING YEAR.

WHEAT AND BEANS—Dr. C. A. Zavitz.

The world is calling loudly for food materials, and especially for wheat. The food situation is undoubtedly very critical at the present time. I ask this representative body of farmers to consider with me most seriously as to what Ontario can do to increase as quickly as possible essential food materials. In this connection, I wish to discuss with you the production of wheat and of beans, as I consider it is exceedingly important to increase these two crops to the greatest possible extent in 1918.

Wheat is used more extensively as human food than any other cereal. It is particularly rich in nutritive constituents, and no other grain except rye contains a gluten which is capable of expanding and forming light, porous bread. Wheat can be easily grown, economically transported, and readily stored when necessary. Canada has a wonderful opportunity of doing a tremendous service at the present time in the production of wheat for export.

WHEAT FOR EXPORT.—It is estimated that the shortage in the wheat crop of the allied countries in Western Europe for 1917 amounted to 570,000,000 bushels. Of this deficiency, only about one-third can be supplied from Canada and the United States. There was a normal surplus for the past year of about 23,000,000 bushels in the United States and of about 138,000,000 bushels in Canada. Although there were nearly three times as many bushels of wheat *produced* in the United States as in Canada, the normal *surplus* of the latter is about six times as great as that of the former. The amount of wheat available for export, and the ready transportation of the same to Western Europe, are the important features at present.

ONTARIO WHEAT PRODUCTION.—The acreage of fall wheat in Ontario was considerably below the average in 1917, and, owing to unfavorable weather conditions last autumn, the area of winter wheat is about the same this year. It will be necessary, therefore, to depend upon the spring wheat for any increase in acreage. It is interesting to note that in 1917 there was an increase of spring wheat over the previous year of, approximately, 38,000 acres.

According to recent estimates, the normal annual consumption of wheat in Ontario is about 13,000,000 bushels, and the production in 1917 was about 17,000,000 bushels. The amount of surplus wheat in Ontario in the past year was, therefore, approximately four million (4,000,000) bushels. It will be seen that, by increasing the wheat production 25 per cent., the amount of wheat available for export is thus increased by fully 100 per cent. An average yield of winter wheat in Ontario in 1918 should be sufficient to supply the people of Ontario under normal conditions. The amount of wheat available for export from this Province during the next year will, therefore, depend largely on, first, the economy on the part of the people in the use of winter wheat, and, second, on the coming season's production of spring wheat. The importance of increasing the spring wheat crop of Ontario in 1918 seems evident. In order to bring this about, I wish to emphasize four points, viz., (1) increase in acreage, (2) sowing the best variety, (3) using seed of high quality, and (4) sowing at the right time on a suitable seed bed.

INCREASE IN ACREAGE.—The average annual number of acres of spring wheat for the six years, from 1883 to 1888, inclusive, was 626,104, and for the six years, from 1912 to 1917, inclusive, was 141,279. The average yield per acre per annum for the first period was 15.5, and for the last period, 18.4 bushels. According to the reports of the Bureau of Industries, the acreage of spring wheat in this Province has decreased more or less gradually from 779,463 in 1885 to 182,957 in 1917. In connection with this, it is interesting to note the average annual yields of spring wheat per acre for Ontario for the past thirty-six years, when divided into periods of six years each, are as follows:

Periods of Six Years.	Average Bushels of Spring Wheat per acre per annum.
1882–1887	15.5
1888–1893	15.0
1894–1899	15.7
1900–1905	17.8
1906–1911	17.4
1912–1917	18.4

It will be seen that the highest average yield per acre was for the last six years. It may be a surprise to many of the farmers of the Province, who have had the impression that the production of spring wheat in Ontario has been a failure in recent years, to know that the average annual yield per acre of spring wheat for the past three years has been greater than that of any three consecutive years from 1882 to 1914. Some of the highest yields in spring wheats during the past five years have been made in some of the counties of both Eastern and Western Ontario, and in some of the districts in the northern part of the Province. Under the circumstances, it seems reasonable to conclude that the acreage of spring wheat in Ontario might be advantageously increased to a considerable extent.

Sowing the Best Variety.—According to the results of co-operative experiments and experience of farmers throughout Ontario, good returns have been made by both the Wild Goose and the Marquis varieties of spring wheat. The average yield in bushels per acre for the last five years has been 20.2 for the former, and 19.0 for the latter. As the Marquis variety of spring wheat is not only a good yielder, but is also a wheat of excellent quality for bread production, it will likely be used extensively for seed purposes in the coming spring.

Using Seed of High Quality.—Not only is it important to sow a good variety of spring wheat, but it is also exceedingly wise to use seed of the highest quality. In an experiment, which was conducted for eight years in sowing different selections of seed of spring wheat, some interesting results were obtained. The following shows the influence of one season's selection of seed repeated for eight years:

Selections.	Weight per Measured Bushel (pounds).	Average Yield per Acre per Annum.	
		Tons of Straw.	Bushels of Grain by Weight.
Large plump seed	59.1	1.4	21.7
Small plump seed	58.3	1.3	18.0
Shrunken seed	56.9	1.2	16.7

This shows that large plump seed gave an increase over small plump seed of about 20 per cent., and over shrunken seed of about 30 per cent. It is exceedingly important to use sound seed of strong vitality in order to get the highest returns.

Sowing at the Right Time.—In an experiment, conducted at the Ontario Agricultural College in each of five years, spring wheats were sown at six different dates in the spring, starting as early as the land was in a suitable condition for cultivation, and allowing one week between each two dates of sowing. The experiment was conducted in duplicate each year. The average results of the ten tests conducted in the five years are as follows:

Seedings.	Weight per Measured Bushel (pounds).	Yield per Acre.	
		Straw (tons).	Grain (bush.)
First	60.1	1.2	21.9
Second	59.6	1.1	19.2
Third	59.0	1.0	15.4
Fourth	58.9	.9	13.0
Fifth	56.5	.6	8.4
Sixth	54.0	.8	6.7

It will be seen that for best results it is of great importance to sow spring wheat as early in the spring as the land is suitable for cultivation. According to the results of the experiment, a delay of one week made a decrease in the yield of 2.7 bushels per acre, or of fully 12 per cent.

By sowing at the right time, on well prepared land, the best seed obtainable of the Marquis wheat, the increase in production would be surprisingly great, and the available amount for export might be easily increased many fold.

FIELD BEANS.—According to the Bureau of Industries for Ontario for 1916, the market value per acre of some of the grain crops of Ontario are given as follows: Beans, $58.95; Corn for Husking, $36.57; Wheat, $34.19; Peas, $27.41; Spring Wheat, $24.89; Barley, $23.91; Rye, $18.81; Oats, $17.50; and Buckwheat, $15.51. Beans occupy a high place in value per acre among the grain crops of Ontario.

Field beans approach animal foods in nutritive value. They contain a high percentage of protein and in this respect surpass the other grain crops frequently used as food. There is a higher percentage of protein in beans than in the best cuts of meat, but it is not quite so completely digested. Protein is a nutrient which serves to build and repair body tissues as well as to furnish energy. It performs essentially the same part in nutrition, whether it is from beans, peas, wheat, meat, milk or cheese.

The Province of Ontario, and the States of Michigan and of New York, have produced about one-half of the beans of the North American Continent within the last few years. In 1916, 83 per cent. of the acreage of beans in Canada was in Ontario. The number of acres of beans in this Province was 53,999 in 1916 and 114,785 in 1917. Beans are one of the most valuable crops which can be grown in Ontario for export. They can be transported readily, and, when well matured, can be stored without much danger of injury. It seems proper for Ontario to produce as large an acreage of beans in 1918 as the limited amount of labor will permit.

BEEF AND BACON—PROF. G. E. DAY.

In normal times it is counted good business to give our beef cattle a good degree of finish before sending them to market. The higher price obtained for well finished cattle has usually been profitable to the feeder.

At the present time, however, we are facing decidedly abnormal conditions. Statistics indicate that the world is facing a heavy shortage of wheat. If these statistics are correct, it looks as though it might be necessary to use grains heretofore employed almost exclusively for the feeding of animals, to help out the supply of wheat. As a matter of fact, investigations are in progress to determine the extent to which wheat flour may be adulterated with the flour of other cereals and still retain its palatability for human consumption.

If it becomes necessary, therefore, to utilize the coarser cereals for human food, it must mean a shortening up of concentrates for fattening animals, and the question arises whether, under present prospects, we should not make a special effort to use the smallest possible amount of concentrates, and utilize to the fullest extent bulky fodders in the fattening of our cattle.

Some years ago the Ontario Agricultural College secured a gain in weight of 2,180 lbs. in the case of fattening steers, from the use of 2,187 lbs. of ground barley and 729 lbs. of bran. This is very little more than one pound of concentrates used for each pound of gain in weight, the balance of the ration being made up of hay, corn silage, and roots, in the proportion of 1, 2 and 3, respectively. The steers used in this experiment were cheap, common cattle, and the gains they made were not large, being approximately 1½ lbs. per steer, per day, for a period of 165 days. The cattle were not well finished when marketed, and dressed a little less than 57 per cent. of their live weight, but the beef from these cattle was much superior to a great deal of the beef we are forced to consume in these days, and, as has been pointed out, it was produced with the use of a very small quantity of material which was fit for human consumption.

One thing is certain, we cannot produce the maximum amount of highly finished beef and, at the same time, produce the maximum amount of cereals for human consumption. It would seem, therefore, the part of wisdom to economize on the use of cereal grains in the feeding of beef cattle, and to utilize to the fullest extent bulky fodders, even though we have to be content with smaller gains in weight and a poorer quality of beef. As previously stated, these are abnormal times, and methods which would have been severely condemned a few years ago may be the very best and safest methods we can follow at the present time. Our great effort must be to get human food from our bulky fodders by converting it into meat, with a minimum reduction of cereals for human consumption.

An objection in the mind of many may be the fact that in the College experiment roots were used very liberally, whereas on many farms roots are not largely grown, owing to the labor involved. This is a perfectly legitimate objection, but, judging from experience, silage can be made to take the place of roots, to a very large extent at least. In addition to this, the hay fed the College steers was mixed timothy and clover, and contained too much timothy to be really satisfactory for cattle feeding. With a good quality of clover hay, or, better still, alfalfa hay, and a liberal allowance of silage, there is every reason to believe that results quite equal to the College results can be obtained. The experiment emphasizes the great importance of clover, alfalfa and silage on the farms of this Province.

Bacon Production.—At the present time a strong plea is being made for increased bacon production. There are several reasons why hogs are especially important in times like these, and the following may be noted:

(1) Hogs multiply rapidly, and mature quickly, so that they offer the quickest means of increasing the world's supply of meat.

(2) Hogs produce more meat from a given amount of food than any other domestic animal.

(3) Hogs give a greater weight of dressed carcass in comparison to live weight than any other animal.

(4) The carcass of the hog contains more edible meat in proportion to bone than that of any other animal.

(5) Pork and bacon contain a large proportion of edible fat, which is vitally needed in the rations of soldiers.

(6) Bacon is perhaps the most compact form in which meat can be shipped.

It will be seen, therefore, that the hog is bound to play a very important part in rationing our armies and those of our allies.

A point which counts against the hog in the eyes of the farmer is the fact that in order to finish it it must be fed considerable quantities of concentrated feed, and when concentrates are high in price, as they are at present, the farmer is inclined to cut down on his hog production. Everything considered, therefore, it would seem that the present is an opportune time to study carefully the possibilities of reducing the amount of concentrates in the ration of the hog and still provide a fattening ration.

Roots are a somewhat expensive crop to handle, but the advisability of growing even a small patch of mangels or sugar beets for winter hog feeding is well worthy of consideration. Experience has demonstrated that roots can be used in such a way as to lessen very greatly the amount of meal necessary to fatten hogs. A plan which has been used successfully, both at the College and on farms throughout the Province, is to pulp the roots, moisten the pulped roots with hot water and mix them with about an equal bulk of dry meal. The moistened roots moisten the meal and cause it to adhere to the roots and the whole constitutes a palatable and satisfactory ration for winter feeding. Sugar beets are preferred by pigs, but mangels are more easily grown and pigs take them quite readily. Turnips are not quite so palatable, but pigs can be taught to eat them if accustomed to them from the start. When practicable, boiling turnips makes them quite palatable and enables one to greatly reduce the consumption of meal. Boiled potatoes have a higher value than roots, and when cheap fuel is available small potatoes should never be allowed to go to waste. Breeding sows can be maintained throughout the winter with a very light meal ration if they are supplied with roots and some fine quality clover or alfalfa hay, alfalfa being the best. The hay may be fed dry in a rack similar to a sheep rack, and is very much relished by pigs, even young pigs will take considerable hay of this kind, but they should not be expected to depend upon it to the same extent as older pigs.

For summer feeding, pasture crops seem to offer the most convenient means of reducing the meal ration. Alfalfa makes an ideal pasture when available, but red clover, especially young red clover, is greatly relished by pigs, and can be utilized in reducing the meal ration.

A thickly seeded mixture of grains such as oats and barley, or oats, wheat and barley, together with about 8 lbs. of red clover per acre, makes a capital pasture quite early in the season. If it is not desired to pasture the mixture during the early part of the season, it can be cut for hay and the clover will then come along and form an ideal pasture for any class of pigs. Rape may also be used as a later pasture crop, and by changing the pigs from one field to another, crops such as rape and clover may be pastured and repastured several times.

Another plan which has been tried in some places, and which is worthy of consideration, is to plant a few acres of corn which will mature in the district in which we live. In this district, and in similar northern localities, a very early maturing variety would need to be used. A crop such as this, however, will supply a large amount of feed for hogs and the corn may be husked, feeding the corn to the pigs and utilizing the stalks for the cattle, or hogs may be turned in to harvest the crop for themselves. If it is intended to pasture the corn, it is a good plan to sow rape between the rows at the last cultivation. A combination of rape and corn such as this will fatten hogs fairly satisfactorily, and in any half favorable season an acre of such pasture should carry ten to twelve hogs at least thirty days.

Pigs weighing 100 lbs. and upwards are best suited for pasturing.

Any ingenious farmer will be able, in all probability, to devise other means of economizing on the meal ration, and the present suggestions are thrown out as merely representative of steps which may be taken to keep down the cost of production.

BUTTER AND CHEESE—Prof. H. H. Dean.

The beginning of the year 1918 finds the world short on food and the people hungry as never before, because it is a peculiarity of humans that the shorter the supply of eatables in the cupboard, the more hungry they become. Particularly short is the supply of butter, more especially in Great Britain, where butter has been selling for as high as $1 per pound during the past year. Fats of all kind are scarce, milk-fat more than all others, because of the slaughter of cows and lack of labor to milk and care for dairy cattle. There is no substitute for milk-butter. The nation that relies on vegetable and animal fats, other than milk-fat, especially for children, has taken the first serious step in physical and mental degeneracy.

However, I am to deal with "Practical Suggestions on the Production of Butter and Cheese for the Coming Season."

The first one is that old one of *Better Cows,* which is at the basis of all increased production of dairy products. In these times, farmers cannot afford to feed poor cows. While we may not be able to breed very many cows which produce 100 lbs. of milk or over in 24 hours, and 20,000 lbs. milk in a year; or make 4 to 5 lbs. of butter in a day, and 1,000 lbs. in a year, the fact that we have a number of such cows should stimulate breeders to greater efforts than ever to secure these phenomenal producers, thus increasing the world's supply of milk-fat without increasing the number of cows, and at the same time we shall be conserving the supply of feed.

The organizations which are doing most to improve the dairy cattle of Ontario are The Records of Performance and The Records of Merit for pure-bred stock, and the Cow-Testing Association for the owner of common cows or unregistered stock. These, coupled with private records, are making a gradual, though slow improvement in the milk cows of Canada.

The second suggestion which, like a good appetite, always remains with us, when in a healthful condition, is to secure more and cheaper feed for butter and cheese production. Cheap and abundant grass, soilage, silage and root crops, with a reasonable quantity of grain and by-products, such as bran, oil-cake and cotton-seed meal, are essential for increasing the production of butter and cheese. Liberal feeding of the right kind of feed is an essential for increased production. Unfortunately the feed problem is a serious one on dairy farms. With the present price of grain and mill-feeds, the temptation is to lessen the quantity of these to a point below what is required for profitable production in winter time, as a certain amount of concentrated feed is essential, along with roughage, to produce milk in large quantities. Large producers require about one pound of meal for three to five pounds of milk produced. The great importance of cheap feed is realized when we consider that approximately one-half the cost of producing milk is for feed.

The third practical suggestion relates to a very acute problem on dairy farms at the present time, namely, the Labor problem. No class of farmers have been hit so hard as have dairy farmers in the present condition of labor. Many have sold their herds of dairy cattle and gone into other lines of farming because of help shortage. This condition is likely to continue for some time. The remedies which have been suggested are, to buy more dairy machinery, such as tractors, milking machines and cream separators; import foreign labor; conscript labor; utilize women help; and grow more help on the farm.

Not only is there a shortage of skilled labor on dairy farms, but the creameries and cheeseries of Ontario are likely to be shorthanded for 1918. This latter is fully serious as the help problem on dairy farms. Without our factory system of manufacturing butter and cheese, milk would be a drug on the market. While it is true that a considerable quantity of butter is still made on Ontario farms, and also some cheese, the quantity is lessening each year and likely to be markedly so from now on, as poor dairy butter will have to compete with "oleo," and will have to be sold at imitation butter prices.

Labor demands may be summed up in six words: Short hours, easy work, big pay.

If we are to increase or even maintain our present cheese output, the price of cheese must advance over the prices allowed by the Cheese Commission of 1917, which was 21¾c. per pound for grade one cheese at the Port of Montreal. We have no hesitation in saying, this is not anywhere near its food value as compared with the prices paid for meat and other protein carrying foods. The competition from milk condenseries is driving the cheese factories to the wall. Both patrons and manufacturers of cheese are having a serious time, and something must be done to relieve the situation or our cheese trade, the result of over half a century of fostering care, will be out of existence in a few years. Some claim that the present condensed milk boom is only temporary. A leading American dairy journal recently said: "We have no food product to-day that is in such great demand for export as is condensed milk, and the manufacturers can afford to pay prices for it that will drive the creamery and the cheese factory, with which the condensery compete, out of business. . . One creamery has put in a part of a condensing outfit, and is selling the condensed product in bulk to another condensery which is canning it."

If the condenseries are allowed to pay the high prices which have prevailed during the season of 1917, then cheese manufacturers must receive at least 25c. a pound wholesale for number one quality of cheese. One of the powder-milk companies paid $2.35 per 100 lbs. for milk testing 3.5 per cent. fat for the month of November, 1917, and $2.50 per hundred for 4 per cent. milk. Milk testing 3.5 per cent. fat will make about 9½ pounds of marketable cheese per 100 lbs., and 4 per cent. milk about 10 1-3 lbs. cheese per 100. One hundred pounds of 3½ per cent. milk, made into cheese, which sells for 25c. per pound would be worth $2.17½c., which means that 17½c. would have to be realized for the by-product, whey, which is practically impossible, if fed to calves or pigs. There is also the cost of manufacturing, which would amount to 19c., at 2c. per pound of cheese. We can readily see that the cheese patron and cheese manufacturer are heavily handicapped when competing with condenseries under present arrangements. It is not too much to say that number one cheese should sell for as high a price per pound as does number one beef or bacon.

The new slogan regarding prices to be paid for farm produce is, "*Cost of Production Plus a Fair Profit.*" Whether this is obtained by means of Government regulation, or through co-operation and organization among farmers, makes little difference, but this principle carried into farm practice means a new era in agriculture.

One other point, only, can be discussed at the present time—the manufacture of cheese from skim-milk and buttermilk. The following are brief directions for making cheese from these two dairy by-products:

Skim-milk Cheese.—Pasteurize skim-milk, then cool to 60 degrees or 65 degrees F., and add from 1 to 2 ozs. of culture to each 10 lbs. of skim-milk. Next morning the curd will be nicely coagulated and ready to make into cottage cheese.

Stir the curd to break it up, then place the can of milk in a vessel containing hot water. Stir gently until the curd and whey separate. This usually takes place between 85 degrees F. and 100 degrees F. If the separation is not complete at 100 degrees F., do not heat higher, but let the cans stand until the whey is clear. High temperatures give a dry, grainy curd.

Drain the curd by hanging it up in cotton bags or putting it on a draining rack covered with cheese cloth.

When sufficiently drained, add about 1 oz. cream to a pound of cheese, and salt at the rate of 1 oz. to 4 or 5 lbs. of cheese.

Buttermilk Cheese.—Heat the buttermilk to 130 degrees F. or 140 degrees F. Let stand from half to one hour, then hang up in a cotton bag to drain or else place on a rack covered with cheese cloth.

When sufficiently drained, salt at the rate of 1 oz. to 4 or 5 lbs. of cheese. The addition of a small amount of cream is an improvement.

While live stock would no doubt suffer considerably if there were neither skim-milk nor buttermilk for calves and pigs, the fact that from 12 to 15 pounds of edible food, highly protein in character, may be made from 100 lbs. of these by-products, and whereas it requires from 25 to 30 lbs. skim-milk or buttermilk to produce a pound of gain in pigs, we see that considerable human food is lost by feeding these to pigs instead of converting them directly into food for humans. Assuming that a pound of skim-milk cheese is equal in food value to a pound of gain in pigs, 100 lbs. of skim-milk or buttermilk converted into cheese would be thrice as economical in the production of human food as feeding hogs on these by-products, and by many, would be considered cleaner and pleasanter work. Whether or not the consuming public is of this opinion remains to be tested.

To sum up:—In order to increase the production of butter and cheese for 1918, more cows and better cows are needed, more and cheaper feed, more labor on dairy farms and in factories, or its equivalent in machinery, higher prices for the cheese produced in 1918 than was paid in 1917, and the manufacture of larger quantities of dairy by-products into palatable, digestible, merchantable food products for *direct* human consumption, rather than through the agency of animals by which latter process a large part of the energy-value and protein compounds of skim-milk and buttermilk are lost.

POULTRY AND EGGS—Prof. W. R. Graham.

Poultry and eggs can be of material assistance in winning the war if used as a substitute of meats such as pork and beef, which are so much in demand. We can each help a little by eating more eggs and more poultry. Last season we had a considerable number of eggs for export, and there was not the usual demand for dressed poultry. I take it that it is our duty to conserve meat for export, and as eggs never increase in food value from the time they are laid, we can not do better than eat them at home. It would, therefore, seem desirable that each and every one of us eat as many eggs and as much poultry as we can. To some this may not appear to be correct, as eggs and poultry are high-priced. There appears to be a feeling that both eggs and poultry are luxuries, and that during war-time they should be avoided. No doubt by so doing you will assist in winning the war, but not by us. As compared with meats, the average householder will find the money spent on a dozen eggs will go about as far and prove to most people more appetizing than the same amount of money spent on any meat.

Poultry and eggs are good foods, are somewhat perishable; then why not consume them in large numbers at home? Again, if you will take the percentage increase in the price of eggs, poultry, pork, mutton, beef, cheese and butter since the beginning of the war, either week by week or year by year, you will find that poultry products are as cheap or cheaper to-day, relatively, than they were at the beginning of the war.

To the producers of poultry there is every reason why you should carry on, at least maintain, production, and, in some cases, increase production. It is true we may have to change our methods a little. We shall have to look after our supplies of wheat substitutes, and not feed as much good wheat. Wheat has been easy to get and fair in price, but hens will lay very well on a mixture of corn, barley, and oats. There is always a little wheat that is not suitable for milling, but try and forget wheat. Then we may be able, with a little patience, to get a substitute in the terminal elevator screenings. While the birds do not take kindly to this now, there is considerable hope that, if they receive it when young, they will eat it readily next winter. Many of us forget that the appetites of poultry vary largely with what they were fed when young. I have seen hens that would not eat corn or wheat, simply because they had never seen them before.

Many of us will have to learn to cull our flocks. In general, it can be said that never was a good laying hen more profitable, and it is equally true that never was a poor layer more unprofitable. Therefore, cull your flocks. Good laying hens lose the yellow color from their shanks; those having white ear lobes, like Leghorns, lose the yellow tinge; the hen's plumage does not appear in perfect condition. The good layer is usually a hustler—goes to bed late and gets up early. She very seldom, when well fed, develops a mass of internal fat. The body cavity, or the space between the pin bones and end of the breast bone, is soft and flexible in good hens. A little practice will assist one to pick out nearly ninety per cent. of the poor producers. A laying hen's pin bones are very seldom close together.

To those who have not been keeping poultry—get enough to supply your own needs. Do not depend on the other fellow, but grow all you need of everything you can.

Hatch your chickens during April and early May. These are among the best winter producers. Market the surplus males and old hens when they are ready. Many keep the old hens and males months after they have outlived their profitable age.

Watch the leaks in your business. Study increased production and decrease the boarders. There is no place to-day for the non-producer.

FRUIT AND HONEY—P. W. Hodgetts.

It has been the aim of our branch for the past two seasons, at least one season, to give just as little devotion as we possibly could to the fruit growers' farms, especially that which required additional skilled labor. Our plan has been to give attention to the saving of labor that was of value.

The situation of fruit growing is somewhat difficult and complicated by the food problem in the countries of Europe. At the present time you can offer to the British Government 30,000 boxes of apples and several tons of jam, as our Government is doing, and to pay all charges—but they have refused to take them. I just got a letter from our agent in London, Eng., to whom we had been writing to get space for these goods, and he tells us that when he goes to the Admiralty for the space, the question is, "Are you going to feed the soldiers apples or bread?" So we cannot get the goods over except we have a little merchandise space occasionally.

This leads me to divide our fruit growers into two classes. The first, those engaged in the business entirely as fruit growers, making a living from it. These men occupy small acreages of land, and this land is covered with orchards and vineyards and small fruit plantations, and are located in the Niagara district and from Hamilton to Clarkson, near Toronto; and isolated sections in Essex, Kent, Lambton, and possibly large apple growers in Northumberland. These men cannot neglect the orchards even one season without causing ruin in the orchards—so they have got to continue in that business, and that alone.

Our advice to these men is that they should cut off all the labor possible that will not interfere with the labor necessary for the essential crops; to make it up with the old and the young, and especially family labor. Last year the family labor was very largely used in the harvesting of the crops in many sections of the Province. And this is working out very successfully. Girls are already making plans to begin work when school closes this summer, and fruit growers are making arrangements to use all this labor that is available. I would say to use this labor for harvesting the small fruits; these crops have paid well the past two seasons, and promise to do well again this year. Small fruits are in demand, not only by the cities, but by the factories, to be put into jam to be sent overseas.

Do not put more labor on the orchards than is absolutely essential to get a good crop. Do not spend any more time on the cultivation than is necessary, unless the season is a dull one. Look out for every bit of labor-saving machinery you can get. For instance, a spray gun was used extensively in the Niagara district last year, and was successful. If you haven't got modern labor-saving machinery and implements, get them as soon as possible, or borrow from the neighbors. Do everything possible to keep down the labor, on the orchards particularly.

Then, in the orchard, grow a crop that will be marketable. During the past season, many grew carrots and cabbage, because the previous season they had been a very high price, with the result, at the present time, these are not paying for the labor put on them. Surely, there are other crops; for instance, tomatoes. The growers are sure of a fair price from the canning factories for the coming season—go into that crop. Attend to the fertilization of the orchards in the winter, when there is more labor available.

And the other class make fruit growing a side line. These orchards can be let go for one, two or three years, and, unless there is a very bad pest in the neighborhood, very little harm will result. The need is so urgent for the essential crops, and beef and pork and the things that are necessary to produce beef and pork and milk, that I think we are quite within the mark in advising no unnecessary work on these orchards this coming season.

I would say to you men, to put in all the time necessary to make these crops a success. Then, if there is any time left, put it on the orchard, and, of course, you will have to put it on the essential operations as much as possible—on the harvesting and the marketing. Let the orchards go into grass or weeds. Cut out the summer pruning or anything of that kind, and, when you have some spare time, do the rough pruning in the orchard, so the air can get through the trees and do that part of the work that spraying takes care of ordinarily.

Honey is in a different position to fruit. Fruit is tolerated simply because it can be used in this country to replace certain foodstuffs which are expensive and necessary, and which will later have to be exported. Honey is needed to replace sugar, which is scarce. Any increase in the production of honey must, of necessity, come from men already engaged commercially in the industry. Not the small bee-keeper with a few hives, but the man or woman who is engaged in the business as a business, and making money out of it. You can take 200 colonies of bees and divide them among fifty men or women who are not particularly skilled in work, and put the same number with a man who already has 200 to 300 colonies, and no doubt the man who has 200 additional can get twice as much honey as the first fifty would. That is because the small bee-keepers do not pay attention or put the time on the bees that they should, and do not get the results.

The high price of honey will undoubtedly stimulate those already in the industry to produce every pound of honey they can possibly get from the hives. The best bee-keeper in the United States at the convention last month told the bee-keepers there that he had every assurance that, so far as the United States was concerned, that the price would be even higher than for the past season. I can assure you those were very high prices.

What about the increase in the stock of bees in the country? The increase generally comes from three methods—natural swarming, nucleus and combless package, which is imported. The aim of the experienced bee-keeper is to do away with natural swarming, because he knows he gets as big a surplus from a colony that has no swarming impulse, and he aims to do away with natural swarming, and, if he wants an increase, he gets it from the nucleus. It is almost impossible to get any surplus from the colonies during the first season from the nucleus. So that there is nothing left for the coming season, and if the bee-keeper wants to get a good surplus, he has to go into the importation of the combless package. The matter was discussed at the convention, and it was turned over to the Bee-keepers' Association to look after the importation of bees in this manner. It has been tried the past two seasons, but trouble was experienced in selecting experienced men. The Association, however, has been engaged for a number of seasons in the importation of queen bees for the improvement in the stock, and that scheme worked out successfully, so they turned over the importation of the combless package to the Association as well. Some preparations have been made for increased production in the coming season. In the spring, of course, where the hives are low in stores, it will be necessary to feed again, so as to have a well built up, beautiful white honey when the season opens.

Re-queening is becoming quite an important matter with the bee-keepers in the Province, and thousands of queen bees are imported every year where there is a deterioration in stock.

Protection from disease has been very largely in the hands of our Department, and we hope to be able to look after it again the coming season as we have in the past.

The indications are that there should be good crops, both of fruit and honey, in the coming season; sufficient, I think, to take care of our markets, possibly more than enough to take care of our markets in reference to apples. This will mean a certain amount of cheap fruit for the consumers in the Province, which they haven't had for some years.

INDEX

PAGE

INTRODUCTION 1

Results of Co-operative Experiments in Agriculture:

Dr. C. A. ZAVITZ 3

Sources of Farm Seed Supply for the Province of Ontario:

Experimental Union: Prof. W. J. SQUIRREL 24

Ontario Seed Trade: WALTER STEELE 25

District Representatives: R. S. DUNCAN 28

Field Crop Competitions: J. LOCKIE WILSON 29

Canadian Seed Growers' Association: L. H. NEWMAN 31

The Western Ontario Seed Growers' Association: A. MCKENNEY 32

Ontario Corn Growers' Association: P. L. FANCHER 33

Dominion Seed Branch: W. J. W. LENNOX 33

Root Seed Growing in Canada:

Dr. M. O. MALTE 36

HENRY STOKES 42

Dr. C. A. ZAVITZ 43

Practical Suggestions in the Production of Food Materials for the Coming Year:

Wheat and Beans: Dr. C. A. ZAVITZ 44

Beef and Bacon: Prof. G. E. DAY 47

Butter and Cheese: Prof. H. H. DEAN 50

Poultry and Eggs: Prof. W. R. GRAHAM 52

Fruit and Honey: P. W. HODGETTS 53

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

BULLETIN 261

WHEAT AND RYE

By

C. A. ZAVITZ, B.S.A., D.Sc.

Professor of Field Husbandry and Director of Field Experiments.

TORONTO, ONTARIO, FEBRUARY, 1918

BULLETIN 261] [FEBRUARY, 1918

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

Wheat and Rye

Dr. C. A. Zavitz.

INTRODUCTION.

Wheat is used more extensively as human food than any other cereal. Rye constitutes the main bread grain of more than one-third of the inhabitants of Europe. Both are particularly rich in nutritive materials, and no other grains contain a gluten which is capable of expanding and forming light porous bread.

Fig. 1.—A partial view of the experimental grounds at the Ontario Agricultural College, showing plots of wheat, etc.

Flour for bread production can be made from these two cereals either separately or in combination with each other or with flour from other grains. Both wheat and rye can be easily grown, readily transported and conveniently stored when necessary.

It is claimed that wheat was used as food by the Chinese 2,700 years before the Christian era, by the Egyptians at even an earlier date, and that it was cultivated by the Swiss lake dwellers and by other pre-historic races. There appears to be no authentic record of wheat growing wild and naturally re-seeding itself without the help of man. The culture of rye, although not as old as wheat, traces back for more than two thousand years. It is doubtful if rye can be found in the wild state at the present time.

Although rye can be grown under a variety of conditions, wheat has a greater range of cultivation throughout the world than any other cereal. It is now grown successfully near the Arctic circle as well as in the tropics. It is produced most abundantly, however, in the temperate climates.

Crop Production.

In the average for the three years immediately before the war, the crop acreages of the most important agricultural nations of the world, excepting China, for which statistics are not available, are given in the following order: United States, Russia, India, Germany, Austria-Hungary, Argentina, France, Italy and Canada. Those countries which have the greatest crop acreage per capita are Argentina, Canada, the United States, the Russian Empire and France. Based largely on Danish experiments, and taking as a criterion the most important food crops, the estimated production per capita in terms of wheat for each of the leading crop-producing countries is as follows:

Countries.	Bushels per capita.	Countries.	Bushels per capita.
Canada	70.4	France	17.9
Argentina	56.3	Russian Empire	17.4
United States	45.3	Italy	9.6
Australia	24.7	India	7.8
German Empire	21.3	Great Britain and Ireland	5.6
Austria-Hungary	21.0		

According to these estimates, determined from reports of the United States Department of Agriculture, regarding the principal crop-producing countries of the world, Canada comes ninth in total crop acreage and third in crop acreage, per unit, of population. Canada stands at the very top of the list, however, of the leading countries of the world in production, per capita, of the essential food materials from farm crops. Skilled agricultural labour in this country is, therefore, at a great premium as a factor in the production of a greater amount of food for export.

Wheat Production.

The total wheat production of the world reaches nearly four billion bushels annually. The four most important wheat regions are Southern Europe, Central North America, India and Argentina. Of these areas the one in Southern Europe is the most extensive. Europe produces about twice as much wheat as North America, while India produces about ten and Argentina four per cent. of the wheat crop of the world.

According to the revised statistics for 1917, Canada produced 231,730,200 bushels, and the United States 650,828,000 bushels of wheat. It is stated that under normal conditions, in estimating the amount of surplus wheat available for export, an allowance should be made from the total wheat production of about 5.5 bushels per capita for domestic consumption, seven pecks per acre for seed purposes, and ten per cent. loss in cleaning and for grain of unmarketable quality. Taking these points into consideration, we find that in 1917 although Canada produced only about one-third as much wheat as the United States, it had a normal surplus for export approximately six times as great as that of the American Union. This gives an explanation as to why it is that the allied powers are placing so much importance on the wheat production of Canada, particularly during the period of great scarcity of essential food materials.

The wheat crop of Ontario, in 1917, was 75 per cent. of the average annual crop for the past thirty-six years, and 88 per cent. for the past five years. The total production of wheat in Ontario in the past year was slightly more than sufficient to meet the demands at home, and was about equal to the surplus production of wheat in the United States over home requirements. If the Province of Ontario could double its wheat acreage, the normal surplus for export from this Province alone would be about equal to that from the United States in 1917.

The price of wheat in England, from 1259 to 1915, varied from 9 cents to $3.85 per bushel, the former price occurring in the years 1287, 1288 and 1509, and the latter in the year 1812. The earliest date at which wheat reached $1 per bushel was 1595. In the one hundred and twenty-two years, from 1764 to 1885 inclusive, wheat did not go below $1 per bushel, and in each of thirty years it reached from $2 to $3.85 per bushel. From 1886 until the beginning of the present war, winter wheat was less than $1 per bushel, excepting in the years 1891, 1898, 1909 and 1912. The lowest price in this period was 69 cents per bushel in 1894.

Botanical Classification of Wheat.

According to most authorities, wheat is divided botanically into eight different types or species. Representatives of all of these types have been under experiment at the Ontario Agricultural College. Only four of the species, however, have been represented by varieties in general cultivation throughout the Province. The following table gives the average yield, in pounds of grain per acre, for ten years, of a leading variety of wheat representing each of the eight different species:

Name of Species.	Names of High Yielding Varieties.	Average yield in pounds of Grain per Acre. (10 years).
1. Common (*Triticum vulgare*)	Dawson's Golden Chaff Winter Wheat	2,586
2. Club (*Triticum compactum*)	Herison Bearded Spring Wheat	1,902
3. Hard or Flinty (*Triticum durum*)	Roumania Spring Wheat	2,238
4. Turgid or Toulard (*Triticum turgidum.*)	Seven Headed Spring Wheat	1,686
5. Polish (*Triticum polonicum*)	Polish Spring Wheat	1,308
6. Emmer (*Triticum dicoccum*)	Common Emmer	2,644
7. Spelt (*Triticum spelta*)	Red Spelt	1,915
8. Einkorn (*Triticum monococcum*)	Einkorn	1,780

In threshing the varieties comprising the first five species, there is a clear separation of the chaff and the grain. When threshing the varieties of the last three species, however, the heads simply break into the separate spikelets and the grain is still enclosed in the chaff, the chaff forming from twenty to thirty per cent. of the weight as given in the accompanying table. The Common wheat (*Triticum vulgare*) includes the greater number of the varieties of both the winter wheats and the spring wheats which are grown in general cultivation throughout Ontario for bread production. These varieties may have bearded or beardless heads, white or red chaff, and white or red grain. The Club wheat (*Triticum compactum*) is not very different, botanically, from the first-named species, but the heads are very compact and the varieties show marked constancy and uniformity. This type is represented in Ontario to a limited extent by the Herison Bearded spring wheat. The Flinty, Turgid and Polish types furnish wheat which is particularly suited for the manufacture of macaroni, and is not used so extensively for bread production. The hard or flinty type is represented by the Wild Goose variety of spring wheat which is grown quite extensively in some parts of the Province. Emmer is a large yielder of grain which is grown to a limited extent in Ontario as a feed for farm stock. It has been improperly called Spelt by a number of the seedsmen. Both Spelt and Einkorn have given results which will not justify their use on the farms of this Province.

1. 2. 3. 4. 5. 6. 7. 8.

Fig. 2.—Eight Species of Wheat as given in connection with the accompanying Botanical Classification.

Popular Classification of Wheat.

But few farmers in Ontario pay much attention to the botanical classification of wheat. There are, however, a number of popular classifications recognized by all of the growers, such, for instance, as the division into spring and fall, bearded and beardless, white and red grain, white and red chaff, and hard and soft grain. For the purpose of this bulletin, particular attention will be given to varieties of winter wheat, varieties of spring wheat for flour production, varieties of macaroni spring wheat, emmer and spelt for feed production, and miscellaneous varieties.

VARIETIES OF WINTER WHEAT.

About two hundred and ninety named varieties of winter wheat and many selections and crosses have been grown under experiment at the Agricultural College within the past twenty-eight years. Nearly all of the varieties have been carefully tested in each of five years, after which the inferior kinds have been discarded and those which have given the best results have been continued in the experiments. Of the named varieties, fourteen have been grown in each of twenty-two years, and the results of these are of special value. The following table gives for each of these fourteen varieties the average weight per measured bushel for twenty-one years and the average yield of both straw and grain per acre for the twenty-two year period:

Variety.	Color of Grain.	Pounds per Measured Bushel. 21 years.	Yield per Acre. Average 22 years. Tons Straw.	Yield per Acre. Average 22 years. Bushels Grain.
Dawson's Golden Chaff	White	59.9	2.9	50.2
Imperial Amber	Red	61.1	3.1	47.2
Early Genesee Giant	White	60.1	3.0	45.9
Egyptian Amber	Red	61.5	3.1	45.5
Early Red Clawson	Red	58.9	2.8	45.4
Rudy	Red	61.4	2.7	44.5
Tasmania Red	Red	61.6	2.8	43.6
Tuscan Island	Red	61.2	2.8	43.4
Geneva	Red	62.0	3.0	43.1
Kentucky Giant	Red	61.0	2.8	43.0
Turkey Red	Red	61.3	2.7	42.7
McPherson	Red	61.9	2.6	41.9
Bulgarian	White	60.7	2.8	41.8
Treadwell	White	59.8	2.8	41.3

The average results of the fourteen varieties for the whole period of the experiment are as follows: Yield of grain per acre, 44.3 bushels; yield of straw per acre, 2.9 tons; and weight per measured bushel, 60.9 pounds. In the last twenty-two years, the lowest average yields per acre of the fourteen varieties mentioned have been 20.2 bushels in 1912, 25.6 bushels in 1917, 28.3 bushels in 1895, 32.0 bushels in 1908, and 34.1 bushels in 1904; and the highest yields have been 66.7 bushels in 1900, 61.6 bushels in 1902, 60.5 bushels in 1903, and 58.9 bushels in 1915. In 1899 and 1901 the results were so poor that no satisfactory tabulated returns could be made.

The Dawson's Golden Chaff is still the most extensively grown variety of winter wheat in Ontario, according to information obtained through an extensive correspondence with practical farmers. This variety, in the results at Guelph for twenty-two years, has given an annual average yield of grain per acre of exactly three bushels over the next highest yielding variety and of practically nine bushels per acre over the lowest yielder of the fourteen varieties included in the test. The Dawson's Golden Chaff was originated in Ontario thirty-seven years ago. It produces a very stiff straw of medium length, beardless heads with red chaff and white grain which weighs about the standard per measured bushel. It is probable that the Dawson's Golden Chaff is improving slightly in bread production. According to the last Annual Report, giving the results of the competitions in standing field crops in Ontario, twelve varieties of winter wheat were entered in connection with the different agricultural societies. The Dawson's Golden Chaff had fifty-eight per cent. of the entries and received sixty-eight per cent. of all the awards and seventy-one per cent. of the first prizes.

Thirty-four varieties of winter wheat have been under test at the College for at least five years. In the five years' experiment, the highest average yields in bushels of grain per acre of the named varieties have been produced by Imperial Amber, 45.8; Kharkov, 45.7; Gillespie Red, 45.2; McBean's Golden Chaff, 45.1; Tuscan Island, 44.9; Grand Prize, 44.7; and American Banner, 44.6. The Imperial Amber possesses bearded heads, red chaff and red grain; the Kharkov bearded heads, white chaff and red grain; and the Gillespie Red beardless heads, white chaff and red grain. The heaviest weights of grain in pounds per measured bushel, in the five years' test, have been produced by Theiss, 62.5; Kharkov, 62.4; Banatka, 62.0; Turkey Red and Virginia Miracle, each 61.9; Tuscan Island, 61.7; and Imperial Amber, 61.5.

In the average results of the five years' test Theiss, Kharkov, Tuscan Island, Yaroslaf and Banatka were the freest from rust, and Tystofte Smaa and McBean's Golden Chaff were the most severely affected by this fungus. Banatka, Theiss, Crimean Red, Geneva and Kharkov were the weakest in the straw, and Dawson's Golden Chaff, American Banner, Imperial Amber, Michigan Amber, McPherson and Scott were the earliest to reach maturity.

Seed Selection.

The results of a duplicate test made in each of six years at the College with selections of winter wheat for seed purposes, show an average annual increase in yield per acre of 6.8 bushels from large as compared with small seed, of 7.8 bushels from plump as compared with shrunken seed, and of 35.6 bushels from sound as compared with broken seed. For this experiment a uniform number of seeds of the different selections was used on the separate plots. The figures here given represent the influence from single and not from continuous selections, and the experiment was repeated in each of six years in order to get average and reliable information. The detailed results show that the large plump seed gave a greater yield per acre than either the small plump seed or the shrunken seed in each year of the test.

Owing to exceptionally wet seasons, winter wheat sometimes becomes sprouted before it is harvested. In each of two years, when winter wheat was sprouted in the fields, the germination tests of the threshed grain were afterwards made. The following results show the average percentage of germination from each selection: skin over germ, unbroken, 94; skin over germ, broken, 76; sprouts, one-quarter inch long, 30; and sprouts one inch long, 18. Not only were the sprouted seeds low in germination, but the plants produced were very uneven in growth.

Each of two varieties of winter wheat were harvested at each of five stages of maturity, one week being allowed between each two cuttings, and the grain produced from the different cuttings was used for sowing. The seed which was allowed to become thoroughly ripened before it was cut produced a slightly greater yield of both grain and straw, and a heavier weight of grain per measured bushel than that produced from wheat which was cut at any one of the four earlier stages of maturity in the average tests for five years.

The information here presented shows the great importance of using large, plump, sound, well-matured grain of a high percentage germination and of a uniform growth for crop production.

Testing the Quality of Wheat.

The quality of wheat is determined largely by the variety used and by the climatic conditions under which the wheat is produced. It is practically impossible, by means of manures and fertilizers alone, to materially increase or decrease the starch or gluten contained in wheat. For the production of pastry, breakfast foods, etc., the soft varieties of wheat grown in comparatively moist climates are used. For the highest results in bread production, however, it is important to grow in a comparatively dry climate those varieties of wheat which naturally produce a high percentage of gluten. Wheat differs in composition from all other cereals in that its gluten is composed of two proteids, gliadin and glutenin. This gives flour its bread-making value.

Fig. 3.—Young growth of Plants from an equal number of small seed and of large seed of winter wheat.

Some indication of the quality of wheat for bread production may be gleaned from the weight per measured bushel, from the transparency of the grain, from the hardness of the kernels, and from the quantity and the quality of the gluten secured from chewing the grain. Certain information is also gleaned from the chemical composition of wheat. The most accurate and reliable information, however, is secured by grinding the grain and by converting the flour into bread.

In each of the past ten years the varieties of winter wheat grown under experiment, in the Field Husbandry Department, have been carefully tested for bread production in the Bakery branch of the Chemical Department of the College. Those varieties of winter wheat which produced the largest loaves of bread from equal quantities of flour in the average tests, made in each of ten years, are given in the following order: Yaroslaf, Banatka, Crimean Red, Tuscan Island, Buda Pesth, Tasmania Red, Egyptian Amber, Kentucky Giant, Rudy, Treadwell, Bulgarian, Geneva and Turkey Red; and those which produced the smallest loaves of bread are the Early Red Clawson and the Abundance. In average bread production for five years of each of twenty-eight varieties, the largest loaves were produced by Yaroslaf, Buda Pesth, Banatka, Bulgarian, Egyptian Amber, Tuscan Island, Kentucky Giant, Tasmania Red, Turkey Red, Crimean Red, Geneva and Kharkov; and the smallest loaves by Abundance and Grand Prize.

Improvement of Wheat by Plant Selection.

The choice of the best plants is the keynote of selection, and selection is the principal factor of plant improvement.

Mass Selection.—The process of selecting from a field the best heads or the best plants, and of using collectively for seed the grain thus collected, is termed "mass selection." If the process is repeated by selecting the best plants from year to year, the process is spoken of as "continuous mass selection." This method has been used by some of the experiment stations, and is the method in use by the members of the Canadian Seed Growers' Association at the present time. This process applied to cereals for three years in succession, under regulations and inspection, furnishes grain which is eligible for sale as pedigreed seed when offered in sealed sacks.

Individual Plant Selection.—Undoubtedly, the most effectual method of improvement by selection of farm crops is worked on the basis of the individual plants. This method may be operated in large fields sown in the ordinary way or in nursery plots planted by hand.

An interesting instance in individual plant selection is the development of the Dawson's Golden Chaff winter wheat. Robert Dawson, a farmer living near Paris, Ontario, had a field of the White Clawson winter wheat in the year 1881, which was badly lodged. In walking over the field, Mr. Dawson observed a plant standing upright in the midst of the lodged grain. He carefully saved this one plant and sowed the seed in the autumn. In a comparatively short time he had sufficient seed, not only for his own requirements, but also for sale to his neighbors. The Dawson's Golden Chaff variety of winter wheat, which possesses very stiff straw, has been grown more extensively throughout Ontario than any other single variety.

From a nursery plot of the Dawson's Golden Chaff winter wheat selections were made at the College. In the experiments of the past five years, however, the Dawson's Golden Chaff and the special selection of this variety have each given an average of 44.5 bushels per acre. This seems to confirm the idea that it is exceedingly difficult to improve a variety of grain which has recently been started from a single seed unless changes have occurred either as mutations or as exceptional natural cross-fertilizations.

In a nursery plot of the Imperial Amber, however, a selected strain has been obtained which, in the average of five years, has surpassed the original variety by 3.9 bushels per acre per annum.

Hybridization.

With the object of originating better varieties of winter wheat than those already in cultivation, crosses have been made between Dawson's Golden Chaff and some of the varieties of particularly high quality for bread production, such as Tasmania Red, Crimean Red, Turkey Red, Buda Pesth, Bulgarian and Imperial Amber. In the average tests for the past five years, each of nine crosses between the Dawson's Golden Chaff and the Tasmania Red, the Bulgarian, and the Turkey Red has surpassed, in average yield of grain, the highest yielder of all the named varieties.

The O.A.C. No. 104 Variety of Winter Wheat.

A cross which has been made at our College between the Dawson's Golden Chaff and the Bulgarian has furnished a new variety of winter wheat which is very promising. In the past six years it has produced an average annual yield of grain per acre of 45.0 bushels, while the Dawson's Golden Chaff for the same period has produced 40.8 bushels, and the Bulgarian 37.5 bushels. It will, therefore, be seen that the O.A.C. No. 104 has surpassed each of its parents in productiveness. It has given a grain which is almost equal to the Bulgarian for bread production.

The O.A.C. No. 104 variety is a vigorous grower, with a comparatively stiff straw. The grain is white, and the variety resembles the Dawson's Golden Chaff

Fig. 4.—The O. A. C. No. 104 variety of Winter Wheat with its two parents, the Dawson's Golden Chaff and the Bulgarian.

in being beardless and the Bulgarian in having a white chaff. This variety was distributed for the first time over Ontario in connection with the co-operative experiments in the autumn of 1916. The following gives the average results of co-operative experiments conducted on twenty-five farms throughout Ontario within the past year:

Varieties.	Comparative Value or Popularity.	Yield per Acre. Straw (tons)	Yield per Acre. Grain (bus.)
O. A. C. No. 104	100	1.78	23.69
Imperial Amber	94	1.78	22.91
Dawson's Golden Chaff	94	1.41	21.47
Kharkov	48	1.72	19.34
Yaroslaf	55	1.79	17.57

It will be seen in the average results of the twenty-five experiments that the O.A.C. No. 104 variety of winter wheat came at the top of the list both in popularity and in yield of grain per acre. In past years the Imperial Amber has been one of the closest rivals of the Dawson's Golden Chaff in yield of grain per acre in the co-operative experiments throughout the Province.

Varieties of Winter Wheat Grown in Combination.

In each of five years an experiment was conducted at the College by growing the Dawson's Golden Chaff and the Turkey Red varieties of winter wheat separately and in combination. The experiment was duplicated each year by sowing the Michigan Amber and the Early Genesee Giant in the same way. When two varieties were grown in combination, exactly one-half the amount of seed was sown of each as was used of the same varieties when sown separately, therefore, a uniform weight of seed was sown on all the plots. The results show that the Dawson's Golden Chaff surpassed the Turkey Red in yield per acre in each year of the test, and that the yield per acre of the mixture of the two varieties occupied an intermediate position between the yields of the varieties grown separately. With two slight exceptions, the mixture of Michigan Amber and Early Genesee Giant gave a yield per acre intermediate between that of the two varieties grown separately. In the average of the five years' experiments, varieties of winter wheat gave practically the same results when sown in combination as when sown separately. There is apparently no advantage in growing different varieties of winter wheat in combination.

Soil, Rotation, Cultivation and Fertility.

Winter wheat can be grown successfully on a variety of soils. It thrives particularly well, however, on a rich loam containing disintegrating limestone and decaying vegetable matter. Fertile clay soils, when well drained, usually give satisfactory results in wheat production.

In the crop rotations followed in Ontario, winter wheat occupies an important place. It does particularly well on a bare summer fallow or after beans, peas or sod, and especially after clover. Wheat makes a good nurse crop with which to seed down grasses and clovers. The clovers should be sown in the spring but the timothy and the other grasses could be sown either in the autumn or in the spring following.

In the experiments at the College, winter wheat which has been grown on clover and on alfalfa sods has yielded much better than that which has been grown on timothy and on orchard grass sods.

Sod or stubble land intended for winter wheat should be ploughed about the first of August. If the soil is dry it should be rolled immediately and harrowed soon afterwards. The land should be worked on the surface occasionally until seeding time. This helps to retain the moisture, mellow the soil and furnish a good seed bed.

An experiment with different preparations of land for winter wheat was conducted in duplicate in each of four years, making eight separate tests in all. In each test two plots were summer fallowed and three plots were sown with crops to be used as green manure. The crops employed were field peas, buckwheat and rape. In the latter part of July, or in early August of each year, the crops were ploughed under as green manure and the land was worked on the surface occasionally during the month of August. In each test one of the bare fallowed plots received farmyard manure at the rate of twenty tons per acre before seeding time. The winter wheat was sown each year during the first week in September. The following table gives the average results of the eight tests conducted in the four-year period:

Soil Preparation.	Weight per Measured Bushel. Average four years.	Yield per Acre.	
		Straw (tons) Average four years.	Grain (bus.) Average four years.
Bare Summer Fallow and 20 tons Barnyard Manure, per acre	61.2	2.8	40.9
Bare Summer Fallow	60.9	2.1	33.8
Field Peas ploughed under	60.8	2.2	36.1
Buckwheat ploughed under	60.7	1.7	29.6
Dwarf Essex Rape ploughed under	60.5	1.8	30.4

As would naturally be expected, the bare summer fallow which received 20 tons of barnyard manure per acre gave the highest yield of grain, the average being 40.9 bushels, which was practically seven bushels per acre more than was produced from the land which was summer fallowed but which received no manure. One of the interesting features of this experiment is the fact that land on which field peas were used as a green manure gave an average annual yield of 6.5 bushels per acre more than land on which buckwheat was used for ploughing under. In each year of the experiment the field peas surpassed the buckwheat as green manure, and in three out of the four years rape gave a slight increase over buckwheat when ploughed under. The crops of buckwheat and peas were good in each of the four years, but the rape was not quite a full crop in one or two of the years. The superior quality of the field peas, as compared with the buckwheat as a green manure, is likely due to the fact that the peas are a leguminous crop and have the power of assimilating the free nitrogen of the atmosphere and of adding this increased fertility to the soil when the crop is ploughed under as a green manure.

In the co-operative experiments conducted through the medium of the Experimental Union with different fertilizers applied in the autumn to winter wheat, the average yields in bushels of grain per acre for eight years were as follows: Mixed fertilizer, 24.1; nitrate of soda, 22.7; muriate of potash, 22.3; and superphosphate, 22.4. On similar land, cow manure, at the rate of 20 tons per acre, gave an average yield of 26.3, and the land which received neither fertilizers nor manure gave an average of 18.9 bushels per acre. The superphosphate was applied at the rate of 320 pounds and the muriate of potash and the nitrate of soda each 160 pounds per acre. The mixed fertilizer consisted of one-third of the quantity of each of the other three fertilizers here mentioned.

In each of three other years the co-operative experiment of fertilizers with winter wheat was the same as in the eight-year test previously referred to, except that the fertilizers were applied in the spring instead of in the autumn of the year. From the spring applications, the land which received the mixed fertilizer gave the highest average yield, and the unfertilized land the lowest average yield of grain, the difference in favor of the former being 7.5 bushels per acre per annum.

The mixed fertilizer, therefore, when applied at the rate of 213 pounds per acre, either in the fall or in the spring, increased the yield of winter wheat from 5.2 to 7.5 bushels per acre over the unfertilized land.

The cost of the fertilizers used in this experiment would be approximately from $4 to $5 per acre under normal conditions.

As the result of the co-operative experiments conducted on average soils throughout Ontario, the mixed fertilizer, as previously described, when used with winter wheat, gave an increase of grain per acre of 5.2 bushels at a cost of 82 cents per bushel when applied in the autumn, and an increase of 7.5 bushels at a cost of 57 cents per bushel when applied in the spring.

In another experiment it has been found that nitrate of soda applied at the rate of 160 pounds per acre in the spring gave slightly over one bushel per acre more than a similar amount which was applied in the autumn. Nitrate of soda, at the rate of 160 pounds, increased the yield of wheat more than common salt at 400 pounds per acre when applied either in the autumn or in the spring.

Dates of Seeding, Seed per Acre, and Method of Sowing.

In each of six years an experiment was conducted by sowing two varieties of winter wheat on each of four different dates, allowing one week between each two dates of seeding. The soil and the cultivation were as uniform as it was possible to have them throughout the entire experiment. The following are the average results of the twelve separate tests conducted in the six-year period:

Dates of Seeding.	Weight per Measured Bushel (pounds) Average six years.	Yield per Acre.	
		Straw (tons) Average six years.	Grain (bus.) Average six years.
August 25-26	59.8	3.4	49.7
September 2-3	59.6	3.5	48.6
September 9	59.4	3.3	49.5
September 16-20	58.0	3.0	45.7

It will be seen that the dates of sowing had to be varied slightly owing to unfavorable weather conditions. The variation, however, was not greater than one day, excepting in the case of the last seeding, which did not take place until September 20th on one occasion. The results indicate that in Ontario winter wheat can be sown satisfactorily any time from the 25th of August to the 9th of September. After that date, however, the yield per acre is somewhat reduced. In two years of the experiment, winter wheat was also sown in duplicate plots on September 23rd and September 30th, and the results for each year show that there was still further reductions in yields per acre as the season advanced. The foregoing averages show not only a decrease in yield of grain per acre after the 9th of September, but also a decrease in both yield of straw per acre and weight of grain per measured bushel.

An experiment in sowing winter wheat at the rates of one bushel, one and one-half bushels and two bushels per acre, was conducted in duplicate in each of six years. The average results of the twelve distinct tests are as follows:

Seed per Acre.	Weight per Measured Bushel (pounds). Average six years.	Yield per Acre. Straw (tons) Average six years.	Yield per Acre. Grain (bus.) Average six years.
4 pecks	59.2	2.68	40.15
6 "	59.3	2.96	43.30
8 "	59.3	3.02	43.87

The heaviest seeding gave about one-half bushel per acre more than the second heaviest seeding, but it should be noted that the former required two pecks more seed than the latter. Grain prepared for sowing is more valuable than the same quantity of grain at the time of threshing. It will, therefore, be seen that after taking everything into consideration, one and one-half bushels per acre surpassed the lighter seeding and was fully equal or probably a little better than the heavier seeding.

Winter wheat, which was sown broadcast by hand, gave practically the same results as that which was drilled in with a machine, in the average of duplicate tests made in each of eight years. It should be understood that the land was in a good state of cultivation in every instance and that the amount of seed used was the same throughout. Had the land been dry and lumpy there would probably have been much better returns from the drill as compared with the broadcast seeding.

In an experiment conducted for two years, winter wheat sown from a tube drill in the ordinary way gave a larger yield than that which was cross drilled or than that which was sown from every second tube. In the cross drilling, one-half the amount of seed was sown in each of two directions, and when only one-half the tubes were used each tube received double the amount of seed. It will, therefore, be seen that the same rate of seeding per acre was used throughout.

The Effect of Cutting Winter Wheat at Different Stages of Maturity.

In the autumn of 1896, five plots of the Dawson's Golden Chaff and five plots of the Early Genesee Giant varieties of winter wheat were sown at the same time and under uniform conditions. In the summer of 1897 each variety of winter wheat was cut at five different stages of maturity. One week was allowed between each two cuttings. The first cutting took place about two weeks earlier than the wheat is usually cut throughout the Province. The third cutting, therefore, would represent pretty closely the condition in which winter wheat is cut on the average. Seed obtained from the different cuttings of the two varieties were secured and again sown under uniform conditions in the autumn of 1897. This process of cutting at different stages of maturity and of using the seed from the different cuttings has been repeated from year to year until the present time, with the exception of 1899, in which year the results were unsatisfactory. This experiment has, therefore, been conducted in full in each of twenty years, from which definite returns have been secured. The following table gives the average results of twenty years' tests in cutting two varieties of winter wheat at five different stages of maturity, also those for each of four periods of five years each:

Winter Wheat.	Cuttings.	1897-1902. Average 5 years.	1903-1907. Average 5 years.	1908-1912. Average 5 years.	1913-1917. Average 5 years.	1897-1917. Average 20 years.
Bushels of Grain per acre ..	1st	24.38	14.93	14.43	30.66	21.10
	2nd	46.13	33.70	28.42	42.02	37.57
	3rd	57.28	46.53	39.19	47.83	47.71
	4th	60.07	55.29	42.62	46.69	51.17
	5th	56.86	52.32	41.24	48.13	49.64
Weight of Grain per measured bushel	1st	44.18	36.84	44.56	55.17	45.19
	2nd	56.22	50.86	55.92	59.49	55.62
	3rd	59.56	57.88	60.63	60.25	59.58
	4th	59.10	59.21	60.70	60.07	59.77
	5th	57.97	59.02	59.81	58.34	58.79
Tons of Straw per acre	1st	4.31	4.15	2.56	2.96	3.49
	2nd	3.80	4.06	2.45	2.64	3.24
	3rd	3.40	3.86	2.22	2.59	3.02
	4th	3.47	3.61	2.12	2.52	2.93
	5th	3.38	3.23	1.99	2.56	2.79

The results here presented are interesting and are worthy of considerable study. It will be seen that in every instance the greatest yield of straw was produced from the grain which was cut when green, and that the yield of straw per acre decreased as the date of cutting advanced. In yield of grain per acre, however, the highest returns were secured from the grain which had been fully ripened. It is interesting to note that the fourth cutting produced winter wheat which weighed more per measured bushel than that which was cut one week later, as shown in the averages of each of the four periods. The determinations in weight per bushel throughout the whole period of the experiment were taken on an average of about ten or twelve days after the threshing had been completed. The whole experiment seems to point to the advantage of allowing winter wheat, grown in Ontario, to become pretty thoroughly ripened before it is cut.

Treatment of Wheat for Smut.

Scientific investigations have been conducted at different institutions in a study of the best methods for destroying the various smuts which occur in grain crops. The Department of Field Husbandry has made careful tests for studying the practical application of some of the most highly recommended treatments. The results of these practical tests are of special value to Ontario farmers who are actually engaged in the growing of grain crops. The spores of the smuts correspond with the seeds of the grains and germinate and grow when the conditions of heat and moisture become favorable. The smuts are fungus plants which enter the tissues of other plants such as those of the cereals, where they live and grow, and finally produce smut pores. The reproductive organs of the loose smut of wheat may exist in the tissues of the ripened grains and it is, therefore, difficult to kill these spores and also to retain the vitality of the wheat. Although the hot water treatment may be effectual in killing these spores, it is rather difficult to carry out satisfactorily in ordinary farm practice. It is important to secure seed wheat from farms which are not infested with the loose smut of wheat. The spores of the stinking smut of wheat, also called Bunt, which attach themselves on the outside surfaces of the ripened grains, can be readily killed by treatment. This fact is of great agricultural and economic importance.

For five years in succession an experiment has been conducted at the Ontario Agricultural College for the prevention of the stinking smut in wheat. There were in all five treatments. In every instance one sample was left untreated as a basis of comparison. The experiment was conducted in duplicate each year. The seed grain was obtained each season from a known source, and where no treatment for smut had been attempted for several years previously. The following treatments were used throughout:

(a) *Untreated.*—One sample of winter wheat of each variety was left untreated in order that the influence of the various treatments might be better observed.

(b) *Immersion in Hot Water.*—The grain was placed in a bag and immersed in water at about 115 degrees F. Soon afterwards, it was placed in water which was kept at a temperature of between 130 degrees and 135 degrees F. The grain was occasionally stirred and was allowed to remain in the water for a period of fifteen minutes. It was then spread out on a clean floor to dry, where it was stirred occasionally.

(c) *Immersion in Bluestone Solution for Twelve Hours.*—The bluestone solution was made by dissolving one pound of bluestone in twenty-five gallons of water, and the grain was immersed in this solution for a period of twelve hours.

(d) *Sprinkling with Bluestone Solution.*—The solution was made by dissolving one pound of bluestone in ten gallons of water, which was used for sprinkling over the grain until it was thoroughly moistened, after being carefully stirred.

(e) *Immersion in Diluted Formalin.*—The solution of formalin (40 per cent. formaldehyde) used for the immersion process with wheat was made by pouring one-half pint of the formalin into twenty-one gallons of water, and the grain was immersed in this solution for a period of twenty minutes, during which time it was stirred occasionally.

(f) *Sprinkling with Diluted Formalin.*—One-half pint of formalin was poured into five gallons of water and the grain was sprinkled with this solution and stirred until it was thoroughly moistened.

After the treatments had been made for a few hours, and the grain had become sufficiently dried, it was carefully sown on separate plots. When the winter wheat was about ready to cut, it was carefully examined and the heads containing stinking smut were gathered and shelled. The rest of the crop was then threshed and again examined for any smut balls from heads which had been missed in the standing crop. The accompanying table gives the average results in percentage of grains of winter wheat affected with the stinking smut. Besides this information, the average yields of winter wheat per acre for five years are included:

Materials.	Percentage of Smut.						Average yield of grain per acre 5 yrs. (bus.)
	1st yr. test.	2nd yr. test.	3rd yr. test.	4th yr. test.	5th yr. test.	Average 5 yrs.	
(*a*) Untreated	3.6	9.3	.6	.6	6.8	4.2	38.0
(*b*) Hot Water	.0	.0	.0	.0	.0	.0	40.6
(*c*) Bluestone—12 hours	.0	.0	.0	.0	.0	.0	40.2
(*d*) Bluestone—sprinkled	.0	.2	.0	.0	.1	.1	41.1
(*e*) Formalin—immersed	.0	.0	.0	.0	.0	.0	43.3
(*f*) Formalin—sprinkled	.0	.0	.0	.0	.0	.0	36.3

The results here show that treatment (e) was not only effectual in killing the smut entirely, but it also was the means of giving the highest average yield of grain per acre of the various treatments used. The immersion process is so complete in its results that it does not need to be repeated every year, providing care is exercised to prevent a further introduction of the smut spores. In preparing wheat for treatment, care should be taken to separate the unbroken smut balls from the wheat, either by cleaning the grain or by placing the seed in water and removing the smut balls as they float on the surface. Not only is it necessary to treat the grain, but the formalin solution should be used to kill the smut spores which are lodged in the bins, on the barn floors, on the bags, in the grain drills or wherever the living spores have an opportunity of reinfesting the grain.

The sprinkling process is used by some farmers, but unless great care is taken the method is not as complete in destroying all of the smut, and as a result it is frequently necessary to treat the grain every year.

Further experimental work in treating grain for smut is now under way. This includes not only the hand methods, but also the use of some machines which are manufactured for this purpose. Different strengths of solution for the sprinkling process are being used. Ten different treatments were tested in duplicate in 1917.

As a result of the past work which we have conducted at the College, we have obtained very satisfactory returns from immersing the winter wheat for twenty minutes in a solution made by mixing one pint of formalin with forty-two gallons of water. This treatment is easily applied, and is comparatively cheap. It has been effectual in completely killing all of the smut spores and in producing the largest average yield of wheat per acre of all the treatments used.

SPRING WHEAT.

According to the Bureau of Industries for Ontario, there were 182,957 acres of spring wheat in this Province in 1917. This is an increase of 38,652 acres over the year previous. The total production of spring wheat in Ontario, in 1917, was 1,465,555 bushels greater than that of the year previous. The average annual yields of spring wheat per acre in Ontario for the last thirty-six years, when divided into four periods of nine years each, are as follows:

Periods.	Years.	Annual yield per Acre (bus.)
1882–1890	9	15.3
1891–1899	9	15.5
1900–1908	9	17.6
1909–1917	9	18.2

It will be seen that as far as can be learned from the statistics of the Bureau of Industries for Ontario, there has been a gradual increase in yield of spring wheat per acre over the past thirty-six years. The average annual yield per acre for the last three years has been greater than that of any other three consecutive years since 1882, which is the full length of time for which data has been obtained.

Spring wheat is grown in every county and district of the Province, varying in area from 52 acres in Elgin county, which has the lowest, to 33,239 acres in Renfrew county, which has the highest. Those counties of the Province which grew the greatest number of acres of spring wheat in 1917 are in the following order; 1, Renfrew; 2, York; 3, Ontario; 4, Durham, 5, Carleton; 6, Lanark; 7, Northumberland; 8, Victoria; 9, Simcoe; and 10, Grey.

By multiplying the average yield per acre in Ontario for the past ten years of spring wheat, barley and oats, by the present price per bushel, we obtain the following figures:

Crops.	Average Annual Bushels per Acre. 10 years. 1908-1917.	Present Price per Bushel.	Average Annual Value of Grain per Acre.
Spring Wheat	18.0	$2.10	$37.80
Barley	29.5	1.20	35.40
Oats	35.7	0.75	26.78

The world is calling loudly for food materials, and especially for wheat. This is a special opportunity for Ontario to be of real service to humanity.

Varieties of Spring Wheat.

Twenty-one varieties of spring wheat, exclusive of Emmer, Spelt and Einkorn, have been under uniform tests at the Agricultural College in each of the past five years. The experiment was conducted on what might be termed an average clay loam. In part of the years the plots were located on a ridge and in other years on lower, sloping land. The following table gives the average results of the five years' experiment with each of twenty-one varieties of spring wheat:

Varieties.	Bearded or Bald.	Average Height (inches).	Per cent Rust.	Days to reach Maturity.	Weight per Measured Bushel (pounds).	Yield per Acre. Straw (tons).	Grain (bus.)
Flour Wheats.							
Saxonka	Bearded	48	10	116	60.94	2.52	38.88
Pringle's Champion	Bearded	48	8	116	60.99	2.58	38.31
Climax	Bearded	47	7	115	60.01	2.63	38.27
Marquis	Bald	41	12	111	61.27	2.09	37.54
Minnesota No. 163	Bald	46	8	115	58.75	2.35	36.47
Herison Bearded	Bearded	45	7	115	61.49	2.47	36.38
White Russian	Bald	44	8	115	58.51	2.37	36.10
Hungarian	Bearded	42	10	111	61.86	2.28	36.02
Red Fife	Bald	44	9	115	58.84	2.33	35.24
Red Fern	Bearded	48	9	115	60.34	2.38	35.09
White Fife	Bald	42	10	117	57.93	2.29	34.58
Colorado	Bearded	46	8	114	60.52	2.29	33.53
Prelude	Bearded	35	13	102	62.10	1.58	27.08
Durum Wheats.							
Arnautka	Bearded	46	4	114	62.66	2.14	40.28
Roumania	Bearded	46	4	115	62.29	2.07	39.38
Wild Goose	Bearded	46	3	114	62.30	2.19	38.90
Kubanka	Bearded	47	4	115	61.87	2.11	37.44
Sorentina	Bearded	46	4	112	61.09	2.10	34.42
Medeah	Bearded	45	4	111	61.35	2.02	33.19
Turgid Wheat.							
Seven Headed	Bearded	47	13	117	58.22	2.30	31.74
Polish Wheat.							
Polish	Bearded	42	9	116	57.19	1.98	24.26

The Saxonka, the Pringle's Champion and the Climax, which occupy the three highest places in yield per acre of the flour wheats, are not grown extensively in Ontario. The Marquis variety of spring wheat, which occupies fourth place in average yield per acre, is a hybrid wheat originated at the Central Experimental Farm, Ottawa, from crossing the Calcutta Hard Red and the Red Fife. It is not only a good yielder, but it is a wheat of excellent quality for bread production and one which is increasing substantially in the Western Provinces and in Ontario. It occupies a somewhat similar position amongst the spring wheats as does the O.A.C. No. 21 barley, the O.A.C. No. 72 oats and the O.A.C. No. 61 spring rye amongst other classes of spring grain. Of the Durum wheats, the Wild Goose variety has been grown for many years in Ontario, and is popular amongst the farmers. The Arnautka is very similar to the Wild Goose but is not grown much in Ontario under that name.

In each of the years 1915 and 1916, the varieties of spring wheat were milled and uniform quantities of flour were tested for bread production in the Bakery branch of the Chemical Department at the College. The leading varieties in volume of loaf are given in the following order: Prelude, Marquis, White Fife, White Russian, Hungarian and Minnesota No. 163. Those varieties which produced the lowest volume of bread were Polish, Seven Headed and Medeah. The Prelude, which came first in size of loaf, was also originated at the Central Experimental Farm. The Saxonka, which secured highest place of the flour wheats in average yield of grain per acre for five years, occupied fourteenth place in comparative size of loaf in the baking tests of two years, but in this respect slightly surpassed both the Pringle's Champion and the Climax varieties.

A new hybrid variety of spring wheat has been originated at our College by crossing the Red Fife and the Herison Bearded varieties, and it has given an average yield of grain of 40.7 bushels per acre per annum in the experiments for the last five years. This is a higher average yield per acre than any of the named varieties. In comparative size of loaf, from a definite quantity of flour, it was surpassed by nine of the twenty-one named varieties reported in the previous table. This new variety has not been distributed for general cultivation.

Seven varieties of flour wheats have been under test at the College in each of the past twenty-seven years. It might be interesting to compare the yields per acre, in periods of nine years, of these separate varieties with the yields of all varieties in general cultivation over the Province, as determined by the Ontario Bureau of Industries and as referred to in an earlier portion of this bulletin:

Varieties.	Annual Yield per Acre. (Bus.)			
	1891-1899 Average 9 years.	1900-1908 Average 9 years.	1909-1917 Average 9 years.	1891-1917 Average 27 years.
Saxonka	30.7	33.6	35.0	33.1
Red Fife	29.4	33.6	33.3	32.1
Pringle's Champion	28.0	33.7	33.9	31.9
White Russian	29.6	32.6	32.1	31.4
Red Fern	29.4	33.0	31.8	31.4
Herison Bearded	30.0	31.7	32.2	31.3
Colorado	26.3	31.1	29.6	29.0
Average seven varieties	29.1	32.8	32.6	31.5

The Saxonka has the highest record in average yield of grain per acre of thirteen named varieties of flour wheat tested for five years, and also of seven varieties tested for twenty-seven years in succession. An average record of 31½ bushels of spring wheat per acre, representing seven varieties grown in the experimental grounds at the Ontario Agricultural College in each of the past twenty-seven years, shows that spring wheat can still be grown in Ontario with a considerable amount of success.

It is interesting to know that each of these seven varieties of spring wheat were grown at the College for twenty-seven years in succession without any plant selection and without any change of seed from an outside source during that period of time. It shows that with care in sowing, nothing but good seed varieties of spring wheat may be grown on the same farm in Ontario for a long period of time without change of seed and without any marked decrease in yield of grain per acre.

Seed Selection of Spring Wheat.

Experimental work in seed selection with spring wheat was conducted at the Ontario Agricultural College in each of eight years. The two varieties used were the Herison Bearded and the Bart Tremenia. As in the case of winter wheat, the selections were not continuous throughout the whole period, but they were made from a bulk lot of spring wheat each year. As this experiment was repeated in so many different seasons, a knowledge of the immediate influence from the different selections should prove of real service to the growers of spring wheat. A uniform number of seeds for the different selections were used. The following table gives the average results of each of three selections of spring wheat conducted over a period of eight years:

Selections.	Yield of Straw per Acre (tons).	Weight of Grain per Measured Bushel (pounds).	Yield of Grain per Acre. (bushels).
Large plump seed	1.4	59.1	21.7
Small plump seed	1.3	58.3	18.0
Shrunken seed	1.2	56.9	16.7

The large, plump seed gave the best results in yield of both straw and grain per acre and in weight of grain per measured bushel. The results show that large, plump seed gave an increase over small, plump seed of about 20 per cent., and over shrunken seed of about 30 per cent. This shows the importance of cleaning and grading spring wheat so as to secure the large, plump, sound grain to be used for seed if the highest returns are to be expected.

Sowing Spring Wheat at Different Dates.

For five years in succession an experiment was conducted at the Ontario Agricultural College in sowing spring wheat at six different dates in the spring, commencing as early as the land could be worked satisfactorily and allowing one week between each two dates of sowing. In each year the experiment was conducted in duplicate by sowing one plot at each date of seeding with the grain drill and another plot broadcast by hand. The average results of the ten separate tests conducted in the five-year period are as follows:

Seedings.	Yield of Straw per Acre (tons).	Weight of Grain per Measured Bushel (pounds).	Yield of Grain per Acre (bushels).
1st	1.2	60.1	21.9
2nd	1.1	59.6	19.2
3rd	1.0	59.0	15.4
4th	.9	58.9	13.0
5th	.6	56.5	8.4
6th	.8	54.0	6.7

The varieties of grain used in this experiment were the Pringle's Champion and the Herison Bearded. The earliest seeding gave the best results throughout. It is interesting to note that there was a gradual decrease in crop production as the dates advanced from the beginning to the end of the test. According to the results of the experiment, there was an average decrease in yield of spring wheat per acre of 26.1 pounds for each day's delay after the first seeding took place. Of all spring cereals grown in Ontario, wheat should be sown earliest. It is therefore essential, if the best results are to be obtained, to sow spring wheat as early in the spring as the season will permit.

Cultural Methods.

Spring wheat thrives on almost any fertile soil which is well drained and in a good state of cultivation. As a rule, however, it does not give as large returns on a sandy or a gravelly soil.

Tests have been made at the College in comparing the results in growing spring wheat after potatoes and fall turnips for each of three years, and after corn, swede turnips, carrots and rape for one year. The results show very good yields of spring wheat per acre after each of these cultivated crops, and particularly good returns after potatoes and corn. It is of great importance to have land either ploughed or cultivated in the autumn so as to permit of early seeding of the wheat in the following spring.

Spring wheat was sown at the College with a tube drill and broadcast by hand on well cultivated land at each of six different dates in each of five years. The results go to show that in yield of grain per acre of the five separate dates for which we have complete returns, the drilled grain gave the highest yields in the average of each of four dates, and the grain which was sown broadcast by hand gave the highest returns in the average of one date. In averaging the results for all dates of sowing, there was but slight difference in the returns from the two methods of seeding. If the land had been poorly prepared and lumpy, it is quite likely that the grain which was sown with the tube drill would have produced a considerably higher yield than that which was sown broadcast.

Spring Wheat Used as a Pasture and in Mixtures.

In each of five years fourteen different classes of spring crops were sown on uniform plots to determine the amount of pasture material which could be obtained. Each of the crops was cut and weighed every three weeks throughout the summer. The average results for the five years show that the spring cereals gave the following amount of green pasture per acre annually: Oats, 8.7 tons; spring rye, 7.4 tons; barley, 6.8 tons; and spring wheat, 5.2 tons. The oats gave the highest amount of pasture and the spring wheat the second lowest amount of pasture of the fourteen kinds of crops under test.

Some farmers seem to be of the opinion that by adding spring wheat to a seeding mixture of oats and barley for grain production they do not reduce the yield of oats and barley per acre, and that they get a fair yield of spring wheat in addition. In our experiments at Guelph, we have obtained particularly good results from a mixture of oats and barley. An experiment was conducted in duplicate in each of five years to ascertain whether any other grains could be added to a mixture of oats and barley to furnish an increase in the yield. In the average of ten tests made in five years, it was found that one bushel of oats and one and one-half bushels of barley sown per acre gave a yield of 2,612 pounds, and that a mixture of one bushel of oats, one and one-half bushels of barley and one-half bushel of Wild Goose spring wheat sown per acre gave a yield of 2,512 pounds of mixed grain. It will, therefore, be seen that by adding one-half bushel of spring wheat to the seeding mixture the resultant crop was reduced by exactly one hundred pounds per acre.

Emmer, Spelt and Einkorn.

Emmer and spelt are used in some countries to a limited extent for flour production. When used for this purpose, however, special machinery is required for separating the chaff or the hull from the grain, as the grain is usually surrounded by the chaff after being threshed. In this country these grains are considered from the standpoint of the amount of feed which they will produce for farm stock. Emmer is about equal to barley for feeding purposes. The following table gives the average results of growing at the College each of three varieties of emmer and of four varieties of spelt over a period of sixteen years:

Classes of Crop.	Varieties.	Average Results for 16 years.					
		Per cent. of Rust.	Per cent. of Crop Lodged.	Per cent. of Hull.	*Weight per Measured Bushel (pounds).	Yield per Acre. Straw (tons).	Yield per Acre. Grain (pounds)
Emmer	Iowa	2	22	19.7	39.6	1.84	2,906
Emmer	Common	2	25	20.2	39.4	2.05	2,869
Emmer	Russian	2	20	20.4	39.6	1.83	2,758
Spelt	Red	12	5	28.8	27.7	1.63	2,120
Spelt	Alstroum	16	3	29.5	27.3	1.61	2,100
Spelt	White	15	3	30.1	27.1	1.58	2,009
Spelt	Bearded	13	11	27.4	28.7	1.64	1,935

*Average results for 15 instead of 16 years.

The emmer surpassed the spelt in freedom from rust, thinness of hull, weight of grain per measured bushel and in yield of both straw and grain per acre. The spelt, however, surpassed the emmer somewhat in strength of straw. The Iowa emmer, which has the smallest percentage of hull of the varieties included in this test, gave the greatest number of pounds of grain per acre.

A co-operative experiment was conducted over Ontario in each of four years in which tests were made on ninety-three separate farms, comparing the average yield in pounds per acre of O.A.C. No. 21 barley and Common emmer under similar conditions. The following were the average yields of grain per acre per annum of all the tests made in the four years: O.A.C. No. 21 barley, 1,673 pounds, and Common emmer, 1,402 pounds. The barley surpassed the emmer in grain production in each of the four years.

Black winter emmer has been grown under test at the College in each of the past ten years, and has given an average annual yield of 2.1 tons of straw and of 2,345 pounds of grain. The average weight per measured bushel of the grain, including the hull, was 27.6 pounds. This yield is somewhat lower than the average yields of the spring varieties of emmer. The yield of grain in pounds per acre has varied from 138 in 1912 to 4,146 in 1915.

The average results of an experiment extending over a period of ten years show that in average yield of grain per acre per annum, the Common emmer gave 2,644 pounds and the Einkorn 1,780 pounds. It will be seen that the Einkorn which is mentioned in the earlier part of this bulletin as a distinct type of wheat, is not of any special agricultural value as a grain producer in this Province.

Dates of Sowing Emmer and Spelt.

In each of five years both emmer and spelt were sown on eight different dates in the spring, by making the first date in the season as early as the land was suitable for cultivation. One week was allowed between each two dates of seeding. The Common Emmer and the Red Spelt were the special varieties used. The average results of the experiment for five years are presented in the following table:

Dates of Seeding.	Average Results for five years.					
	Pounds per Measured Bushel.		Tons of Straw per Acre.		Pounds of Grain per Acre.	
	Spelt.	Emmer.	Spelt.	Emmer.	Spelt.	Emmer.
First	28.3	40.1	1.6	1.9	2,377	2,747
Second	27.3	39.1	1.6	2.0	2,163	2,848
Third	26.3	39.1	1.7	2.0	1,898	2,646
Fourth	24.9	37.6	1.6	2.1	1,582	2,754
Fifth	24.2	36.7	1.5	2.1	1,287	2,569
Sixth	21.6	36.1	1.6	2.3	933	2,465
Seventh	19.6	35.4	1.5	2.4	685	2,312
Eighth	19.9	34.0	1.5	1.9	499	1,953

The figures representing the pounds per measured bushel and the pounds of grain per acre include the chaff or hull surrounding the grain, as well as the grain itself. In the examination of the results here presented, the reader will be impressed with the superiority of the emmer as compared with the spelt in weight of grain per measured bushel, and in yield of both straw and grain per acre. In no instance does the spelt show a better record than the emmer. It will be noticed that even the fourth seeding of emmer produced a higher yield of grain per acre than that obtained from the first seeding. The results seem to indicate that emmer may be sown at a later date than the ordinary varieties of spring wheat.

RYE.

In Canada and in the United States rye is principally used as a feed for farm stock, but in Europe it is used extensively for bread production. Rye is more hardy than wheat and can be grown in more extreme northern latitudes. At the Ontario Agricultural College, winter wheat sometimes becomes winter killed, but winter rye practically always survives without injury. According to the report of the Bureau of Industries for Ontario, the following average annual number of acres of rye grown in this Province in each of four periods of nine years is as follows:

Periods.	Years.	Average Number of Acres of Rye grown in Ontario annually.
1882–1890	9	107,610
1891–1899	9	117,700
1900–1908	9	126,219
1908–1917	9	123,061

In 1917 there were 133,077 acres of rye produced in this province. The average yield in bushels of rye per acre in Ontario is given as 17.0 for the last three, and as 16.5 for the past thirty-six years. The statistics gleaned by the Bureau of Industries for rye are for all varieties, and no distinction is made between those which were sown in the autumn or in the spring.

According to the agricultural statistics of Canada for the past two years, Ontario has thirty-eight per cent. of the acreage of the rye of the Dominion.

In 1916, of all the States of the American Union, each of nine had a greater acreage of rye than the Province of Ontario. The annual average yield in bushels of rye per acre for the whole of the United States, from 1906 to 1915 inclusive, is given as 16.2.

Varieties of Winter Rye.

Four varieties of winter rye have been under test at the Ontario Agricultural College in each of the past fourteen years. The following gives the average results for the whole period:

Varieties.	Per cent. of Crop Lodged.	Weight per Measured Bushel (pounds).	Yield per Acre.	
			Straw (tons).	Grain (bushels).
Mammoth White	12	57.2	3.9	55.8
Washington	22	57.3	3.7	53.0
Common	11	57.4	3.8	52.0
Thousand Fold	19	57.0	3.8	51.4

It will be seen that all varieties of winter rye have produced a high average yield of grain per acre. It should be understood that these have been grown on similar soil to that used for the other cereals. In many cases over Ontario, winter rye is sown on land which is so poor that it will scarcely grow any other crop. If winter rye were sown under similar conditions as winter wheat over Ontario, the yields per acre would surprise many farmers.

For six years in succession the Petkus variety of winter rye has been included in the experiments and has surpassed all other kinds with two slight exceptions in each of the six years. The average yield per acre per annum of the Petkus winter rye surpassed that of the next highest yielding variety by 4.7 bushels.

Petkus winter rye was distributed throughout Ontario for co-operative experiments in the autumns of 1914 and 1915 with Imperial Amber winter wheat, and in 1916 with American Banner winter wheat. The average results show that the rye surpassed the winter wheat by 380 pounds in 1915, 344 pounds in 1916, and 240 pounds in 1917.

Winter Rye as a Nurse Crop for Hairy Vetches.

In each of two years three plots of Hairy Vetches, with some other kind of grain, have been tested at the Agricultural College for seed production. The Hairy Vetches were used at the rate of 60 pounds per acre throughout and were mixed with other grains as follows: Petkus winter rye, 56 pounds; Dawson's Golden Chaff winter wheat, 60 pounds; and Black Winter emmer, 40 pounds. The average results for the two years are here presented:

Mixtures.	Average Yield per Acre (pounds.)	
	Vetches.	Cereals.
Hairy Vetches and Winter Rye..........	489	1705
Hairy Vetches and Winter Wheat	337	849
Hairy Vetches and Winter Emmer	422	286

These results show that Hairy Vetches and Winter rye grow very satisfactorily when sown in combination. In some places in the southern extremity of the Province, Winter rye and Hairy Vetches are now grown in combination with much satisfaction. The combination might be used for different purposes, and especially as a cover crop for orchards. The rye makes an excellent nurse crop for vetches when it is desirable to produce the seed of Hairy Vetches in Ontario.

In another experiment which was conducted in each of the past two years by sowing in combination three different quantities of Hairy Vetches and three different quantities of Petkus winter rye per acre for seed production, the average results show that in yield per acre of both the winter rye and the Hairy Vetches the highest returns were obtained by using 60 pounds of the former and 50 pounds of the latter, or a mixture of 110 pounds of seed per acre.

Winter Rye as a Pasture and as a Fodder Crop.

Winter rye, when sown in August or very early in September, is frequently pastured to a limited extent in the fall or in the spring, and occasionally it is pastured in both seasons and afterwards allowed to produce either a crop of fodder or a crop of grain. Winter rye forms an excellent grazing crop in the autumn, and especially for milk production. The special advantage of sowing winter rye in the autumn for pasture or for green fodder in the spring is the fact that it will furnish a considerable amount of green material earlier in the spring than other forage plants and before the pasture grasses are available. Experiments are now under way at the College in the sowing of winter rye in the spring of the year for summer pasture. When winter rye is sown in the spring, it gives a heavy leaf development but produces only a very small amount of grain. As yet sufficient work has not been carried on to furnish results for publication.

Green rye has been placed in the College silo on two or three occasions, but it has been found very difficult to make good rye silage. This is probably owing to the hollow stems of rye holding considerable air and, therefore, not forming as compact a body of material as some of the other crops such as corn.

A co-operative experiment was conducted on different farms over Ontario in testing winter rye for the production of green fodder. In the average of five years' experiments, the winter rye gave 7.93 tons per acre per annum.

Cultural Methods for Winter Rye.

Rye does particularly well on clay or sandy loam soils, and better than wheat or barley on poor soils and under unfavorable climatic conditions. All soils for rye, however, should be well underdrained. It is claimed that rye has a greater water requirement than any other cereal except oats.

Winter rye occupies about the same place in a rotation and requires about the same preparation of soil as winter wheat. As rye is not a heavy stooler, eight pecks per acre is frequently sown. Although best results are usually obtained in Ontario from sowing winter rye in the early part of September, it is frequently not sown until the latter part of the month or even into the month of October. Rye will stand later seeding than winter wheat without serious injury.

Varieties of Spring Rye.

Statistics are not collected in Ontario in regard to the relative proportions of spring and winter rye which are grown. The spring varieties, however, are grown to a limited extent, although the yields per acre are not usually as large as those obtained from sowing in the autumn. An experiment has been conducted at the College with four varieties throughout the past ten years, with the following results:

Varieties.	Weight per Measured Bushel (pounds).	Yield per Acre.	
		Straw (tons.).	Grain (bushels).
O. A. C. No. 61	54.0	2.2	30.1
Saatroggen	54.4	2.2	29.6
Prolific	54.2	2.0	26.6
Common	53.9	2.1	26.3

The O.A.C. No. 61 variety of spring rye was obtained through selection of individual plants from a variety of winter rye obtained from Germany.

A co-operative experiment with two varieties of spring rye was conducted over Ontario in each of the past seven years. The following gives the average yields per acre in each of the years and for the whole period:

Varieties.	Average Yield of Grain per Acre (bushels).							
	1911.	1912.	1913.	1914.	1915.	1916.	1917.	Average 7 years.
O. A. C. No. 61	17.9	26.8	20.0	25.4	18.2	42.1	22.5	24.7
Common	16.3	24.5	15.9	25.0	12.5	36.4	20.4	21.6

In the average of these co-operative tests conducted on thirty farms throughout Ontario, it will be seen that the O.A.C. No. 61 surpassed the Common variety of rye in each of the seven years. The average yield for the whole period was 3.1 bushels per acre per annum in favor of the former.

Seed Selection of Spring Rye.

In each of the six years, from 1912 to 1917 inclusive, different selections of seed of spring rye have been tested at the College under similar conditions. Careful selections were made from a bulk lot of rye each spring and a uniform number of seeds were used for each plot. The following table gives the average of six years' results of the different selections:

Selections.	Weight per Measured Bushel (pounds).	Yield per Acre.	
		Straw (tons).	Grain (bus.).
Large seed	53.3	2.0	26.0
Medium seed	53.3	2.0	24.4
Small seed	53.5	1.9	22.3
Broken seed	52.8	1.6	16.9

It will be seen that the influence of selection of seed in spring rye is not quite as marked as in the case of either winter wheat or spring wheat. The results, however, of this experiment, as well as all others which we have conducted in seed selection, show the importance of thoroughly cleaning grain so as to get the very best seed possible if the highest returns are to be obtained.

CONCLUSION.

This bulletin on "Wheat and Rye" is submitted to the farmers of Ontario with the expectation of the writer that it will prove of real service in increasing the production of essential food materials. These important grains might be considerably increased in this Province without the requirement of much additional labor. The increased production of wheat and rye occupies the unique position of filling a world-wide need and of furnishing greater remuneration to the growers.

INDEX.

	PAGE.
Introduction	3
Crop Production	4
Wheat Production	4
Botanical Classification of Wheat	5
Popular Classification of Wheat	6
Varieties of Winter Wheat	7
Seed Selection	8
Testing the Quality of Wheat	9
Improvement of Wheat by Plant Selection	10
Hybridization	10
The O. A. C. No. 104 Variety of Winter Wheat	11
Varieties of Winter Wheat Grown in Combination	12
Soil, Rotation, Cultivation and Fertility	12
Dates of Seeding, Seed per Acre, and Method of Sowing	14
The Effect of Cutting Winter Wheat at Different Stages of Maturity	15
Treatment of Wheat for Smut	16
Spring Wheat	18
Varieties of Spring Wheat	19
Seed Selection of Spring Wheat	21
Sowing Spring Wheat at Different Dates	22
Cultural Methods	23
Spring Wheat Used as a Pasture and in Mixtures	23
Emmer, Spelt and Einkhorn	24
Dates of Sowing Emmer and Spelt	25
Rye	26
Varieties of Winter Rye	26
Winter Rye as a Nurse Crop for Hairy Vetches	27
Winter Rye as a Pasture and as a Fodder Crop	28
Cultural Methods for Winter Rye	28
Varieties of Spring Rye	28
Seed Selection of Spring Rye	29
Conclusion	30

LIST OF BULLETINS

Published by the Ontario Department of Agriculture, Toronto.
Available at Date of Issue of Latest Bulletin.

Serial No.	Date.		Title.
135	June	1904	The Cream-gathering Creamery.
138	Feb.	1905	The Composition of Ontario Feeding Stuffs.
141	April	1905	Gas-producing Bacteria and Their Effect on Milk and its Products.
156	May	1907	Tillage and Rotation.
164	March	1908	Legume Bacteria.
167	Oct.	1908	Mitchell-Walker Moisture Test.
170	March	1909	Mitchell-Walker Test Bottle.
174	Dec.	1909	Farm Underdrainage: Does It Pay?
175	Dec.	1909	Farm Drainage Operations.
178	Dec.	1909	Character and Treatment of Swamp or Muck Soils.
184	Nov.	1910	Uses of Vegetables, Fruits and Honey.
187	Jan.	1911	The Codling Moth.
188	April	1911	Weeds of Ontario (No. 128, revised).
195	Jan.	1912	Insecticides and Fungicides (No. 154 revised).
198	Feb.	1912	Lime-Sulphur Wash.
205	Sept.	1912	Dairy School Bulletin (No. 172 revised).
			Part I. Cheese-making and Butter-making.
207	Dec.	1912	Ice Cold Storage on the Farm.
209	March	1913	Farm Forestry (No. 155 revised).
211	March	1913	Fruits Recommended for Ontario Planters.
212	April	1913	Orchard Surveys in Dundas, Stormont and Glengarry.
213	April	1913	Bee Diseases in Ontario.
216	Oct.	1913	Box Packing of Apples.
218	Dec.	1913	Birds of Ontario (No. 173 revised).
219	Jan.	1914	The San José and Oyster-Shell Scales.
220	March	1914	Lightning Rods.
221	April	1914	Food Value of Milk and its Products.
222	April	1914	Currants and Gooseberries.
223	May	1914	Fertilizers.
224	Sept.	1914	Greenhouse Construction.
225	Dec.	1914	Swine.
226	Dec.	1914	Plum Culture in Ontario.
227	Jan.	1915	Cherry Fruit-Flies.
229	Feb.	1915	Smuts and Rusts of Grain Crops.
230	March	1915	The Cherry in Ontario.
231	April	1915	Vegetable Growing.
232	April	1915	Field Beans.
237	March	1916	The Grape in Ontario.
238	May	1916	Lime and its Use in Agriculture.
239	May	1916	Potatoes.
240	June	1916	Bacterial Diseases of Vegetables.
241	July	1916	Peach Growing in Ontario.
242	Dec.	1916	Diseased Mouths a Cause of Ill-health.
243	Dec.	1916	Nature Study, or Stories in Agriculture.
244	Dec.	1916	Hints for Settlers in Northern Ontario.
245	Dec.	1916	Food Values.
246	Jan.	1917	Suggestions on Feeding Stock.
247	April	1917	Farm Poultry (No. 217 revised).
248	April	1917	Pruning.
249	May	1917	The Pear in Ontario.
250	July	1917	Insects Attacking Fruit Trees.
251	July	1917	Insects Attacking Vegetables.
252	July	1917	The Preservation of Food: Home Canning.
253	Aug.	1917	Dairy Cattle.
254	Aug.	1917	War Breads.
255	Oct.	1917	Tuberculosis of Poultry in Ontario.
256	Oct.	1917	Wintering Bees in Ontario.
257	Dec.	1917	Diseases of Fruit Trees.
258	Jan.	1918	Diseases of Vegetables.
259	Feb.	1918	Books on Agriculture.
260	Feb.	1918	Co-operative Experiments with Farm Crops.
261	Mar.	1918	Wheat and Rye.

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

BULLETIN 262

SUGAR BEETS

By

C. A. ZAVITZ, B.S.A., D.Sc.,
Professor of Field Husbandry, Director of Field Experiments

and

A. W. MASON, B.S.A.,
Assistant Experimentalist.

TORONTO, ONTARIO. MARCH, 1918.

KLEINWANZLEBENER SUGAR BEETS.

Left: Root grown under adverse soil conditions.
Right: Root grown in mellow soil.

BULLETIN 262 MARCH, 1918

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

SUGAR BEETS

By C. A. Zavitz and A. W. Mason

SUGAR PRODUCTION.

The sugar production of the world, under normal conditions, amounts to about twenty million tons annually. Approximately one-half of the total supply is made from beets and one-half from cane. About three-quarters of the cane sugar is produced in Cuba, India, and Java and one-quarter of the beet sugar in Germany.

In the average for the nine years from 1905 to 1913 inclusive, five countries which are now at war, namely, Russia, France, Belgium, Germany and Austria-Hungary, produced 40 per cent. of the world's total supply of sugar and 87 per cent. of the sugar made from beets. Of the amount of sugar produced in the five countries here referred to, Germany and Austria-Hungary produced 60 and Russia, France and Belgium produced 40 per cent. Practically all of the sugar of Russia, comprising about 9 per cent. of the sugar of the world, was produced in the south-western portion known as Little Russia or Ukraine.

Before the outbreak of the war, England imported about 1,400,000 tons of sugar from Germany and other neighboring countries. France produced 750,000 and Italy 210,000 tons before the war, and in 1917 the production had fallen to 207,000 tons for France and 75,000 tons for Italy.

It has been recently stated that Great Britain, France and Italy require for use during 1918 approximately two million tons of sugar to be secured from countries outside of Europe. To obtain this supply from India or Java would take three times as long for transportation as to secure it from Cuba. As Cuba furnishes 48 per cent. of the sugar used in the United States, the supply for export to Europe is, therefore, greatly reduced. The domestic production of sugar is 23 per cent. in the United States and only about 5 per cent. in Canada, the rest of the supplies being imported.

The estimated consumption of sugar per capita per annum in the United States for the five years from 1912 to 1916 inclusive, was 84.7 pounds, and for the year from August 31st, 1916, to August 31st, 1917, 88.3 pounds. The consumption of sugar in Canada per unit of population is estimated to be fully as great as that of the United States. In August, 1917, the British Government reduced the household sugar ration to a basis of 24 pounds per annum per person, and in the following month the French Government reduced the annual ration per capita to 13.2 pounds.

THE SUGAR BEET INDUSTRY IN ONTARIO.

Not only have sugar beet experiments been conducted at the Ontario Agricultural College, but co-operative experiments have been conducted by the Department of Field Husbandry through the medium of the Experimental Union and by the Department of Chemistry in testing and analyzing sugar beets in various parts of the Province. The Chemical Department analyzed samples of sugar beets which were forwarded to the College from different parts of the Province as follows: 26 in 1889, 117 in 1890, 32 in 1891, 40 in 1897, and 89 in 1899. These samples varied greatly in amount of sugar, many of them giving less than twelve per cent. The low percentage of sugar was due to the fact that some of the varieties forwarded by the growers were unsuitable for sugar production, and in many instances the beets were grown as ordinary root crops with but little special reference to high sugar production. Of all the samples analyzed 158 out of 304 or practically 52 per cent. were below the standard for factory purposes. The investigational work, however, showed that under proper conditions, Ontario could grow sugar beets with good satisfaction for sugar production. By more thorough and systematic experiments conducted by the Chemical Department it was clearly shown that in yield, in quality, and in cost of cultivation of sugar beets, Ontario farmers in certain extensive districts of the Province could realize comparatively large profits by growing sugar beets and selling the same at the prices paid by American beet sugar factories.

In 1901, four sugar beet factories with an aggregate capacity for slicing two thousand two hundred tons of beets per day were built at Berlin, Waterloo County; at Wiarton, Bruce County; and at Wallaceburg and Dresden, Kent County. In 1904, the Dresden Sugar Company removed their factory to the State of Wisconsin, and the Wiarton Sugar Manufacturing Company suspended operations. In 1915 and 1916, an exceptionally fine sugar beet factory was erected at Chatham, and in 1917 beet sugar was manufactured by the Dominion Sugar Company at their three factories in Kitchener, Wallaceburg, and Chatham. These three factories collectively can manufacture sugar from approximately thirty-three thousand acres of sugar beets. They are offering for 1918 an option of $9 per ton for sugar beets with an increase of $1 per ton for each advance of one cent over eight cents in the wholesale price of sugar or of $8.75 per ton for beets analyzing twelve per cent. sugar with an increase of 33⅓ cents per ton for each advance of one per cent. of sugar. In the past few years the sugar beets grown in Ontario have given an average of about ten tons per acre and of sixteen and one-half per cent. of sugar. In consideration of the great scarcity of sugar throughout the world it seems reasonable to expect that a sufficient quantity of sugar beets of high quality will be grown in Ontario to supply the three factories to the limit of their capacity.

In France, Germany and Austria-Hungary, women and girls did much of the thinning and the weeding of the sugar beets previous to the war. Owing to the present scarcity of labor in Ontario, women and girls from towns and cities could help materially in thinning, weeding and hoeing the sugar beet crops during the war period.

Varieties of Sugar Beets and of Sugar Mangels.

The percentage of sugar amounts to approximately five per cent. in mangels, ten per cent. in sugar mangels, and fifteen per cent. in sugar beets. There are, of course, quite decided variations in the percentage of sugar owing to varieties used and methods of cultivation practised. Mangels grow largely above the ground, sugar beets almost completely under the surface of the soil, and sugar mangels occupy an intermediate position in this respect. Mangels and sugar mangels are grown for feed production and sugar beets for the manufacture of beet sugar.

Numerous experiments have been conducted at the Ontario Agricultural College in growing mangels and sugar mangels as feed for farm stock, and in growing sugar beets to determine the quantity and the quality of the roots produced in Ontario for sugar production.

For six years in succession fourteen varieties of sugar beets and sugar mangels were carefully tested under uniform conditions in the Field Husbandry Department at the College. The tests were made in the experimental field which is composed principally of an average clay loam. The land received one application of farm-yard manure in each rotation of four years, no commercial fertilizers being used. The roots followed grain crops, the land being ploughed in the autumn. The rows were 21 inches apart and the roots 7 inches apart in the rows. At the time of harvest careful determinations were made of the weights of both the roots and the tops and of the number of roots of each variety. A number of average roots were collected each year and taken to the Chemical Department, where they were analyzed. The following table gives the average results of the six years' experiments in showing the yields per acre and the quality of the roots for sugar production:

Varieties.	Average 5 years. Length of Roots. Above Ground (ins.)	Average 5 years. Length of Roots. Below Ground (ins.)	Average 6 years. Weight per Root (lbs.)	Average 6 years. Yield per Acre. Tops (tons).	Average 6 years. Yield per Acre. Roots (tons).	Average 6 years. Analysis of Juice. Purity.	Average 6 years. Analysis of Juice. Sugar.
1 Improved Imperial....	.57	5.66	.99	5.98	18.42	88.5	17.0
2 Kleinwanzlebener	.58	6.02	1.04	8.47	20.68	87.8	16.6
3 Petzscheke's Elite....	.62	5.97	1.06	6.62	19.07	87.1	16.1
4 Champion	1.31	6.77	1.05	7.79	20.69	85.0	15.6
5 White Silesian........	1.14	6.14	1.19	5.77	22.57	83.0	13.7
6 Lane's Improved	1.61	5.73	1.11	5.22	21.54	82.5	12.8
7 French Yellow........	1.45	6.36	.95	4.59	17.81	82.7	12.7
8 Green-Top White.....	1.08	5.77	1.15	5.72	22.61	81.0	12.6
9 Red Skinned.........	1.83	6.22	1.18	4.45	22.94	80.8	11.7
10 Red Top..............	2.72	5.47	1.24	3.96	24.54	81.4	10.9
11 New Danish Improved	2.66	5.59	1.27	6.66	25.20	80.3	10.8
12 Giant Rose Feeding...	3.22	5.15	1.29	2.48	25.93	81.7	10.3
13 Royal Giant..........	3.50	5.27	1.36	2.95	26.97	79.7	9.9
14 Giant White Feeding..	3.78	4.68	1.49	3.48	29.91	72.2	8.4

Of the fourteen varieties of roots included in the table here presented, the Kleinwanzlebener gave the highest average total yield of sugar per acre, when both the yield and the quality of roots were taken into consideration. This variety originated in Germany by selecting for many years only those roots which had a very high sugar content. The Kleinwanzlebener variety of sugar beets has been used more extensively for sugar production in America than any other variety. It will be seen that those varieties of beets which gave the highest percentages of sugar produced medium sized roots, which grew almost entirely underground. In comparing the different varieties it will be noticed that as the percentage of sugar decreased there was usually an increase in the yield of roots and a decrease in the yield of tops. There are, however, some marked exceptions to this rule, as the New Danish Improved gave a very large yield of tops and a comparatively low percentage of sugar, and the French Yellow variety which furnished an average amount of sugar was the lowest yielder of roots on the list. This table is worthy of careful study.

At least nine dollars per ton is being offered for sugar beets in Ontario for 1918. The average yield per acre at Guelph of the Kleinwanzlebener variety was 20.68 tons per annum. This yield multiplied by the price per ton, less the tare, would furnish a large return per acre. This, of course, would be higher than average returns for the Province, but with present prices there are special opportunities for sugar production in Ontario.

Four varieties of sugar beets and sugar mangels have been grown under similar conditions in the experimental grounds in each of twenty-one years. The following gives the average results for the twenty-one year period in pounds per root and in tons per acre of both tops and roots: Kleinwanzlebener, 1.1, 6.5, 16.7; Improved Imperial, 1.2, 5.1, 16.5; White Silesian, 1.3, 5.4, 19.2; and New Danish Improved, 1.4, 4.0, 21.5. The percentage of sugar of these varieties was not determined except in the six years already reported in the foregoing table.

In each of the past four years, Ontario grown seed, from a special variety of sugar beets particularly rich in sugar content, has been obtained from the Dominion Sugar Company. This variety and the Kleinwanzlebener have been grown in the experimental plots under similar conditions for the four-year period. The following gives the results of this experiment in yield per acre of both tops and roots:

Variety.	Tons of Tops per Acre.				Tons of Roots per Acre.			
	1914	1915	1916	1917	1914	1915	1916	1917
Kleinwanzlebener	6.1	13.6	1.8	5.5	15.4	18.8	3.9	14.6
Dominion Sugar Co....	6.3	15.9	2.1	6.3	15.6	19.8	5.0	15.8

It will be seen that the new strain which is now being grown and used by the Dominion Sugar Company has produced a higher yield of roots per acre than the Kleinwanzlebener variety in each of the past four years.

To grow sugar beets to supply the three large sugar beet factories in Ontario will require about 450,000 pounds of seed per annum. In 1917 the Dominion Sugar Company grew one hundred acres of seed, which furnished about one-fifth of the requirements. It is proposed in 1918 to grow at least two hundred acres of beet seed, which should produce under favorable conditions, 150,000 pounds of seed or about one-third of the requirements for Ontario. It is expected by 1919 or 1920 to grow at least five hundred acres of beets for seed production. In former years practically all of the sugar beet seed was obtained from Europe. At the annual meeting of the Experimental Union, held at the Agricultural College in January, 1918, Mr. Henry Stokes, Agriculturist of the Dominion Sugar Company, stated that he was obtaining excellent results from sugar beet seed produced in Ontario. Great care had been taken in the selection of roots for seed production, with the result that there had been an increase in the amount of sugar from beets of one-half per cent.

Whole and Broken Seed Clusters.

Sugar beet seeds are about equal in size to the seeds of common red clover. They are embedded in a dry husk which surrounds from one seed to six or seven seeds. These husks with the enclosed seeds are usually called clusters. When the whole clusters are used for sowing there is an unevenness in the stand of plants. Naturally, the number of plants from the clusters vary from one to several. Where a number of plants are produced from one cluster, a considerable amount of labor is involved in thinning the roots. Various methods have been tried at our College with the object of breaking the clusters, so that the seed could be sown more regularly and thus permit of a uniform distribution of plants. Of the various methods of breaking or crushing the husks, no simple process has yet been found for liberating the seeds without injuring their power of germination. In an experiment conducted in duplicate in each of two years with seeds which had been broken, it was found that whole seed gave an average yield of 30.1 and broken seed of 11.8 tons of roots per acre per annum. It is possible that some process may yet be devised by which the sugar beet seeds may be separated from the husks without seriously injuring their vitality.

Soaking Sugar Beet Seed Clusters.

In each of five years an experiment was conducted at the College in studying the influence on root production from soaking sugar beet seed clusters before sowing. The experiment was conducted in duplicate each year. For each test, seed was soaked 12, 24 and 36 hours, and these lots were tested with another lot of seed which had not been soaked. In the average of the ten tests conducted in the experimental grounds in the five years, the following average annual yields in roots per acre were obtained: Seed soaked 12 hours, 14.7 tons; seed soaked 24 hours, 15.2 tons; seed soaked 36 hours, 14.8 tons; and unsoaked seed, 13.3 tons. In each of the five years the unsoaked seed gave the lowest results and in each of three years the seed which was soaked for 24 hours gave the highest returns.

Selection of Sugar Beet Seed Clusters.

A large amount of experimental work has been done at the Ontario Agricultural College recently in determining the influence of different selections of seed upon the resulting crop. The tests with cereals and with turnips, carrots and rape are quite definite. Those with mangels and sugar beets, however, are somewhat peculiar, owing to the fact that it was necessary to plant clusters instead of single seeds. In the case of sugar beet seed clusters, duplicate experiments were conducted in which the clusters of the different selections were planted separately, and duplicate experiments were also conducted by planting three large, five medium or eight small clusters in each place where it was desirable for a root to grow. This was done to insure a perfect stand of roots. The plants were afterwards thinned, leaving one plant in each place, and having the plants of the different selections of each class at equal distances apart. When the roots were harvested, the yields of the duplicate tests of each method were averaged. The following table gives the average results of the duplicate tests made by means of each of two methods of comparison in order to ascertain the amount of influence of the size of root clusters on the yield of roots produced:

Method of Planting.	Size of Clusters.	Yield of Roots per Acre. (Tons.)
Plots in which one plant was left from each seed cluster	Large	23.25
	Medium	21.32
	Small	13.48
Plots in which one plant was left from each of several seed clusters	Large	22.54
	Medium	22.37
	Small	15.05

Each of the two sets of results represents the average of ten separate tests conducted in the five-year period. In every instance the mangels produced from seeds in the large clusters were higher in average yield per acre than those from seeds in the smaller clusters. It has been the aim of some sugar beet seed growers to produce single seeded clusters. Whether this can be done and at the same time realize as large yields per acre from the single seeded clusters as from the larger clusters appears doubtful. These experiments seem to show that the largest yields of sugar beets per acre are obtained from seed clusters of good size.

Flat and Ridged Cultivation.

An experiment was conducted for five years in succession by sowing sugar beets on the level and on ridges. The ridges were made with a double mouldboard plough and to a height of about three inches. The soil on which the experiment was conducted was an average clay loam, and the elevation of the land varied somewhat in the different years. The Kleinwanzlebener variety of sugar beets was used, and the experiment was conducted in duplicate throughout. The rows were twenty-one inches apart and the plants were thinned to seven inches apart in the rows. The following table gives the average of the two tests in each of the five years of the experiment and for the average of the five-year period:

Cultivation.	Yield of Roots per Acre (Tons.)					
	First Year.	Second Year.	Third Year.	Fourth Year.	Fifth Year.	Average Five Years.
Flat	20.6	21.0	14.8	18.2	20.5	19.0
Ridged	19.8	19.7	15.1	18.6	17.1	18.1

In three out of five years the flat cultivation gave the highest returns, the average for the whole period being almost one ton per acre in favor of working the land on the level. In the two years in which the yield per acre was slightly better from the ridged cultivation, there was more rainfall than usual in the early part of the season. On an average clay loam and in ordinary seasons the land which is cultivated on the level seems to give rather higher returns than that which is ridged before the seed is sown.

Sowing Sugar Beet Seed at Different Depths.

In each of five years an experiment was conducted in sowing sugar beet seed at the depths of ½ inch, 1 inch, 1½ inches, 2 inches, 3 inches and 4 inches in order to glean information regarding the depth at which the best results would likely be obtained throughout a series of years. The experiment was conducted in duplicate each year and on an average clay loam of different elevations. Level cultivation was used throughout. The rows were twenty-one inches apart and the roots were thinned to seven inches apart in the rows. The following table gives the average results of the two tests in each of five years and for the average of the five-year period:

Depths.	Yield of Roots per Acre (Tons).					
	First Year.	Second Year.	Third Year.	Fourth Year.	Fifth Year.	Average Five Years.
½ Inch	27.0	15.1	20.9	18.3	18.1	19.9
1 "	25.3	11.6	14.1	15.1	19.8	17.2
1½ Inches	24.5	5.5	14.3	10.6	17.1	14.4
2 "	24.6	2.6	13.5	9.8	18.3	13.8
3 "	21.8	.3	9.6	7.6	13.8	10.6
4 "	14.3	1.6	1.2	4.5	7.6	5.8

The results show that in four out of the five years, the highest yields per acre were secured from the seed which was sown exactly ½ inch below the surface, and in the other year the highest yield was obtained from the seed which was sown 1 inch deep. In the average of the five years the results are decidedly in favor of the shallow sowing. It should be understood that the land in every instance was in a good state of cultivation. Had the land been lumpy or poorly worked it is quite possible that a slightly deeper sowing than ½ inch might have been necessary for the best returns.

Quantity and Quality of Sugar Beets as Affected by the Distances Between the Rows.

An experiment was conducted in duplicate in each of five years by sowing sugar beet seed clusters in rows which were made at different distances apart. Seven rows were sown in each plot. The outside rows were discarded and only the five inner rows were taken into consideration when determining the yields of the plots. The roots were thinned to a distance of seven inches apart in the rows. The Kleinwanzlebener variety was used. The test was conducted in the experimental grounds on an average clay loam, varying slightly in elevation from year to year.

Not only were the yields per acre determined, but the roots were also analyzed in the chemical laboratory at the College and the quantity and the quality of the sugar was thus ascertained. The following table gives the average of the five years' results of the percentage of sugar, the purity of juice, the average weight per root, and the yield of both tops and roots per acre for each of the different distances allowed between the rows:

Distance Apart (Inches).	Juice. Average Five Years (10 Tests).		Roots. Average Five Years (10 Tests).	
	Percentage Sugar.	Percentage Purity.	Weight per Root (Pounds).	Yield per Acre (Tons).
12	17.0	86.7	.62	20.52
14	16.9	87.4	.65	19.19
16	16.7	86.1	.73	19.30
18	16.8	87.7	.80	18.90
20	16.8	87.1	.87	18.65
22	16.3	86.0	.94	18.44
24	16.7	87.3	.99	18.10
26	16.6	87.7	1.04	17.68
28	16.6	86.9	1.11	16.96

Claims were made in Europe that sugar beets grown comparatively close together possessed a higher percentage of sugar than those grown at a greater distance apart. In our experiments at Guelph, however, the composition of the roots grown in rows at different distances apart shows but slight variations either in the percentage of sugar or in the purity of the juice. It should be remembered, however, that in no cases were the plants far enough apart to produce very large roots. It is interesting to note that, with one slight exception, as the distance between the rows increased, the average yield per acre decreased. It is a general practice in Ontario, when growing roots for sugar production, to have the rows from 18 to 22 inches apart.

Thinning Sugar Beets at Different Distances Apart in the Rows.

In each of five years in succession an experiment was conducted by thinning plants 2, 4, 6, 8 and 10 inches apart in the rows. This experiment was conducted in duplicate each year and the Kleinwanzlebener variety was used. The roots were grown on an average clay loam and the elevation varied somewhat with the different seasons. Flat cultivation was used throughout. The rows were twenty-one inches apart throughout, except in one year when they were only eighteen. The following table gives the average of ten tests conducted in five years:

Distance Between Plants.	Average Weight per Root (Pounds).	Average Yield per Acre (Tons).	
		Tops.	Roots.
2 Inches	.39	9.45	17.75
4 "	.64	6.96	15.80
6 "	.83	6.89	15.74
8 "	1.03	6.82	15.67
10 "	1.25	6.35	15.48

The results show that as the distance between the roots increased, there was an increase in the average size of the roots, but a decrease in the yields of both tops and roots yer acre. Taking everything into consideration, the roots which are thinned from eight to ten inches apart usually give good results.

Thinning Roots at Different Stages of Growth.

In thinning sugar beets at different stages of growth in a duplicate test in each of five years, it was found that those roots which were thinned when at a height of two inches, surpassed those which were not thinned until they had made a growth of eight inches, by an average of 1.3 tons per acre per annum. Sugar beets thinned when two inches high gave an increase in yield of one-half ton per acre over those thinned when only one-half inch high, and one-third ton per acre more than those which were not thinned until they had made a growth of five inches. In the average of the five years results, sugar beets which were thinned when two inches in height, produced the heaviest average weight of roots and the lowest yield of tops per acre in comparison with those thinned at any one of three other stages of growth.

Cultural Methods.

The sugar beet does best on a warm, moist soil having an open subsoil which is also naturally warm and moist. Almost any soil, however, by proper cultivation in a suitable climate, will grow sugar beets. Good crops may be grown on clay, loam or sandy soils, providing they are not cold or wet, or that the subsoils are not hard and impervious to air and moisture. A soil capable of producing a good crop of potatoes or of corn will yield, with proper cultivation, satisfactory crops of sugar beets.

It is a good plan to grow sugar beets after such crops as potatoes, corn or winter wheat which had previously received a good application of farmyard manure. Sugar beets can be followed to good advantage by spring wheat, spring rye, barley or oats, any one of which could be seeded with clover alone or with a mixture of clover and timothy. It will, therefore, be seen that sugar beets fit in nicely in either a four or a five years' rotation. If it is necessary to apply farmyard manure immediately before the sugar beet crop, it is considered best to use well rotted manure in the autumn and have this worked into the soil. The use of commercial fertilizers can best be determined by local experiments to ascertain the requirements of the soil. In the use of fertilizers it will also be necessary to consider the prices of potash, phosphoric acid and nitrogen as some of these are abnormally high at the present time.

Sugar beets require a deep, mellow soil. It is advisable to plough the land to a good depth in the autumn. If well rotted manure is spread on the land in the autumn it is an excellent practice to make ridges about thirty inches apart with a double mould-board plough. This conserves the fertility in the ridges and enables the frost and the water to disintegrate the subsoil. Land treated in this way is in an excellent condition for cultivation in the spring. Before the sugar beet seed is sown the land should be thoroughly cultivated and rolled so as to make the soil compact and firm. By means of a light harrow, a fine seed bed could then be formed. About fifteen pounds of seed per acre is usually sown either with a beet drill or with an ordinary grain drill by using every third tube, which makes the rows about twenty-one inches apart. It is usual to sow sugar beets during the first half of May. If large areas are to be sown, however, it is well to sow the seed at two or three dates, allowing from ten days to two weeks between each two sowings. This distributes the labor of thinning and harvesting over longer periods. Cultivation should start as soon as the beets appear above ground and should be continued at frequent intervals in accordance with the weather and soil conditions throughout the growing season.

By-products of the Beet Sugar Industry.

In connection with the growing of sugar beets and the production of beet sugar there are several by-products which will undoubtedly be used to greater advantage in the future than they have been in the past. Three of the important by-products are here referred to.

Sugar Beet Tops. The yield per acre per annum of the sugar beet tops grown at the College by the Kleinwanzlebener variety in the average of twenty-one years has been 6.5 tons, or practically two-fifths of the yield of roots. According to Henry's book on "Feeds and Feeding" the following gives the fertilizing constituents per ton of sugar beet roots and of sugar beet tops:

Sugar Beets.	Fertilizing Constituents per Ton.		
	Nitrogen (Pounds).	Phosphoric Acid (Pounds).	Potash (Pounds).
Roots	5.2	1.6	6.4
Tops	8.4	2.0	12.8

It will be seen that the tops are much richer in fertilizing constituents than the roots of sugar beets when equal quantities are compared. It is exceedingly important to carefully retain on the land the fertility contained in the tops. As a rule the tops are ploughed in the soil. They are occasionally, however, fed green or in the form of silage. Caution should be used in feeding sugar beet tops as they tend to purge the animals, and, therefore, should be fed in limited quantities in conjunction with dry roughage.

Sugar Beet Pulp. Formerly, sugar beet pulp was fed when fresh in a limited way to farm stock in near proximity to the factories. More recently, however, the pulp has been dried, shipped and sold as stock feed.

Lime. A large amount of lime is used in the process of manufacturing beet sugar. At present this by-product is wasted. It seems a great pity that this lime could not be used for agricultural purposes. There is room for greater economy along this line.

Conclusion.

As sugar beets are grown with the definite object of sugar production, the growers of the beets and the manufacturers of the sugar should work in wholesome co-operation. The sugar manufacturers furnish seed of high quality at low prices, give directions regarding cultivation and offer to buy the beets under contract. Ontario farmers desiring to grow sugar beets should therefore make their contracts before planting.

BULLETIN 263] [JUNE, 1918

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

Common Edible and Poisonous Mushrooms of Ontario

By R. E. STONE, Ph.D.

INTRODUCTION.

At the present time when the world is threatened with a shortage of food, it becomes necessary to utilize all our food resources. We are advised to use more corn, to grow and consume more vegetables and fruit and to have smaller portions of food served. All this will help, but we should also see to it that all possible sources of food are utilized. At the present time there is in Ontario a supply of food going to waste which should form an important addition to our diet. Every year thousands of tons of mushrooms are allowed to decay. These plants are extensively utilized in European countries not only by the wealthy but also by the poorer classes. In this country few people gather wild mushrooms and such high prices are charged for the cultivated kind that they cannot be used except occasionally as a luxury.

Food Value of Mushrooms.

The food value of mushrooms is not as great as that of many of our staple foods such as meat, wheat, flour or beans, but it is about equivalent to that of our fresh vegetables. In addition, they give distinct and pleasing flavours to other food, and by furnishing the needed variety to our diet they become valuable as food accessories also. Further, if one knows wild mushrooms this extra food and luxury may be had at the expense of a few minutes walk on a cool morning or a trip to the woods or parks on a holiday.

During the past year numerous articles have appeared in newspapers and elsewhere advocating the use of wild mushrooms for food. From these articles one might be led to suppose that they had a very high food value, *i.e.* "twice that of fresh vegetables or half that of lean meat." A careful examination of the chemical analyses of many species shows that mushrooms vary considerably in composition but in general are 90 per cent. water and 10 per cent. solid matter. In fact their composition resembles very closely that of turnips or cabbage. They are not "animal-like" in their nature as one might suppose from the popular statement that mushrooms are "vegetable beefsteak." A glance at the following table will show the food value of some common kinds compared with some of our staple foods:

NUTRITIVE VALUE OF TEN POUNDS OF SEVERAL FOODS.*

	Proteids.	Fats.	Carbo-hydrates.	Calories.
a. Beef (round)	1.87	.88	....	7,200
Beans (dried)	2.23	.18	5.91	15,900
b. Cabbage	.18	.03	.49	1,400
Potatoes	.18	.01	1.53	3,250
Flour (roller process)	1.13	.11	7.46	16,450
c. Shaggy Mane (*Coprinus comatus*)	.04	.025	.434	987
Oyster Agaric (*Pleurotus ostreatus*)	.051	.042	.828	1,811
Morel (*Morchella esculenta*)	.094	.05	.306	955
Common Cultivated Mushroom (*Agaricus campestris*)	.18	.03	.46	1,316
Oysters	.61	.14	.33	2,350

*Atkinson, Geo. F.—Mushrooms, Edible, Poisonous, Etc.

What Mushrooms Are.

All of us are acquainted with green plants such as trees, flowers and grass, and when we think of plants it is these which we have in mind. But there are other plants which are not green and which do not produce flowers or seeds, and are often more or less inconspicuous. They are associated with the spoiling and decay of food, wood, etc. When a piece of bread is left in a warm, moist place, it soon becomes covered with blue or black mold. This mold is a plant belonging to a class of plants known as fungi. In like manner wood, straw or leaves if kept moist, are soon covered with a growth of fungi which may form large, woody or fleshy masses.

The term mushroom is used to mean these large, woody or fleshy fungi. They may be seen growing on the trunks of trees, on stumps, or fallen logs, coming out of the leaf mold on the forest floor, or in the grass in yards, lawns, fields and pastures or along the roadside. The plants may look like round balls, or shelves or brackets, or caps supported on slender stems, or branched and coral-like. In color they may vary from white through pink, red, yellow, blue, brown to nearly black, but never grass green.

It is seldom that we see the entire plant. The part we usually see is the fruiting body, which compares to the whole plant much as an apple to an apple tree. The feeding part, called the spawn or mycelium, consists of fine white or colored threads running all through the material upon which the plant is growing.

Parts of a Mushroom.

In order to understand the structure of the mushroom let us examine the common cultivated kind. (Fig. 1).

What we commonly call a "mushroom" is the fruit body of a fungus growing in decaying organic matter such as old leaves, straw or rotting stable refuse. This fruit body consists of a fleshy cap or pileus two or three inches in diameter supported on a stalk or stipe which comes up out of the ground. This stalk is three or four inches long and one-half inch thick and quite solid. On the under side of the cap are the gills or lamellæ. These are thin plates standing on edge and radiating out from the stalk like the spokes of a wheel. In a young fruit, called a button, these gills are protected by a curtain or veil which stretches from the stalk to the edge of the cap. As the cap expands the veil is torn apart, a little of it remaining as a ragged fringe on the edge of the cap but most of it remaining as a ring or annulus on the stalk.

In some of the wild mushrooms the stalk may be absent, the cap being attached by one side to logs or stumps on which the fungus is growing. In a few forms, especially in some poisonous plants, there is at the base of the stalk a large, shaggy or scaly bulb or a distinct cup called the poison cup or volva.

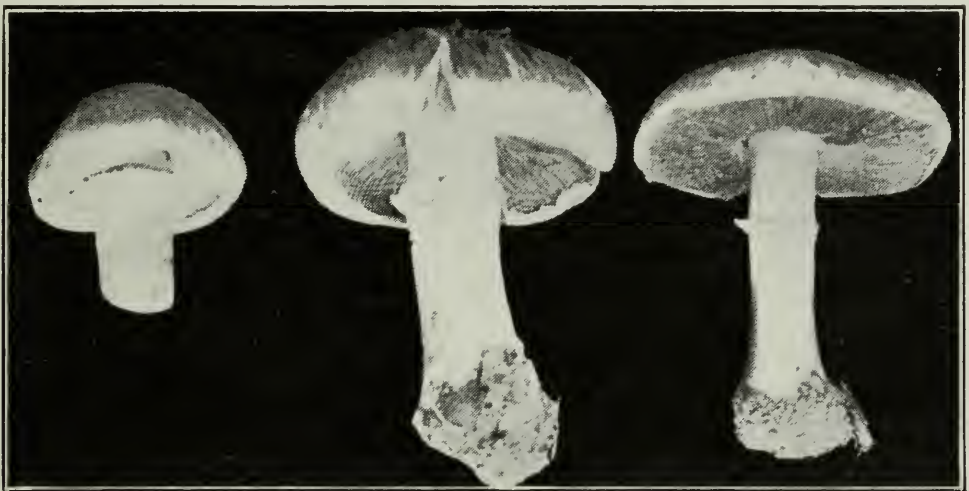


Fig. 1.—Common or Cultivated Mushroom. Edible. Natural Size (Original).

How Mushrooms Grow.

Mushrooms are flowerless plants without leaf green (chlorophyll). Since they have no flowers they have no seed, but reproduce by means of minute bodies called spores, which are formed on the gills. As they have no leaf green (chlorophyll), they cannot make their own food as the green plants do, so they depend upon the food made by other plants or upon animals. Some get their food from living plants and animals; they are robbers (parasites). Others live on the dead decaying remains of other plants or animals, and are scavengers (saprophytes).

When the "mushroom" or fruit body is ripe the spores are shed and are blown away by the wind. If the spores settle in a favorable place, warm, moist and with food present, they sprout or germinate. Finally they form many fine white or colored threads which spread all through the material which can furnish food. These fine threads are the spawn or mycelium. As the spawn grows it gives off substances called enzymes, which digest the wood, old leaves, straw or manure in which the fungus is growing. As the material is digested it is absorbed by the spawn and used as food. The substance upon which the fungus is feeding gradually breaks down, that is it decays and disappears.

The spawn may grow a long time before it fruits. Even in the cultivated mushroom, when conditions for growth are made as favorable as possible, it is usually six weeks from the time the spawn is planted until the "mushrooms" appear.

When the spawn has gathered sufficient food it then begins to form the fruit bodies or "mushrooms." (See Fig 2). These at first are tiny white balls, smaller than a pin head. They grow rapidly in size, and when they are as large as a small marble one can recognize the main parts. In the top will be the cap, with the gills underneath, protected by the veil, while the lower part is the stalk or stipe. When the parts have all been formed the "mushroom" enlarges rapidly and pushes up out of the ground. Very frequently the stalk elongates so rapidly when the fruit body is nearly grown that the cap may be pushed up out of the ground during the night, so that some people have thought that these mushrooms grew in a night.

When and Where to Look for Mushrooms.

Mushrooms may be found from the time the ground thaws out in the spring until it freezes up in the fall. They are most plentiful after prolonged wet weather or after warm rains when the days are warm and the nights fairly cool and damp.

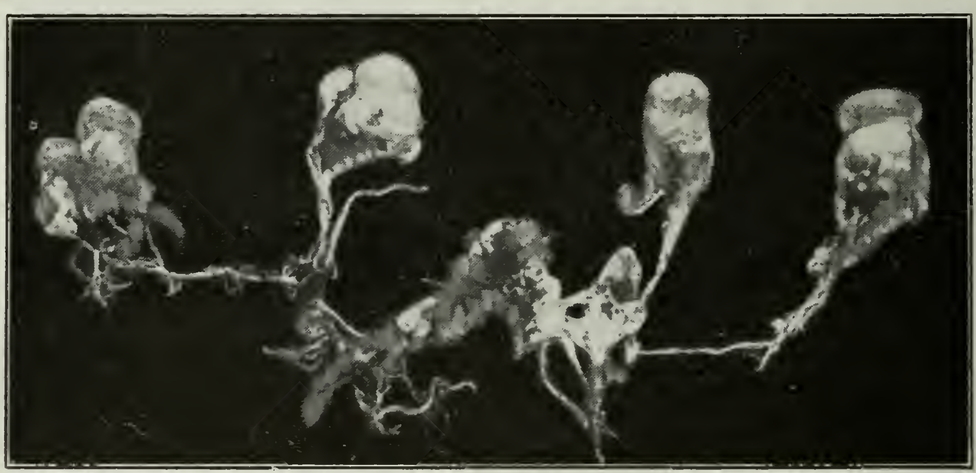


Fig. 2.—Button Stage of Common or Cultivated Mushroom. Natural Size (Original).

It is best to look for them on cool, dewy mornings, a day or two after warm, heavy rains.

They grow any place where there is plenty of decaying vegetable or animal material which is not too much disturbed by cultivation. Some kinds grow in rich, well manured lawns, others in pastures, several varieties along the roadside. Some delicious kinds grow in barnyards. Many grow best in the woods, some in the leaf mold on the forest floor, some on stumps, some on fallen logs and a few on standing trees.

To Know Wild Mushrooms.

There are in Ontario at least 150 kinds of fleshy fungi, which are large enough to attract the attention of a person collecting mushrooms for table use. However, not all of these can be used, as some of them are poisonous. Four of these are deadly poisonous and four are reputed mildly poisonous and a few, which occur only occasionally, have unknown properties.

When one is gathering mushrooms one of the first questions he is asked is, "How do you tell mushrooms from toad stools?" This question implies that the inquirer thinks of mushrooms as edible and "toad stools" as poisonous. This question may be answered by saying that mushrooms and toad stools are the same. There is no sharp line of distinction, and no simple test which can be applied to distinguish the edible from poisonous forms. The so-called peeling test is useless, as one of our most poisonous forms peels as readily as the cultivated mushroom. The blackening of silver was at one time supposed to show that mushrooms were poisonous, but this test is of no value, as the blackening of silver only indicates the presence of sulphur or its compounds, and has no relation to poisons present. Some people say, "Collect only those mushrooms which grow in fields and pastures." Unfortunately, our deadly poisonous mushrooms, although generally growing in the woods, sometimes grow in lawns and pastures. On the other hand, if one does not gather mushrooms in the woods and parks many of the very best kinds will be missed.

The only way to be sure that the mushrooms gathered are wholesome is to learn to know the mushrooms from their characters the same as we learn to know other plants. When one goes out to gather berries he must distinguish between nightshade and strawberries or between elderberries and spikenard. He comes to know the edible ones and to recognize those that are not edible, and leaves the latter alone. In the same manner one must learn to distinguish the mushrooms. This may be done by going out with someone who is familiar with mushrooms and has gathered them for use many times, or one may learn to know mushrooms by gathering the different kinds and carefully comparing them with descriptions and pictures. This method is, perhaps, the one which many will have to use.

In order that more people may learn to know some mushrooms and thus utilize part of the food that is being wasted, the most common edible kinds and also the poisonous ones that are likely to be found in Ontario are described and photographs of them are shown.

There is still another way to learn mushrooms. The Department of Botany of this College will be very glad to identify any mushrooms sent in for this purpose. In order to have them identified they should be prepared as follows:

Carefully dig up the mushrooms so that all the fruit body, including the very base of the stalk, is present. Wrap in dry paper, taking care not to crush the specimens. A note should be attached which describes where the plants grew, whether in fields, or woods, or on the roadside. Whether it grows in the ground or on wood, and finally the color of the plant in a fresh condition. They should then be enclosed in a strong cardboard box or tin can to protect them from being crushed, and addressed to

DEPARTMENT OF BOTANY,

ONTARIO AGRICULTURAL COLLEGE,

GUELPH, ONT.

EDIBLE MUSHROOMS.

Common Mushroom, Cultivated Mushroom (*Agaricus campestris*, Linn.). Edible.

This is the mushroom commonly cultivated. (Fig. 1.) It also grows wild, and may be found in lawns, meadows, pastures, cultivated fields, greenhouses, and is very common on well-cared-for golf links. It may be found from late spring until fall, but is more abundant in summer and early autumn, when nights are cool and the days warm and not too dry.

The cap 2 to 4 inches wide, at first hemispherical, later becoming flat; white or with brown threads over the surface, giving a greyish or brownish silky appearance; flesh solid and white. The stalk or stripe is 2 to 4 inches long, ½ to ¾ of

Fig. 3.—Scaly or Forest Mushroom. Edible. Natural Size (Original).

an inch thick, firm, colored like the cap. The gills are free from the stalk at the inner end; at first pink, later becoming purple brown or nearly black. The gills are at first hidden by the veil which later is torn apart, leaving a fringe on the edge of the cap and a small ring on the stalk.

Field Mushroom or Horse Mushroom (*Agaricus arvensis*, Schæff.). Edible.

Grows in fields and meadows.

This is very much like the common mushroom, except that the stalk is longer and becomes hollow in age and the veil is thicker, so that the ring or annulus may appear double. The gills are at first pink, then turning brown. Some spawn companies claim to have the "spawn" of this species for sale.

Rodman's Mushroom (*Agaricus rodmani,* Pk.). Edible.

This mushroom occurs very commonly in cities and towns, on lawns and boulevards. The plant is entirely white with tinges of yellow. It is about the same size as the common mushroom, but the stalk is very short and solid. The veil is quite thick and forms a distinct double ring or annulus. The gills are at first pink, then dark brown. Some seed companies claim to have the "spawn" of this species for sale.

Scaly or Forest Mushroom (*Agaricus placomyces,* Pk.). Edible.

This mushroom grows in woods or borders of woods, coming up from the fallen leaves. (Fig. 3.) It most frequently occurs where there are some hemlock or pine trees. It may be found from June to September.

The cap is 2 to 5 inches in diameter, at first rounded, finally nearly flat, but thicker in the centre. It is first brown, but as the cap expands the brown surface

Fig. 4.—Smooth or White Mushroom. Edible. Natural Size (after Atkinson).

breaks up into numerous small scales exposing the white flesh below. The stalk is 2 to 5 inches long, $\frac{1}{4}$ to $\frac{1}{3}$ of an inch in diameter, white, slightly bulbous at the lower end, often becoming hollow. The gills are free from the stalk, at first white, but very soon becoming pink and finally dark brown. The veil is thick, so that a large prominent ring is formed which sometimes appears double.

White Mushroom or Smooth Mushroom (*Lepiota naucina,* Fr.). Edible.

This mushroom grows in lawns, pastures and along roadsides, and is most abundant in September and early in October. (Fig. 4.) The plant is entirely white or in old specimens somewhat buff.

The cap is 2 to 4 inches broad, globose to hemispheric, entirely white or slightly tinged with buff and smooth. The stalk is $1\frac{1}{2}$ to 3 inches long, $\frac{1}{3}$ to $\frac{1}{2}$ an inch thick, often hollow, white and generally with a *smooth* bulb at the base. The gills are free from the stalk, white or a dirty pink in old specimens.

The veil at first hides the gills, later the veil breaks away from the edge of the cap and forms a ring on the stalk. The ring often fits loosely to the stalk and may be slipped up and down.

CAUTION. Although this mushroom is very good, care must be taken to distinguish it from some deadly poisonous plants which sometimes grow in the same situations. The white mushroom described here, although white is not shiny, is dry, not slimy or viscid, and has a smooth bulb at the base of the stalk, not a shaggy bulb or cup.

PARASOL MUSHROOM (*Lepiota procera,* Scop.). EDIBLE.

This is one of our striking mushrooms, and is not inappropriately named. (Fig. 5.) It grows in pastures, lawns, gardens, along roadsides, and in open woods in late summer and early autumn.

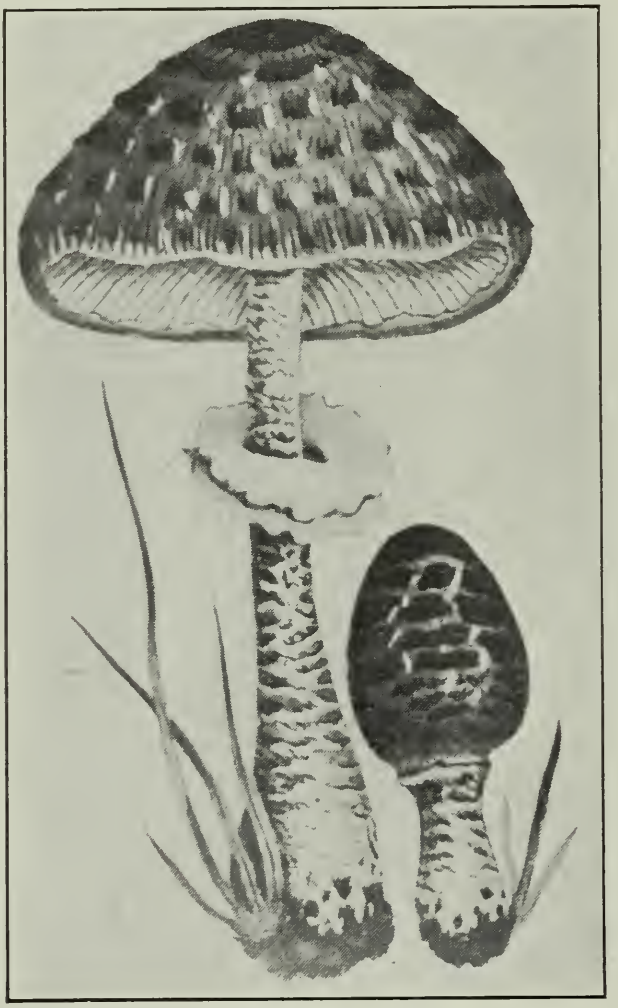


Fig. 5.—Parasol Mushroom. Edible. Natural Size (after Massee).

Fig. 6.—Shaggy Mane. Edible. Natural Size (Original).

The cap is at first bell shaped, later becoming parasol shaped. It is 2 to 5 inches in diameter, at first greyish or brownish red, but as the cap expands the colored surface breaks up into scales, showing the white flesh underneath. Finally the cap becomes shaggy in appearance.

The stalk is 4 to 8 inches long, $\frac{1}{6}$ to $\frac{1}{4}$ of an inch in diameter, the same color as the cap, and generally becomes hollow in age.

The gills are white, free from the stem, and closely crowded.

The ring is stout, narrow, and usually quite free from the stem, so that it may be moved up and down.

Shaggy Mane (*Coprinus comatus,* Fr.). Edible.

The Shaggy Mane is one of the most prized mushrooms by those who know it. (Fig. 6.) The plant is quite large and distinguished by its shaggy cap, which melts down, forming inky liquid as the plants become old. It occurs in lawns and other grassy places, especially in richly-manured ground. The plants sometimes occur singly or a few together, but often quite large numbers of them appear in a small area. They occur most abundantly during quite wet weather, or after heavy rains, in late spring or early autumn, sometimes in summer.

The cap is cylindrical, usually brownish at first, but the surface becomes broken up, forming shaggy scales and exposing the white flesh underneath. The cap is 4 to 7 inches long, 2 inches thick. As the plant becomes old the cap melts down into an inky liquid and wastes away.

The stalk is white, 6 to 9 inches long, thickened at the base and hollow.

The gills are at first white, then pink, changing to brown, finally becoming black and melting down into an inky liquid.

There is a ring in young specimens, but this usually disappears.

Fig. 7.—Ink Cap. Edible. Natural Size (after Atkinson).

Since the cap and gills turn into an inky liquid the plants should be gathered early in the morning before the cap and gills have begun to change color or when the gills near the edge are flesh color. It may be also eaten after the gills become black, but the inky looking mass is not inviting.

Ink Cap (*Coprinus atramentarius,* (Bull.) Fr.). Edible.

The ink cap occurs in much the same places as the shaggy mane and is sometimes found accompanying it, but is usually more common and abundant. (Fig. 7.) Sometimes the plants are scattered, but usually there are ten or twenty in a dense cluster.

The cap is egg-shaped or oval, generally smooth or somewhat scaly, 2 to 3 inches long, silvery grey, or ashen grey, or smoky brown. At maturity the cap melts down into an inky liquid.

The stalk is 3 to 4 inches long, ½ an inch thick, hollow, the same color as the cap, or in some a little lighter in color. There is no distinct ring, but an irregular raised ridge about the stalk at the bottom of the cap.

The gills are packed very close together; at first whitish, soon becoming pink, then moist and black, and dropping away as an inky liquid.

Like the Shaggy Mane, this mushroom must be gathered early if one is to enjoy them, as on warm days the cap may be entirely gone by noon, but if they are gathered early and kept in a cool, dry place, they may be preserved for a few hours.

Mica Cap (*Coprinus micaceous*, (Bull.) Fr.). Edible.

This little mushroom is generally very abundant in late spring and early summer, and sometimes in the autumn. (Fig. 8.) It grows about the bases of stumps

Fig. 8.—Mica Cap. Edible. Natural Size (Original).

or trees, or from wood buried in the soil. It forms in dense tufts of ten to thirty, sometimes several hundred coming up from the roots of a dead tree or stump, forming large masses in the lawn or boulevard. It is sometimes found on logs in the woods.

The plant gets its name from the numerous glistening scales on the cap, causing it to appear as if powdered with mica.

The cap is oval, then bell shaped, with fine lines from the centre to the edge. When young it is covered with glistening mica-like scales. The color is tan, light buff or tawny yellow. The cap is 1 to 2 inches broad.

The stalk is slender, smooth, white, hollow, 1 to 3 inches long.

The gills are at first white, finally becoming black.

In wet weather the cap and gills melt down into an inky liquid, but may simply dry up at other times.

WHITE OYSTER MUSHROOM (*Pleurotus ostreatus*, Jacq.). EDIBLE.

This mushroom is so named because the white, one-sided caps resemble, to some extent, oysters. (Fig. 9.) The plant grows on dead logs and stumps in dense clusters, the caps overlapping each other. It occurs in late summer and autumn.

The cap is one sided, with a very short, solid stalk or none, 2 to 8 inches wide, white or greyish, thick and fleshy.

The stalk is at one side short, thick, solid, or absent.

The gills are white, running down the stalk.

DARK OYSTER MUSHROOM (*Pleurotus serotinus*, Schrad.). EDIBLE.

This mushroom resembles the preceding one, but is darker in color. It also grows on logs and stumps, either occurring singly or in small, overlapping clusters. It is common in damp woods in the autumn.

Fig. 9.—White Oyster Mushroom. Edible. Natural Size (Original).

Fig. 10. — Fawn Cap. Edible. 2/3 Natural Size (Original).

The cap is attached by one side, 2 to 5 inches wide, sometimes yellow, but more often greenish brown or with an olive tinge. The flesh under the "skin" or pellicle is white or whitish.

The stalk is very short or none.

The gills are white or with a yellowish tinge.

In cooking this mushroom it is best to remove the dark skin or pellicle, as it improves the appearance of the food, although it does not improve the flavor.

FAWN CAP (*Pluteus cervinus*, Schæff.). EDIBLE.

This mushroom occurs in mixed woods, on and around old stumps. (Fig. 10.) It appears after damp weather in early spring and autumn.

The cap is light brown or fawn colored, streaked with darker brown; surface dry and shining; slightly hairy; 3.5 to 5 inches broad.

The stalk is creamy white streaked with brown, 3 to 6 inches long.

The gills are almost white when young, but soon become flesh color, free from the stalk.

There is no ring.

Orange Flow (*Lactarius deliciosus,* (L), Fr.). Edible.

This mushroom occurs abundantly in balsam and spruce woods in the autumn. (Fig. 11.) When broken the flesh gives out an orange-colored juice. The plants have a pleasing sweet odor.

The cap is 3 to 5 inches broad, funnel shaped, yellow or pale orange with bands of lighter color; slightly hairy; juice or milk orange colored.

The stalk is 2 to 3 inches long, about an inch thick, hollow and brittle.

The gills are yellow or orange, running down on the stem.

There is no ring.

Coral Fungus or Fairy Club (*Clavaria flava,* Schæff.). Edible.

This fungus occurs commonly in the woods, growing on stumps and rotting logs, and is most abundant after warm, wet weather in late summer and early autumn. (Fig. 12.)

The plant is 3 to 6 inches high and 2 to 4 inches broad. At the base it is thick and fleshy, but the upper half is divided into numerous, upright, pale yellow

Fig. 11.—Orange Flow. Edible. 2/3 Natural Size (Original).

branches, whose tips are more deeply colored. Usually when the plant becomes old it fades out to nearly white. The flesh is firm, white and solid.

There are some kinds of coral fungi which are always pure white, as well as some in which the branches are tipped with red. There are also a few kinds that do not branch, but are firm, upright and club shaped.

All of these coral fungi and Fairy Clubs are edible, and there is no danger in collecting them for the table.

Hedge Hog Fungus (*Hydnum erinaceus,* Bull.). Edible.

This fungus occurs on stumps and logs in the woods, and is often found growing from wounds on living trees in the fall. (Fig. 13).

It forms large, white masses, with long, slender, downward hanging spines.

In some cases the mass may be much branched, or in a few forms the plant may be shaped like a mushroom with a cap and stalk, but with spines in place of gills.

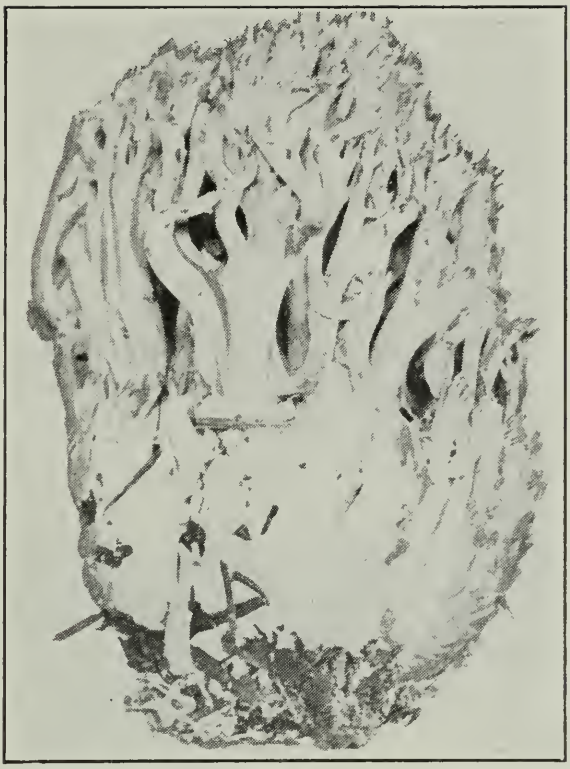


Fig. 12.—Coral Fungus. Edible.
Natural Size (Original).

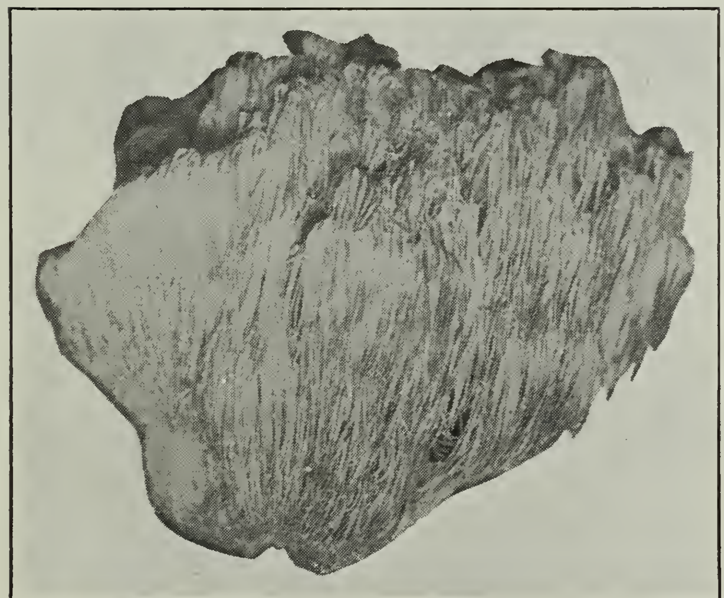


Fig. 13.—Hedge Hog Fungus. Edible. Natural Size
(Original).

GIANT PUFF BALL (*Lycoperdon giganteum,* Batsch.). EDIBLE.

This fungus sometimes occurs abundantly in pastures and on roadsides in August and September. (Fig. 14.) The fruit body is very large, usually 8 to 15 inches in diameter or even larger. In 1915 a report was received by this Department of six of these puff balls weighing 48 pounds, two just as large and a dozen smaller ones, all found on a piece of ground but 2 rods square. There are reports of these puff balls which were over three feet in diameter and weighed 47 pounds.

The fruit body is flattened ball shaped. It is at first pure white and quite smooth. Later it becomes light yellowish brown, and then cracks into many fine areas. When young the interior of the ball is white and cheesy, but when it becomes old it breaks up into a yellowish or snuff-colored powdery mass.

The puff balls should be gathered while still white inside.

If one succeeds in finding a single one of these balls he is assured of having several mushroom feasts.

Fig. 14.—Giant Puff Ball. Edible. 1/4 Natural Size (Original).

Fig. 15.—Common Morel. Edible. 1/2 Natural Size (Original).

PEAR-SHAPED PUFF BALL (*Lycoperdon pyriforme,* Schæff). EDIBLE.

This is a much smaller fungus, the ball being only 1 to 2 inches high. It grows on old timber or on the ground, but the balls occur in great numbers, sometimes forming dense clusters several feet across. The fungus is excellent while still white inside. It is most commonly found in woods from July to October.

THE COMMON MOREL (*Morchella esculenta,* Pers.). EDIBLE.

This is one of the best of the few edible fungi which occur in abundance in the spring and early summer. (Fig. 15.) May and June are the usual months. They have the further advantage that there are no poisonous kinds closely resembling them. They are not very variable either in form or color. Both the cap and stalk are hollow, and the surface of the cap bears a number of prominent ridges joined together to form an irregular network. This distinguishes them from all the other fungi except the "stink horns," which differ in having the long stalk arising from a cup partly buried in the soil and having a penetrating, disagreeable odor. Even the "stink horns" are edible when young.

There are four species of Morel, but as they are all edible no separate descriptions of them are given.

POISONOUS MUSHROOMS.

As previously stated, there are a few poisonous mushrooms. Some of these are deadly poisonous, and occur in considerable numbers. In this region the deadly poisonous kinds are all closely related, and a description of three common species will enable one to avoid all of them.

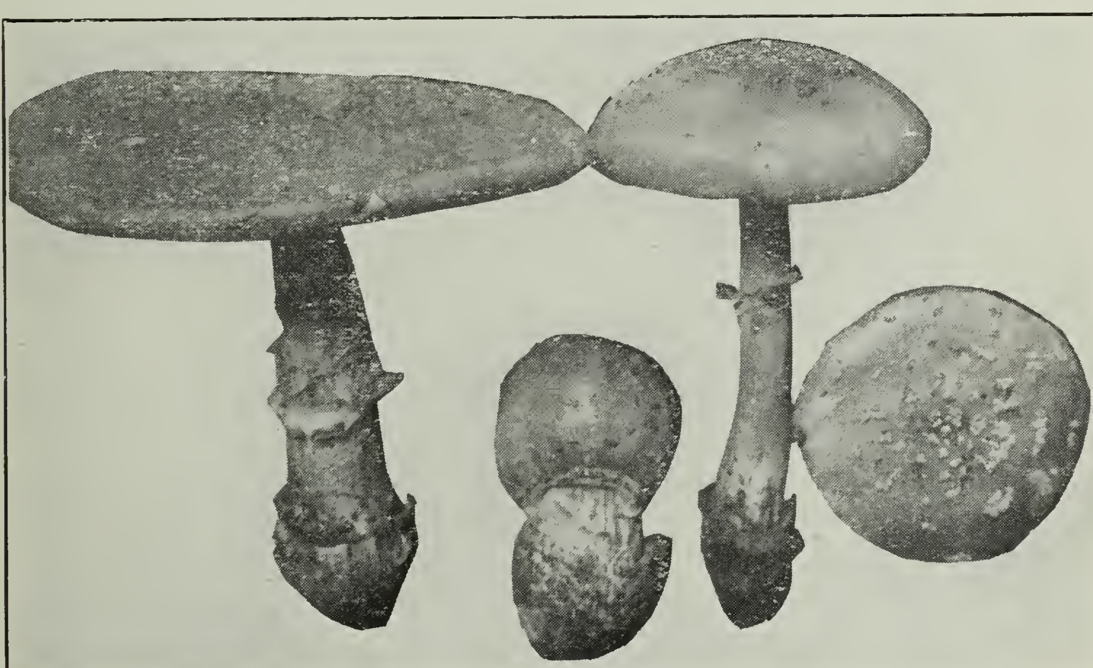


Fig. 16.—Fly Agaric. *Deadly Poisonous.* 1/2 Natural Size (Original).

FLY AGARIC (*Amanita muscaria,* Linn.). DEADLY POISONOUS.

This fungus appears in July and August in groves and open woods or along roadsides near trees, usually preferring rather poor soil. (Fig. 16.) It is called "Fly Agaric," because an infusion of the plant was at one time used as a fly poison. The plant is typically large and handsome.

The cap is 3 to 5 inches broad, rounded when young, nearly flat when old, yellow or orange or even bright red in color, and covered with numerous angular scales, which are white or light yellow in color, and can easily be brushed off. As the cap becomes old it fades out, so that it may become nearly white and the scales may be washed off by rains.

The stalk is 4 to 6 inches long, about ½ an inch thick, usually white, but often yellowish in color, hollow in age. The bottom of the stalk is enlarged into a prominent bulb, which is more or less rough and shaggy or scaly. The lower part of the stalk above the bulb is also shaggy.

The gills are white or slightly tinged with yellow, and do not become pink or brown as do those of many edible mushrooms.

The ring is quite large, white, and firmly attached to the stalk.

The main points to remember about this fungus are:—The yellow or orange cap with loose white scales. Gills white, never becoming pink or brown. Ring large, white, firmly attached to the stalk. *The stalk enlarged at the base into a prominent shaggy or scaly bulb and the stalk shaggy between the bulb and the ring.*

The poison in this mushroom is known as muscarin. This substance, fortunately has an unpleasant bitter taste, so that the plant is seldom eaten even if collected by mistake. The poison does not act immediately, but the symptoms appear in from ½ to 2 hours, and are: vomiting and diarrhœa, with a pronounced flow of saliva, suppression of urine, giddiness, uncertainty of movement, derangement of vision. This is followed by stupor, cold sweats and weakening of the heart action.

Fig. 17.—Deadly Agaric. *Deadly Poisonous.* 1/2 Natural Size (Original).

Of course when symptoms such as these appear after eating mushrooms a physician should be sent for immediately.

The system should be freed of the undigested fungus as soon as possible. Strong emetics, such as zinc sulphate, apomarphime or warm mustard and water should be used. If these are lacking or produce no effect, tickle the throat with a feather or the finger to cause immediate and violent vomiting. This should be followed by strong dose of castor oil.

THE DEADLY AGARIC (*Amanita phalloides*, Fr.). DEADLY POISONOUS.

This fungus is called the Deadly Agaric because it is extremely poisonous, and there is no known antidote for the poison. (Fig. 17.)

The plant usually grows in the woods or along the borders of woods, but has also been known to appear in lawns. It generally appears in July and August.

It is quite variable in color, varying from pure white through yellowish to olive. Some place the white forms in a different species.

The cap is 1.5 to 4 inches broad, at first bell shaped, finally nearly flat, fleshy, viscid or slimy when fresh, smooth, often with a few loose white scales. The color varies from white through yellow to olive green, the dark forms being more common in Ontario.

The stalk is 2 to 8 inches long, $\frac{1}{4}$ to $\frac{1}{2}$ an inch thick, hollow, white, or colored like the cap, but lighter in shade, becoming discolored on handling. It ends in an abrupt bulb which generally has a sharp rim standing up around it, forming a sort of cup, called poison cup or volva. This poison cup is usually deeply buried in the soil, so that in order to find it it is necessary to dig the plant up.

Gills white and remain white, never becoming pink or brown.

Fig. 18.—Destroying Angel. *Deadly Poisonous.* Natural Size (after Atkinson).

Fig. 19.—Young Stage of the Destroying Angel. *Deadly Poisonous.* Natural Size (Original).

The ring is white, prominent, and is high up on the stalk close to the cap. The ring is attached to the stalk, not loose as in the smooth white mushroom or parasol mushroom.

The poison in the Deadly Agaric is phallin. This poison, unfortunately, has no pronounced taste or odor, and gives no warning of its presence. Unfortunately, also, the symptoms of poisoning do not manifest themselves until 9 to 14 hours after the fungus is eaten. There is then considerable abdominal pain, and there may be cramps in the legs accompanied by convulsions and even lock-jaw and other tetanic spasms. The pulse is weak and abdominal pain is rapidly followed by vomiting and extreme diarrhœa, the intestinal discharges assuming the rice-water condition characteristic of cholera. These later symptoms persist, generally without loss of consciousness, until death ensues, which happens in from two to four days.

There is no known antidote for phallin. The undigested portions of the fungus should be removed from the stomach and intestines by methods similar to those suggested under the Fly Agaric. If the poison already absorbed is not too great, it may wear itself out and the patient recover.

Of course when symptoms of poisoning appear a physician should be sent for immediately.

The Destroying Angel (*Amanita verna,* Bull.). Deadly Poisonous.

This fungus is probably the cause of more cases of mushroom poisoning than any other. (Fig. 18.)

The plant is pretty, clean, pure white and attractive.

It usually occurs in the woods or near them, but may grow in lawns newly made from forest soil. It is generally found in June and July.

The cap is 1.5 to 4 inches in diameter, at first bell shaped, later becoming nearly flat; *pure white, shining, viscid or slimy when fresh.*

Fig. 20.—Scarlet Cap. *Mildly Poisonous.* About Natural Size (after Marshall.)

The stalk is 2 to 6 inches long, $\frac{1}{4}$ to $\frac{1}{2}$ an inch thick, pure white, hollow in age. The stalk ends in an abrupt *bulb,* with a free border closely surrounding the base of the stalk and forming the poison cup or volva. This may be seen in even young specimens as shown by Fig. 19. This poison cup is buried in the soil, so that in order to see it it is usually necessary to dig the plant up. For this reason wild mushrooms growing in the soil should always be dug, not pulled up or broken off.

The gills are pure white and remain white, never becoming pink or brown.

The ring is broad and high up on the stalk, just under the cap. It is firmly attached to the stalk, and is not loose, as in the smooth, white mushroom.

Since this is our most poisonous mushroom its main characters should be thoroughly learned and remembered.

The cap is pure white, shining and slimy when fresh. The stalk is pure white, ending in a distinct poison cup or volva. Gills pure white and remain white. Ring white, broad, high upon the stalk to which it is firmly attached.

The poison in this fungus is the same as that in the Deadly Agaric, and the symptoms of poisoning and treatment are the same.

Scarlet Cap (*Russula emetica,* Fr.). Reputed to be Mildly Poisonous.

This fungus occurs very commonly in the woods from summer till autumn. It gets its name from the bright scarlet cap. (Fig. 20.) It is hot and peppery to the taste, and some report it to be mildly poisonous, while others say that it is edible.

The cap is 1.5 to 3 inches wide, thin, brittle, deep pink to rich red; furrowed near the edge, rounded when young, depressed in the centre when old.

The stalk is 2 to 3 inches long, white or tinged with yellow. Very brittle.

There is no ring and no volva or poison cup.

Besides the scarlet cap, some of the forms with milky juice are mildly poisonous. They are very hot and the milk is not reddish, as with the Orange Flow (*Lactarius deliciosus*), described under edible mushrooms.

There are some mushrooms which have tubes in place of gills. Some of these are edible and others poisonous. The poisonous ones have a flesh that changes color when cut or broken or have tubes with red mouths. There are a few mushrooms that have clay-colored gills and a cobwebby veil that should also be avoided.

Many mushrooms are wholesome when fresh, but become dangerous when they begin to decay, or show evidence of the work of insects or worms.

GATHERING WILD MUSHROOMS.

When one is gathering wild mushrooms a basket is the best receptacle for carrying them, as different compartments may be made for holding the various kinds, and thus keep from crushing and spoiling the more tender ones.

When collecting mushrooms for the table they should never be pulled up or broken off. In the deadly poisonous mushrooms the most marked characteristic, the poison cup or volva, is deeply buried in the soil. If the plant is pulled up or broken off the poison cup is lost, and it is impossible to distinguish the poisonous kinds from certain edible ones. After a mushroom has been carefully dug up and examined and the collector is certain that it is edible, the lower part of the stalk may be cut off to get rid of the dirt. It is often very difficult to determine mushrooms from the young or button stage, so that unless buttons are accompanied by mature plants they should generally be avoided. In case of doubt the fungus should be discarded or the complete specimen shown to one who knows mushrooms very thoroughly.

Rules to be Observed in Gathering Wild Mushrooms.

It is impossible to give a simple rule or test for detecting poisonous mushrooms. Care must be taken to observe the characteristics of each mushroom gathered.

The following rules, if carefully followed, will enable one to avoid the poisonous forms:—

(1) Avoid fungi when in the button or unexpanded stage; also those in which the flesh has begun to decay, even if only slightly.

(2) Avoid all fungi which have stalks with a swollen base surrounded by a sac-like or scaly envelope, especially if the gills are white.

(3) Avoid fungi having a milky juice, unless the milk is reddish.

(4) Avoid fungi in which the cap is thin and very brittle, and in which the gills are nearly all of equal length, especially if the cap is bright colored.

(5) Avoid all tube-bearing fungi in which the flesh changes color when cut or broken, or where the mouths of the tubes are reddish, and in the case of other tube-bearing fungi experiment with caution.

(6) Avoid fungi having clay-colored gills and a spider web or woolly ring on the stalk.

(7) In case of doubt discard the plant.

Mushrooms which May be Gathered.

The foregoing rules are given as a warning against comparatively few plants; the edible mushrooms are more numerous, and those that may be gathered are as followed:—

All the puff balls and coral fungi; any of the hedge hog or spiny fungi and the morels; also any mushroom whose gills become brown; mushrooms having reddish or orange milk; all mushrooms that melt down into an inky liquid when mature; many mushroms with white gills, but care must be taken to be absolutely certain that they have no poison cup or volva.

RECIPES FOR USING MUSHROOMS.

1. To Can Mushrooms.

Sometimes more mushrooms are gathered at one time than can be used immediately. These cannot be kept like vegetables, but can be preserved by canning.

Peel, dry, wash thoroughly and boil in well salted water until done. The very tender kinds, such as ink caps, require little boiling. The tougher kinds may be boiled for an hour. Morels and puff balls should be cut into small pieces. Be sure to salt abundantly and have boiling hot when put into the glass jars, then seal as for any canned fruit or vegetable.—*Benedict.*

2. Mushrooms may be Dried.

Take those neither very young nor very old. Remove the butts. Then slice and string or skewer lightly and expose to a current of warm, dry air. A warm oven with the door open is a good place. When quite dry and shrivelled pack in tins with spice at the top and bottom. When wanted for use soak in tepid water for some hours, then cook.—*Hay.*

3. Soup.

1 quart mushrooms
3 pints water
½ pint milk
1 tablespoon flour
2 tablespoons butter
1 dessertspoon salt
1 teaspoon pepper.

Carefully clean the mushrooms. Put in a covered boiler with water, and boil slowly for an hour. Put through a colander. Reject that which does not pass through. Add milk thickened with flour, butter, salt and pepper. Bring to a boil. Serve. This makes two quarts of soup.—*McIlvaine.*

4. Stewed Mushrooms.

Cut into small pieces of even size, place in a covered saucepan. To each pint add two tablespoons of butter. There will be enough water from washing to make liquor. Stew slowly twenty minutes; season to taste with pepper and salt. May be served either alone or on toast.

The tougher kinds should be soaked in warm water half an hour before stewing. Parsley, nutmeg or beef gravy may be added.

5. Fried Mushrooms.

1 pint mushroom caps
1 teaspoon salt
½ teaspoon black pepper
2 tablespoons butter.

Put the mushrooms into boiling hot butter and fry for 10 minutes. Add a little milk or cream thickened with flour. May be served alone or on toast.

6. Baked Mushrooms.

Wash, place the caps in a tightly covered dish or pan, after dipping them in bread crumbs. Arrange in layers with a small piece of butter on each mushroom, with a little pepper and salt. Bake from 20 to 40 minutes until done. Serve on toast. Cheese grated on each layer makes a desirable addition.—*McIlvaine.*

7. Scalloped Mushrooms.

Put in a baking dish layers of cold cooked meat, diced or sliced. (Stewed until tender.) Moisten with gravy or sauce. Alternate with stewed mushrooms. Cover with buttered biscuit or bread crumbs. Bake about 20 minutes.

8. Salads.

Many kinds of mushrooms make good salads. The shaggy mane, ink cap and many of the coral fungi are good raw. The tougher kinds should be first stewed, then drained and cooled.

Mix with mayonnaise dressing or make a dressing to taste of oil, vinegar, salt and pepper. Serve on lettuce.

9. Fresh Mushroom Sauce.

2 tablespoons butter
2 cups freshly prepared mushrooms
salt and pepper.

Put butter in a granite or porcelain lined saucepan. When hot add mushrooms. Cover closely and cook briskly two or three minutes. Season to taste with salt and pepper, and serve with broiled beefsteak, birds or sweetbreads.—*Mr. E. B. Irving.*

Literature.

Those who are interested in mushrooms can obtain further information on them from the following books:—

McIlvaine, Chas. .... One Thousand American Fungi.
Hard, M. E. .... Mushrooms, Edible and Otherwise.
Atkinson, Geo. F. .... Mushrooms, Edible, Poisonous, Etc.
Marshall, Nina L. .... The Mushroom Book.
Gibson, Hamilton .... Our Edible Fungi.
Murrill, W. A. .... Edible and Poisonous Mushrooms.

GROWING MUSHROOMS.

Many people would like to grow mushrooms for home use or for a small local market. For such limited production elaborate mushroom houses are not necessary.

Mushrooms may be grown any place where conditions of temperature and moisture are favourable. A shed, cellar, cave or a vacant space in the greenhouse may be utilized to advantage for this purpose. The most essential factor, perhaps, is that of temperature. The proper temperature ranges from 53° to 60° Fahrenheit with the best from 55° to 58°. Any severe change in temperature will retard the growth or may do more serious harm, even to destroying the crop. High temperatures are especially harmful as diseases then develop. From this it is evident that mushrooms cannot be readily grown in summer nor as an outdoor crop. With artificial heat they may be grown almost any place in the winter.

The best material upon which to grow mushrooms is a compost made from horse manure. The manure should contain considerable straw, but not too much long, coarse material. The best material will be quite damp, containing a large amount of urine. Manure containing shavings or sawdust is not so good. Garden refuse should not be used. Manure from veterinary hospitals should be discarded, as it contains quantities of disinfectants which will prevent the growth of the mushrooms.

A wagon load of manure is sufficient to make a bed containing 80 or 90 square feet, which should yield at least a hundred pounds of mushrooms.

Preparing the Compost.

The fresh manure should be well shaken to rid it of coarse straw and to mix it thoroughly. It should then be placed in a pile about three feet deep and kept moist and allowed to heat or ferment, taking care that it does not get so hot and dry as to burn—that is to get white and dry inside. To prevent burning the pile should be forked over every three or four days and watered if necessary. The manure should feel damp to the hand but should not drip water when squeezed or pressed. It is best to keep the pile under cover so that it will not be leached by rain. Furthermore, it should not be allowed to freeze. The best time to ferment the manure is September or October.

While fermenting, the manure will attain a temperature of 100° to 150° Fahrenheit, but after a week should begin to become gradually cooler, and when it has cooled down to 70° will be ready to use. If the fermentation is thoroughly done the manure will by this time have lost all objectionable odour; will have an odour suggesting mushrooms; will have a slightly greasy feel and the straw will have a uniform dark brown colour and the droppings will appear as brown powder.

Making the Beds.

For growing mushrooms in small quantities beds may be made directly on a cellar floor or under the greenhouse benches. The boxes a foot deep and as large as desired may be made with sides of board or plank, a bottom is not necessary.

Place in the bottom of the box four or five inches of manure and pack it down tightly. Then add two inches of rich garden soil. Pack down. Add another layer of manure and another of soil and continue until the box is full, taking care to keep the compost firmly packed.

A very simple method of preparing the beds is as follows: Mix thoroughly the manure with good garden soil, using three bushels of manure to one bushel of soil. Place the compost in the boxes prepared and pack firmly by tamping with a brick.

After the beds are prepared they will probably heat to some extent but will again cool. After the temperature has cooled down to 70° they may be planted.

Planting or Spawning.

We have not yet been successful in growing mushrooms from spores. In planting mushrooms we use spawn.

What Spawn Is.

Spawn is dry compost containing the mycelium of mushrooms. There are two forms of spawn, brick spawn, in which the compost is compressed into blocks $8\frac{1}{2}$ inches by $5\frac{1}{2}$ inches by 1 to $1\frac{1}{2}$ inches, and flake spawn, in which the compost is in the form of loose masses. Brick spawn generally comes from England or the United States, while flake spawn comes from France. It is generally conceded that brick spawn is the best, as it does not dry out and deteriorate to such a great extent as does flake spawn.

Mushroom spawn can generally be obtained from any of the larger seed firms. After the bed has cooled down to 70°, the spawn may be planted.

The bricks are broken into pieces about 2 inches square. A hole about 2 inches deep is then made in the bed and a piece of the spawn pressed firmly down, then thoroughly covered with the compost which is then firmly packed. A piece of spawn should be planted to every square foot of the bed. Now cover the bed with about four inches of clean straw and, if convenient, with a piece of old carpet.

After ten or twelve days the bed should be examined. By this time the spawn should have begun to grow, forming fine white threads all through the bed. The straw should be removed and a layer of garden soil 1 or 2 inches thick should be added to the bed and firmly but gently packed down. Then replace the straw and carpet.

Care should be taken to keep the bed moist but not too wet. It is better to apply water with a watering pot every few days rather than drench the bed with a hose or buckets of water.

After about 40 days mushrooms should begin to appear and the straw and carpet should then be removed. The bed should continue to bear for three months or more, giving successive crops of mushrooms every few days. A pound to the square foot is a good yield, although 2 pounds may sometimes be obtained.

When no more mushrooms appear the beds should be thoroughly cleaned out, all the compost being removed. It will also be well to scrub the bed thoroughly with formalin before attempting to grow mushrooms again. The compost cannot be used again for growing mushrooms, but it will make excellent fertilizer for the garden, and is also very good for potting plants.

Gathering the Mushrooms.

It is best to gather the mushrooms just before the veil breaks. They are then as heavy as they will become. If left until the veil breaks they begin to lose weight and also the gills rapidly become brown and when cooked do not present the best appearance, as well as giving the liquor a brown colour.

When the mushrooms appear singly or in small clusters the best way to gather them is as follows: Take hold of the stalk just under the cap and give the mushroom a slight twist. This will break it loose from the spawn and it can then be lifted up without disturbing the bed. The compost should be pressed firmly into the cavity formed. The soiled end of the stalk should be cut off and discarded but not allowed to remain on the bed.

If the mushrooms come up in large clusters, the clusters should be cut off close to the soil and placed in a receptacle. The stubs of the stalks should then be carefully removed and the cavity formed filled in with compost.

The foregoing account of mushroom growing applies particularly to growing them in small quantities for the home or limited local use. There are a number of good books and bulletins which can be secured, dealing with mushroom growing on a commercial scale.

Literature.

Atkinson, Geo. F., and Shore, R.—Mushroom Growing for Amateurs.—N. Y. Coll., Agr. Bul. 227.

Duggar, B. M.—The Cultivation of Mushrooms.—U. S. Dept. of Agr., Farmers' Bul. 204.

Duggar, B. M.—The Principles of Mushroom Growing and Spawn Making.—U. S. Dept. Agr. Bur., Pl. Ind., Bul. 85.

Duggar, B. M.—Mushroom Growing.—Orange Judd Co.

Falconer, W.—Mushrooms: How to Grow Them.

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

BULLETIN 264

Common Diseases of the Digestive Organs of Horses and Cattle

By

J. HUGO REED, V.S.
Professor of Veterinary Science

TORONTO, ONTARIO, JULY, 1918

BULLETIN 264] [JULY, 1918

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

Common Diseases of the Digestive Organs of Horses and Cattle

J. HUGO REED, V.S.

It is probable that the owner of live stock who does not attempt to treat any but the more simple cases of disease will have better success than if he attempts home treatment for all, regardless of their nature. While each disease, to a certain extent, presents typical symptoms, yet in the early stages of the disease, in many cases, they simulate each other to such an extent that it is not possible for the amateur, and often very difficult for the veterinarian, to decide the exact nature of the trouble. Hence, there is great danger of a mistake being made, wrong treatment given, and this continued until the disease has reached that stage in which the most skillful treatment would be ineffective. It does not pay for the farmer to attempt to treat dangerous or complicated cases.

In advising treatment for the difficult ailments to be discussed, we shall recommend only such treatment as can be given by the amateur. We shall assume that those who decide to treat their own stock know how to administer medicines in the usual manners.

In a large percentage of cases diseases of the digestive organs are the result of errors in feeding.

The intestines of the horse are more subject to disease than the stomach, while the reverse is the case with the ox. The reason for this is that the stomach of the horse is a comparatively small and simple organ when compared to the volume and length of the intestines. The food is arrested for only a short time in it, soon passing on to the intestines, where the chief part of the process of digestion takes place. In the ox the large and complicated stomach not only digests, but prepares the food for digestion, while the intestines have a much smaller capacity than those of the horse.

THE HORSE

DANGER IN SUDDEN CHANGES OF FEED.

In feeding horses we shall assume that the food given is of good quality. Musty or partially decayed food of any kind should, under no circumstances, be given to a horse. Such food may, to a limited degree, be fed with reasonable impunity to cattle, but it is very dangerous to feed even small quantities to the horse.

In feeding horses, all changes in the kind or nature of the food should be made gradually. For instance, a sudden change from hay to straw, or from straw to hay, from oats to other kinds of grain, or even from whole oats to rolled oats or vice versa, from green food to dry food, or more especially from dry to green food, tends to excite digestive trouble. In fact, any change in the kinds, quality or quantity of food should be gradual.

Acute digestive troubles seldom, if ever, occur from underfeeding, but very frequently from overfeeding.

A very large percentage of horses, especially in country districts, are fed too much bulky food. The average horse will eat too much hay if allowed access to it. In discussing the proper manner of feeding horses we shall consider hay as roughage and oats as the grain ration. Where substitutes for either are used, the feeder should exercise reasonable consideration as to its nature.

It is not possible to lay down hard and fast rules as to the exact amount in weight or bulk of either hay or grain that a horse of a certain weight should be given. As all feeders have observed, horses have their individualities. Hence some require a little more feed than others of apparently the same character and general size.

One pound of hay for every 100 pounds of the animal's weight is supposed to form the proper ration for twenty-four hours. Some horses require a little more, but the excess should, in all cases, be slight. Of this the animal should be given about one-quarter in the morning, one-quarter at noon, and the remaining half in the evening. The smaller meals are given in the morning and at noon, as the horse will be taken out to work soon after eating, and if his stomach is overloaded, it tends to cause digestive trouble. At any rate, if over fed, he does not perform his labor with that comfort to himself and satisfaction to his driver that is desirable, until he has been at work for an hour or two. The large meal is given in the evening, as he will have several hours of idleness in which to digest it.

TOO MUCH HAY INJURES HORSE.

In no case should he be given more food, including both hay and grain, than he will consume in about one and one-half or at most two hours. The too common practice of keeping hay before horses at all times when they are standing in the stable is as harmful as it is wasteful. Whether a horse be performing hard work or light work, or standing idle, the amount of roughage should be about the same. He should have sufficient to satisfy his hunger, but not sufficient to cause engorgement. Most horses are gluttons, and should be treated as such.

As regards feeding grain, the amount given should depend largely upon the nature of the work he is expected to do. Even an idle horse should be given a little grain. As with hay, we may say that under ordinary conditions one pound of oats to every 100 pounds of the animal's weight makes a reasonable ration for a day—we assume that the grain is of standard quality, viz., 34 pounds to the bushel. The grain should be given in equal quantities at each meal. If by reason of the horses having to perform more than ordinary labor we wish to feed more grain, the best results will be obtained by feeding a fourth meal late in the evening. When this is not expedient the extra amount may be divided among the three meals, giving one-quarter of the total quantity in the morning and at noon and the remaining half at night.

Opinions differ greatly as to the better form in which to feed oats. The writer's experience, both in feeding his own horses and in giving professional attention to others, is, that under any conditions rolled or crushed oats give the best results. We have noticed this in our own stable, and noted that in stables of horses used either for light and fast work or for heavy and slow work, the stable that feeds rolled oats has need of the veterinarian much less often than the one in which whole oats are fed.

In addition to hay and oats a horse should be given a feed of bran at least once or twice weekly. Many feeders, especially where whole oats are fed, add to each feed of oats a quantity of bran. This practice gives good results, but we have always favored feeding bran by itself, either as an extra or as a substitute for oats, according to conditions. During the months when no pasture is available, it is good practice to give a horse a couple of carrots or a small mangel or turnip once daily.

WATERING HORSES.

Opinions differ greatly as to the proper method of watering horses. Some claim that horses should be watered only before meals, and never when they are perspiring. The prevalent idea that if a horse be watered after a meal the water will force the food out of the stomach before it has been properly acted upon by the juices of the stomach, has practically no force.

As before stated, the stomach is comparatively small; hence after a meal it is, or should be, practically full. The opening of the gullet into the upper portion of the stomach is somewhat constricted, and the opening at the lower part (called the pylorus) into the small intestine, is quite constricted. The contents of the stomach after a meal consist in small particles of solid matter mixed with the juices of the organ. It is a mechanical fact that fluids introduced into a receptacle containing particles of solid matter will not force the solids out of a small opening, but will percolate through the particles, and when the interstices become full, if the fluid does not escape, no more can enter. Hence, are we not justified in assuming that when a horse with a full stomach drinks water it percolates downwards and fills the intestines, then reaching the pylorus passes through it into the small intestine, and passing through that reaches the first division of the large intestine called the cæcum, a sack-like organ of considerable capacity, where it is stored and taken up by absorption as required? If this theory be correct, it can readily be seen that a horse may be allowed to satisfy his thirst any time without forcing unprepared injecta out of the stomach.

Again, the idea that it is dangerous to allow a horse that is perspiring to drink cold water is too firmly impressed upon the mind of the ordinary teamster. Of course, there are cases in which it would be dangerous to allow a horse free access to cold water, such as a case where the animal had been subjected to long continued and very strenuous labor, either fast or slow, and had become excessively warm. The introduction into the system of large quantities of cold water might develop such severe reactions as to cause serious trouble. In such cases a few mouthfuls should be allowed, the horse well rubbed, and in a few minutes a little more water allowed. After the abnormal heat of the body has subsided he may safely be allowed to quench his thirst. Conditions of this kind seldom occur. The fact that in hot weather a horse doing ordinary work will perspire freely is no reason why he should not be allowed to drink as much water as he wants.

The teamster is justified in supposing that his horse's sensation of thirst is as acute as his own. This is frequently impressed upon his mind by the desire the horse exhibits in his haste to reach water when he is thirsty. When the teamster is thirsty he usually finds means of allaying his sensation. When his horse is thirsty he "wants a drink" and, except under exceptional circumstances his desire should be gratified as soon as possible.

Some horses are particularly predisposed to colic and will suffer if given food or water under certain conditions. Such animals should be treated accordingly.

MEDICINES SHOULD BE ON HAND.

The owner or teamster who considers treating cases of illness in his own stock should provide himself with the drugs he is likely to require. These should be kept in as even a temperature as possible, bottles should be kept well corked and plainly labeled, powders and crystals kept carefully wrapped and plainly labeled and all kept in some secure place, out of reach of careless people and children.

He should also provide himself with a graduate for measuring liquids and scales for weighing solids. Where a graduate or other correct means of measuring liquids is not kept some of the ordinary domestic utensils may be used with reasonable accuracy. Common tumblers contain eight to ten fluid ounces; wine glasses about two fluid ounces; table spoons half a fluid ounce; dessert spoons two fluid drams, and teaspoons one fluid dram of sixty minims or drops.

In prescribing we shall use the following abbreviations: lb. for pound, oz. for ounce, dr. for dram, gr. for grain, m. for minims or drops, qt. for quart, and pt. for pint.

CHRONIC INDIGESTION.

This kind of indigestion without engorgement, is caused by improper food, imperfectly masticated food due to the process of dentition, diseases or irregularity of the teeth, voracious feeding, irregularity in feeding, debility or partial inactivity of the digestive glands.

Symptoms.—A capricious appetite, and often a tendency to eat filth; usually increased thirst; the animal becomes hide-bound, has a dry scruffy skin; irregularity of the bowels; general unthriftiness, dulness and more or less marked inability to perform work. When caused by imperfectly masticated food, the cause can usually be told by the appearance of the fæces. Colicky pains are sometimes present an hour or so after feeding.

Treatment.—Ascertain and remove the cause if possible. In all cases examine the mouth and teeth. If they require attention and the owner has neither the necessary instrument nor the skill to correct the fault he should take the horse to his veterinarian.

Where the fault is not in the mouth, and the animal be not too weak, give a laxative of 6 to 8 drams of aloes and 1 dram ginger.

(We may here state that in all cases where a laxative or purgative is to be given, and prompt action is not necessary, it is wise to prepare the patient by feeding bran only for 18 to 24 hours. In all cases after the administration, the animal should be given rest, and bran only to eat until purgation commences, which is usually 20 to 24 hours or longer. When the first dose fails to act, a second should be given in about 48 hours.)

After the bowels have regained their normal condition mix equal quantities of powdered sulphate of iron, gentian, ginger, nux vomica and bicarbonate of soda, and give a tablespoonful three times daily. Give food of good quality in small quantities, and as digestion improves gradually increase the quantity until the desired amount can be fed.

In speaking of the different forms of digestive troubles in horses modern veterinary writers generally speak of them as different forms of colics. We shall speak of them by their old familiar names, as we think this will be more readily understood by those who may study the information given in this bulletin.

ACUTE INDIGESTION.

This kind of indigestion, with engorgement, may arise from repletion with solid food or from the evolution of gases arising from the fermentation of food. It is often very difficult to determine whether the trouble is confined to the stomach or whether the intestine also is involved. This is not very important, as affections of this nature are concomitant, and require the same treatment as far as treatment by an amateur is concerned. When the trouble is confined to the stomach the modern veterinarian can act directly by the use of the stomach pump.

Causes.—The usual causes are: too much food; food swallowed greedily without proper mastication; feeding immediately after severe and long continued exercise; severe exercise too soon after a hearty meal, especially if the horse has been given something to which he is not accustomed; sudden changes of food; and drinking excessive quantities of water too soon after a hearty meal. It is not uncommon to see a well marked case for which no well marked cause can be given.

One of the most frequent causes is what may be called mistaken kindness on the part of the owner. A horse that has been idle for some weeks and has been given no grain is unexpectedly required to go a journey or do a day's work. In order to fortify him for the unusual exertion he is given a full feed of grain, hitched and driven or worked. The stomach is charged with grain to which it is not accustomed, and the horse performing physical work to which he is not accustomed. These two conditions in many cases cause "acute indigestion." When horses under the conditions noted are required for service care should be taken to feed very lightly on grain until after the service has been performed. Then, in order to compensate for the extra labor, they should be fed a moderate allowance of grain for a few days.

Horses whose digestive organs are either congenitally or temporarily weak, or whose organs have become weakened by disease, also those horses which are weak, anæmic, poorly fed and emaciated animals, or very young or very old animals and animals recovering from disease, etc., are especially predisposed to digestive trouble.

Among the direct irritating causes are green food, food and drinks that are hot, or that are frosted, unclean or partially decayed foods, mouldy hay or grain, matters undergoing fermentation or decomposition, as decomposing roots, fruit, grass, or germinating grain.

In cases where no well marked cause can be given we must decide that there is some temporary weakness of the digestive organs, which, while producing no visible symptoms, render the horse in that condition in which indigestion is easily produced. At the same time, an attack seldom occurs except in horses congenitally predisposed, that cannot be traced to carelessness or ignorance in feeding or usage.

Symptoms.—The symptoms of many diseases of the digestive organs simulate each other so much that it is often difficult to say, in the early stages, just what the disease is. Hence, the advisability, when convenient, of procuring expert attention, as an attack of a serious nature may be mistaken for a simple ailment, and if not energetically and skillfully treated early may reach that stage in which treatment will be of no avail. There are many cases in which the symptoms are not typical.

The first symptoms usually are uneasiness, dulness, stamping of the feet, lying down, probably rolling, rising again, looking toward the flank, lying down again, etc. The pulse at first increases in force and frequency, but if relief be not given in a few hours loses force while still increasing in frequency.

In many cases these symptoms are preceded by a semi-diarrhœa, the horse voiding semi-liquid fæces frequently, but in small quantities.

There is usually more or less well marked fulness (bloating) noticed, more marked on the right side. In some cases, however, the formation of gases is confined to the stomach, when little fulness of the abdomen is apparent. Eructation of gas is not uncommon, and in rare cases there is actual vomition of small quantities of ingesta. Either of these symptoms indicates a very serious case. When relief is not given the symptoms increase in intensity.

In some cases death occurs in one or two hours after the first symptoms are noticed, while in others twenty-four to forty-eight hours, or even longer, may elapse before either recovery or death takes place. In cases that do not yield to treatment the violent symptoms are usualy succeeded by dullness and stupor. The pulse becomes weak and very frequent, almost or quite imperceptible at the jaw. The patient will either stand, or walk aimlessly around the stall or paddock, breathing shortly and frequently and often perspiring freely, the visible mucous membranes highly injected, the eyesight evidently impaired. This indicates that inflammation of the stomach, and probably also of the bowels, has resulted and the patient will probably remain standing, or wander around until he falls and expires. In the meantime there is usually little or no passage of fæces, and the intestinal murmur is absent or of a metallic sound.

Treatment.—Place in a large, comfortable box-stall or small paddock. Do not force exercise nor prevent him from lying down. Give 2 to 3 oz. of oil of turpentine (according to size of patient) mixed with a pint of raw linseed oil, as a drench. It is good practice to apply to the abdomen cloths wrung out of hot water and give injections of warm soapy water per rectum. If the pain be severe give 1 to 2 oz. of chloral hydrate or 1 to 2 drs. of the solid extract of belladonna, or 1 to 2 oz. of the tincture of belladonna in a pint of water as a drench. Do not give opium in any form, as it checks the action of the bowels, which we want to encourage. Watch him closely and if he becomes stall-cast relieve him. If relief be not obtained in two hours repeat the dose, and it will be wise to get expert attention as soon as possible. If this cannot be done continue treatment, repeating the doses every two hours as required, but after the second dose of turpentine mix it with new milk instead of oil. When bloating is excessive it is good practice to puncture at the most prominent part between the point of the right hip and the last rib, but for this purpose it is necessary to have an instrument called a trocar and canula. It is good practice to administer a purgative of 6 to 9 drs. of aloes and 2 drs. ginger, either moistened, rolled into cylindrical shape and wrapped in tissue paper and administered as a ball, or mixed with a pint of cold water and given as a drench after the acute symptoms have passed.

The patient should not be exercised until the bowels have regained their normal condition after the administration of the purgative, and he should be very carefully fed and lightly worked for a few days afterwards.

CONSTIPATION.

A partial or complete inaction of the bowels may be looked on more as a symptom than as a disease of itself.

Causes.—An absence of laxative food, change from green to dry food, change from hay to straw, a partial inaction of the glands of the intestines, a partial or complete paralysis of the coats of the intestines. The bowels of some horses appear to be naturally torpid.

Symptoms.—A dulness, impaired appetite, passage of small quantities of hard, dry fæces, and in some cases slight colicky pains, an alteration in the nature of the intestinal murmur and sometimes an absence of sound.

Treatment.—In many cases a change to more laxative food will correct the fault. If colicky pains be present the administration of 1 to 1½ oz. each of the tincture of belladonna and sweet spirits of nitre in a pint of cold water, as a drench, will usually be effective. Opium in any form must be avoided as it tends to increase constipation. As in mostly all cases there is partial or complete paralysis of the muscular coats of the intestines, active purgatives must be avoided, as they cannot act while the paralysis continues. The paralysis must be overcome by the administration of 1½ to 2 drs. powdered nux vomica three times daily and rectal injections of warm soapy water. When the paralysis is overcome, which can be told by the passage of fæces, even in small quantities, and a return of the normal intestinal murmur, a laxative of 1 to 1½ pints of raw linseed oil should be given and the animal fed on laxative, easily digested food.

Note.—The *intestinal murmur* can be detected by holding the ear to the animal's flank. In order that a person may be able to detect an abnormal sound, or the absence of sound, he must, of course, be familiar with the normal sounds. This familiarity can be gained only by listening to the sounds in the abdomen of a healthy horse.

IMPACTION OF THE COLON.

Causes.—Horses over abundantly fed or fed upon food containing large quantities of indigestible or woody fibre, as over-ripe hay of any kind, are liable to suffer from an accumulation of such matter in any part of the large intestine, especially in the large colon. This condition is not uncommon in horses whose ration has been suddenly changed from hay to straw. It may be due to an unexplained weakness of the digestive organs, or partial inactivity of their glands, want of exercise, or any sudden change of food. It is not uncommon in horses that do not thoroughly masticate their food, due to too greedy feeding, irregularities of the teeth, or diseased liver, or, in fact, to any inaction or partial inactive condition of the glands of any portion of the digestive tract.

The same causes largely operate in exciting the various diseases of the digestive organs. It may not be considered out of place to repeat that when horses are intelligently fed and exercised digestive diseases seldom occur. Care must be taken that the quality of the food is good, that the quantity is in accordance with the size of the animal and the amount of work performed, and any change of diet is made gradually.

It may also be wise to remark that all horses over five years old, and often those even younger, would be better if they had their teeth examined, and, if necessary, dressed by a competent man once every year. This statement will probably be considered by some as extravagant, but it is a fact nevertheless, and the horse owner who attends to this matter regularly is amply repaid for the outlay. His horses can then masticate their food more thoroughly and without irritation to tongue or cheeks, and consequently will thrive better, look better, and be less liable to the class of diseases under discussion. Many will say, "My horses' teeth are all right; the animals eat well and keep in good condition." This may be quite true, but it does not follow that because a horse consumes his food without apparent difficulty and without quidding, that his teeth are in first-class condition. If examined, there will, in most cases, be seen or felt, sharp points on the inner margin of the lower molars, and the outer margin of the upper ones. These projections, while probably not materially interfering with mastication, cause more or less irritation to the tongue and cheeks, make mastication more or less unpleasant and warrant the expense of having the cause of irritation removed.

Symptoms.—The symptoms of impaction of the colon are not usually alarming. The conditions may be present for some time without any serious symptoms being noticeable. It may be noticed that for a day or two the animal has not voided his normal quantity of fæces, while that voided has been somewhat dry; also that his appetite, spirits and ambition have not been quite normal. He will probably now begin to show more or less well marked colicky pains, become restless, lie down, get up again, etc., and show more or less general uneasiness, but seldom shows violent symptoms. The pulse, in most cases, is slightly increased in force and frequency, and, as the disease advances, it increases in frequency but decreases in force. The mucous membranes are usually injected. A peculiarity of the symptoms usually shown is a desire to sit upon his haunches, or when standing to press his croup against some stationary object. He resists the introduction of the hand, or injections into the rectum, and, if the ear be placed against the abdomen, an absence of the normal intestinal murmur will be detected—there will be either an absence of sound or sounds of a metallic nature. There will be little or no fæces voided, and a fulness of the abdomen, better marked on the right side, will be more or less evident. When relief is not afforded, the symptoms increase in intensity, gases form and increase the fulness of the abdomen, the pulse becomes more frequent, but weaker—often almost, or quite, imperceptible at the jaw—and the patient either walks aimlessly about or throws himself violently down, rolls and struggles. Rupture of the intestine may now take place (especially in cases where the symptoms are violent) which causes death in a few hours, or inflammation of the bowels results, which is equally as fatal, but not often so quickly.

Treatment.—As there is always partial or complete paralysis of the coats of the intestines, the administration of large doses of purgative medicines must be avoided until the paralysis is overcome. It is good practice to administer a laxative, say, 6 drs. of aloes and 2 drs. ginger, or a pint of raw linseed oil to a horse of ordinary size. Follow up with 2 drs. nux vomica every eight hours.

Combat pain by giving 1½ ozs. chloral hydrate, or 2 drs. solid extract of belladonna, or 2 oz. each of tincture of belladonna and sweet spirits nitre in a pint of water as a drench every two or three hours as the symptoms indicate. Do not give opium in any form, as it increases the constipation.

Remove the contents of the rectum by hand and give injections of warm soapy water per rectum every three or four hours. Some recommend the injection of a solution of aloes into the rectum, about 1 oz. to a gallon of water, and when the patient will retain the fluid for a considerable time it may give fair results.

If gases form and the patient becomes bloated, give 2 to 3 ozs. of the oil of turpentine in a pint of raw linseed oil. This may be repeated every two hours, but after the first dose it will be wise to mix the turpentine with new milk instead of oil in order to avoid too much purgative medicine.

Note.—In recommending doses we always mention the proper doses for animals of ordinary size. Very small or very large animals should be given doses in accordance with their size.

SPASMODIC COLIC.

Probably the most common form of indigestion in horses is that form commonly known as "Spasmodic Colic." Some horses are particularly predisposed to it. It consists in a spasmodic contraction of a portion, or portions, of the muscular coat of the intestines, usually of the small intestine. It is not uncommon for the muscular fibres of the neck of the bladder to be involved.

Causes.—The disease is usually due to the nature of the food, or improper feeding, sudden changes of diet, exhaustion from overwork, particularly if associated with long fasting. A drink of cold water may cause it, especially if the horse be exhausted by a long journey or several hours hard work. Some horses are particularly predisposed, such as those in which there are concretions of different kinds in the intestines, abscesses in the mesentery, parasites in the intestines, ulcers in the stomach, canker or chronic thickening of the intestinal walls, also those with congenital or acquired weakness of the digestive powers or disease of the digestive glands.

While simple spasmodic colic is a comparatively unimportant disease, which readily yields to treatment in most cases, fatal cases have occurred, the patient dying from exhaustion, and a post mortem revealing no lesions or chronic disease of the digestive tract, the only abnormal conditions being a rigid contraction of small portions of the small intestine. Repeated attacks of colicky pains occurring in a horse without apparent cause, indicate some structural change in the digestive organs, in many cases the presence of concretions or tumors in the intestine. If such be present, and are movable, we are justified in assuming that they occasionally, by change of position, occlude the canal, and thereby check the backward passage of fæcal matter, check peristaltic movement, and cause pain. In such cases the violent movements of the animal are liable to dislodge the obstruction, reopen the canal and consequently relieve pain. In other cases the obstruction does not become dislodged, the case does not yield to treatment, and after several hours, inflammation of the bowels results and causes death. A post mortem reveals the presence of a calculus or tumor.

A horse that is predisposed to colic from any cause will probably, sooner or later, suffer from an attack that will cause death. Some horses suffer from colic if allowed water shortly after a meal, others if given even a light change of food, others if fed certain foods, etc. When such is the case the attacks can usually be prevented by exercising care not to subject the animal to the conditions that cause the attacks.

Symptoms.—These usually appear suddenly and are very violent and alarming. The patient suddenly expresses pain by pawing, kicking at the abdomen, throwing himself down violently, rolling and struggling, jumping suddenly to his feet, probably repeating these actions, and, in other cases, shaking himself, then becoming quiet and commencing to eat as though nothing were wrong. After a variable interval of ease the pains recur, sometimes in an aggravated and sometimes in a modified form. During the attacks the pulse is full and frequent, but during the intervals of ease it is normal. The attacks may occur again and again, the periods of pain and of ease being of various duration, until the patient is relieved by treatment or spontaneous cure or the disease becomes complicated by inflammatory action, which complication usually terminates fatally. At the commencement of the attack fæces are often voided frequently and in small quantities and may be either soft or hard, while frequent voiding of small quantities of urine is often noticed. In other cases frequent but ineffectual attempts to urinate are noticed.

These symptoms indicate that the neck of the bladder is involved in the spasms, and as a consequence urine cannot be voided. This leads the uninitiated to conclude that the horse is suffering from disease of the urinary organs. This idea is very common. The owner or driver decides that there is an obstruction in the urinary passage, and proceeds to remove it by giving a dose of sweet spirits of nitre. This is usually followed by relief but it does not act as it is generally supposed to. It will not remove obstructions, but it tends to relieve the spasm of the neck of the bladder, hence allows escape of urine, after which the horse will probably show no more pain. We often hear a man telling that his horse was very sick from "stoppage of his water," that he gave him a dose of sweet nitre, after which the animal urinated and then got all right. The fact is, the nitre relieved the spasm of the neck of the bladder, the horse became "all right"—and then urinated. If there be an occlusion of the urinary passage from other causes than that mentioned, the treatment named would make matters worse, because the drug, as well as being an anti-spasmodic, increases the activity of the kidneys, but does not remove obstruction; hence it causes an increased flow of urine into the bladder, but does not remove the obstruction that prevents its escape from the organ.

During the paroxysms of colic the pulse becomes altered, as stated, the respirations are also accelerated, and in some cases perspiration is profuse. During the intervals of ease these functions become normal. The symptoms, while usually short, are generally more violent and alarming than those of more serious intestinal diseases.

Treatment.—In many cases a spontaneous cure takes place without treatment in from a few minutes to an hour or two, but it is wise to administer an anti-spasmodic in all cases. The following is a favorite and effective colic drench: 1½ fluid ozs. each of laudanum, tincture of belladonna, and sweet spirits of nitre, in a pint of cold water. This being the dose for an ordinary sized horse, young, small, or very large animals require less or more according to size. Instead of this we may give 1 or 2 ozs. of chloral hydrate or 2 to 3 fluid drs. of chloroform in a pint of water. The patient should be placed in a roomy, comfortable box-stall or paddock, and carefully watched to prevent him from hurting himself or becoming fast. It is good practice to give a rectal injection of soapy, warm water. If relief be not apparent in an hour the dose should be repeated. If the first mentioned drench be used the laudanum must be omitted, as it tends to constipation. After this the dose may be repeated every two hours as indicated by the symptoms. If relief be not noticed in at most four hours we may suspect a more serious condition than ordinary spasmodic colic, or that the disease has become complicated. When practicable, the services of a veterinarian should then be procured. If professional assistance is not available, the owner should repeat the doses as noted. If bloating occurs, the patient should be treated as for flatulent colic, a discussion of which will follow.

It is good practice to administer a laxative of 5 to 7 drs. of aloes and 2 drs. ginger or 1 to 1½ pts. of raw linseed oil after the acute symptoms have passed.

FLATULENT COLIC.

A disease commonly called "Flatulent Colic" is quite common in horses. It is a form of indigestion, and in the early stages the symptoms strongly simulate those in acute indigestion.

Causes.—This condition is much more serious than spasmodic colic although the causes are much the same, viz., changes of food or water, over-feeding (especially after a long fast or when overheated), food of poor quality, severe exercise too soon after a hearty meal, a weakness, or partial inactivity, of the digestive glands, etc., food that ferments readily, as green clover, turnip tops, etc., especially if wet or frosted is a fertile cause. It sometimes occurs during the progress of other diseases, indicating a very grave condition. This, and in fact, mostly all intestinal diseases, occasionally appear without recognizable cause, due, no doubt, to a non-active state of the digestive glands.

Symptoms.—The symptoms do not generally appear so suddenly, nor yet are they so violent and alarming to the ordinary observer, as those of spasmodic colic. The animal becomes dull, uneasy, stamps his feet, probably kicks at his abdomen, looks around at his flanks, paws, lies down carefully, may roll, rise again and continue to show uneasiness. The pulse is increased in both force and frequency and respiration is often more or less labored. The symptoms of pain are practically constant, but vary in intensity. In a short time after the first symptoms are shown there will be noticed a more or less well-marked fulness of the abdomen (bloating) more marked on the right side just in front of the point of the hip. The visible mucous membranes become injected, the pulse continues to increase in frequency, but usually gradually loses force, and the respiration will be labored in proportion to the degree of distention of the abdomen with gas. The extremities are usually cold, and there is often a twitching of the muscles. If relief be not effected, the symptoms continue to increase in severity, bloating becomes excessive, and death takes place from rupture of the intestine, suffocation or absorption of gases into the circulation.

Treatment.—Place in a roomy box-stall or a paddock. Agents which combine with, or neutralize, the gases are indicated. For this purpose there is probably nothing that can be safely given by the stomach that acts as well as oil of turpentine (commonly called spirits of turpentine) and raw linseed oil, 1 to 3 fluid ozs. of the former in one-half to one pint of the latter (according to the size of the patient). If necessary, the dose may be repeated in an hour, but if given the third time new milk should be substituted for the oil. When this medicine is not quickly obtainable 2 to 3 ozs. of bi-carbonate of soda (baking soda) dissolved in water should be given. The patient should be well bedded and kept as comfortable as possible. A couple of gallons of warm soapy water should be injected into the rectum occasionally. If the pain be severe it should be combatted by the administration of 1 to 2 ozs. of chloral hydrate dissolved in a little water, or 1½ fluid ozs. each of tincture of belladonna and sweet spirits of nitre in a pint of cold water as a drench. This anodyne may be repeated about every two hours as needed. If bloating becomes excessive, care should be taken to prevent the patient from throwing himself down violently, as there is danger of this causing rupture of the distended intestine. If the bloating becomes so marked that there is imminent danger of suffocation or rupture, the patient should be punctured on the right side at the most prominent part between the point of the hip and the last rib to allow the immediate escape of gas. This operation, if skilfully performed with a trocar and canula (an instrument especially designed for the purpose), has proved successful in most cases, but the use of knives and other crude instruments has not usually been followed by satisfactory results.

In a case of this nature when the administration of the drugs mentioned does not give relief in at most two hours, it is better, where possible, to secure the services of a veterinarian, but where this cannot be done the attendant can only follow the above treatment to the best of his ability.

INTUSSUSCEPTION.

Intussusception is a name given to a form of indigestion which is caused by a portion of the intestine (either small or large) slipping into the portion immediately behind it, like the drawing of a finger of a glove into itself. As a result of this, the normal course of the intestine is interrupted. In consequence nothing can pass through, the action in the bowel is checked and the circulation of the blood through the bowel involved is also checked. While this is practically an incurable condition, it may be wise to draw attention to its occurrence and symptoms. Recovery of cases where this condition has been suspected has occurred, the imprisoned portion (if the condition really existed) having been released during the struggles of the animal, while other cases have recovered by a rapid sloughing of the imprisoned portion, and union taking place between the several ends, the sloughed portion passing off with the fæces.

Treatment, other than an operation, has no action in rectifying the trouble, and the veterinarian does not operate in such cases, as it is practically impossible to make a correct diagnosis or to exactly locate the lesion, and, though such were possible he cannot provide surroundings where antiseptic measures can be observed to a sufficient degree to afford probable favorable results.

Symptoms cannot be said to be diagnostic, but are a combination of those observed in other diseases of the digestive organs, particularly resembling those of obstinate constipation. There is a cessation of intestinal murmur, restlessness, pain shown by pawing, wandering about, lying down, endeavoring to lie on the back, sweating, crouching, sitting upon the haunches, pressing the rump against any solid object when standing, anxious expression. The pulse is at first full and frequent, but as the disease advances it decreases in force but increases in frequency, in many cases becoming intermittent and afterwards imperceptible at the jaw, There will be little or no passage of fæces. The mucous membranes become injected and red, respirations are frequent, and apparently labored. The abdomen, at first of normal appearance, becomes fuller, and in some cases distended with gas. The mouth may be moist and clean, or dry and hot, with an offensive odor. The restlessness continues, the extremities are usually cold. He may rear on his hind legs. After a variable time pain usually ceases, and he will stand quietly, usually covered with a cold sweat, pulse imperceptible at the jaw, breathing frequent, and usually sighing. To the uninitiated these symptoms indicate an improvement, but they really indicate that the inflammation has terminated in mortification and the approach of dissolution. In some cases there is retching and attempts to vomit. He will usually stand thus until he begins to stagger, and at last falls and dies with a few convulsive struggles. In other cases the symptoms of pain endure until the last.

VOLVULUS OR TWISTED BOWEL

Volvulus or twisted bowel consists of a rolling on itself of a portion of intestine (either large or small) until nothing can pass through. A knot practically exists. The symptoms and results are identical with intussusception. The existence of either condition can be suspected only, and treatment should be directed to relieve pain by administering 1 or 2 ozs. of chloral hydrate either in bolus or solution every two or three hours. If gases form give 2 to 3 ozs. oil of turpentine in a pint of raw linseed oil. Keep comfortable, apply to the abdomen cloths wrung out of hot water, and give rectal injections of warm, soapy water. If the pain becomes relieved give a laxative of 5 to 8 drs. of aloes and 2 drs. ginger, and follow up with 1 to 3 drs. of nux vomica three times daily. Of course, if either of the above-mentioned conditions exist, treatment will be of no avail, and death will take place unless a spontaneous righting of the involved bowel takes place; but if it be a case of constipation without displacement of intestine a recovery will probably take place.

Intestinal Concretions of different kinds occasionally form in the stomach or intestines, probably more frequently in the large intestine than in other parts. Some are composed of phosphates—called phosphatic calculi; these are hard, smooth and polished, having a nucleus, generally a piece of iron or stone, others are composed of beards of grain, hair or other indigestible matter, often mixed with phosphatic salts.

Symptoms.—No reliable diagnostic symptoms are present. Their presence can be suspected only by repeated attacks of colic without appreciable cause. As a calculus is usually movable it is probable that it gets into a position that obstructs the passage, hence causes colicky pains. The violent actions of the patient, doubtless, in many cases change the position of the obstruction, open the passage and relieve the symptoms. At last a time comes when, by reason of inflammatory action and swelling, the concretion retains its position and causes death, preceded by symptoms resembling those of the conditions just discussed. In some cases the calculus is situated in the rectum and can be reached by the hand and removed. This teaches the advisability of exploring the rectum in all such cases of a doubtful nature.

Treatment.—The treatment indicated is that for colic, viz., the administration of anodynes, as 1 to 2 ozs. chloral hydrate, or 1 to 2 drs. of the solid extract of belladonna or 1 to 2 ozs. each of laudanum, tincture of belladonna, and sweet spirits of nitre, in a pint of cold water as a drench. This dose may be repeated every two or three hours as indicated, but when more than one dose is required it is wise to omit the laudanum, as it tends to constipate. If a calculus be present, treatment will be of no avail, but as we cannot be certain of its presence we are justified in treating for colic. Horses that are subject to repeated attacks of this nature, whether the cause be calculi or a weakness of the digestive organs, are very undesirable. When the cause is purely digestive weakness the attacks can often be prevented by regularly giving the animal a good stomachic, as a dessert spoonful of ginger and a teaspoonful of gentian in an evening feed of damp grain. This usually tones the digestive glands, thereby aiding digestion and preventing the attacks.

ENTERITIS.

Enteritis, or inflammation of the bowels, is one of the most rapidly fatal inflammatory diseases to which the horse is liable, often causing death in a few hours. Many of the diseases of the digestive organs, some of which have already been discussed, result in enteritis, but we will now discuss it as a primary affection. Any portion of either the large or small intestine is liable to be the seat of the trouble, and in some cases the greater part of each is involved. The inner or mucous coat is usually first attacked, but the inflammation extends and involves the middle or muscular coat, and also the outer coat, and there is often an extravasation of blood into the canal due to rupture of the small blood vessels.

Causes.—The principal causes are fatigue, exposure to cold, standing in a cold draft, or drinking large quantities of cold water when overheated, but, like other intestinal diseases, it frequently occurs without well-marked cause.

Symptoms.—The first well-marked symptoms are usually those of abdominal pain, evidenced by uneasiness, stamping of the feet, whisking of the tail, looking around towards the flank, a desire to lie down, etc. These symptoms are, however, usually preceded by some degree of constitutional disturbance (which may pass unnoticed) as shivering, acceleration of the pulse and respirations, repeated evacuation of small quantities of semi-liquid fæces, and general depression. The mucous membranes soon become deeply congested, the mouth dry and hot, the tongue contracted, and sometimes of a brownish color; the appetite is, of course, lost; the pulse is hard, strong, wiry, and frequent; the abdomen is tender upon pressure; the abdominal muscles more or less contracted. In some cases slight bloating is noticed. In a variable time the symptoms of dulness and depression give way to those of pain and excitement: the horse stamps with his feet, strikes at his abdomen, lies down—but usually does so very carefully, often making several attempts or feints, and then goes down with great care, and will probably endeavor to lie on his back—looks toward his flank, pants, blows, and perspires freely. There are no sharp paroxysms of pain with periods of ease as in many cases of colic. The pain is constant, distressing and agonizing, but to some extent varies in intensity. The body is usually covered with perspiration. In some cases he will stand for hours with his head in a corner and paw persistently with one or both feet. In other cases he will walk around in the stall or paddock in a circle, apparently almost blind, knocking his head against the wall or fence. The pulse is at first hard, full and frequent, varying from 80 to 120 per minute, but generally decreases in strength and fulness and becomes thready and almost or quite imperceptible at the jaw. He sighs or groans from pain, and perspiration drops from the body. The skin is seldom dry, at one time hot and another cold; the countenance becomes haggard, the eyes expressive of delirium with the pupils dilated.

He may now throw himself about in a dangerous manner, but usually stands as stated or moves aimlessly about, then stand and balance himself as long as possible, when he will fall and expire with a few convulsive struggles.

In other cases the symptoms of pain subside and he will stand quietly, even drink a little water or endeavor to eat, and his breathing becomes more or less tranquil. This often leads the owner to think that recovery is taking place, but the symptoms indicate that mortification is commencing; the haggard expression remains, the pulse continues imperceptible at the jaw, cold sweat bedews the body, the abdomen usually becomes bloated, he trembles, ears and legs become cold, mouth and breath cold and often foul smelling; the lips drop pendulous, the eyes become glassy, and in a variable period he drops and dies. The bowels usually remain inactive to the last. If, however, in three or four hours from the commencement of the attack there is some abatement of the symptoms; if the surface of the body becomes dry, if there be passage of fæces or gas, the pulse becoming softer and less frequent, and the characteristic anxiety of expression disappears, a favorable termination may be looked for.

Treatment.—As the mucous tract of the bowels is the primary seat of trouble, treatment must be directed with a view to checking the action of the bowels until the inflammatory action has ceased, and although there is usually an inactive condition of the bowels purgative or laxatives must, on no account, be given. Treatment must tend to relieve pain and check the movement of the intestines. For these purposes opium must be administered in large doses. In the early stages, when the pulse is full and strong, if depression be not well marked it is good practice to give 12 to 15 drops of Fleming's tincture of aconite in a little cold water, or extract 3 to 4 quarts of blood from the jugular vein. From 2 to 3 drs. of powdered opium should be given in a pint of cold water as a drench, and rather smaller doses every two hours until the symptoms are relieved. Cloths wrung out of hot water should be applied to the abdomen continuously for a few hours, and care be taken to clothe the patient well afterwards to prevent too great reaction. If, after abatement of the symptoms, the bowels remain torpid (as they generally do) the removal of this torpidity must not be attempted by the administration of drastic purgatives. Very small doses of raw linseed oil, say 4 to 6 ozs. with 2 drs. nux vomica, may be given about every eight hours, and the contents of the rectum removed by injections of warm soapy water occasionally. When the appetite returns the most easily digested food, as bran and boiled linseed, should be given, and the eating of dry food prevented until the bowels commence to act; and then solid foods should be given in only very small quantities for a few days.

DIARRHŒA.

Diarrhœa is the term applied to all cases of simple purging if the fæces are loose, liquid or semi-liquid, and frequently voided, without co-existing inflammation. Diarrhœa is sometimes a spontaneous effort to discharge from the intestines something which is irritant or obnoxious to them, or to the system generally. It is also induced by a variety of causes, such as indigestible food, food imperfectly masticated, sudden changes in diet, particularly from a dry to a moist one, medicinal agents, parasites in stomach or intestines, derangement of the liver, drinking large quantities of water when overheated, etc. Probably the most frequent cause is the consumption of stagnant or impure water.

Some horses are particularly predisposed to attacks of diarrhœa from trivial causes. Short-ribbed, flat-sided, narrow-loined horses, and those of very nervous temperament are apt to purge without apparent cause. They are commonly called "washy" horses. They will start upon a journey in apparently the best of health, but after being driven a variable distance will commence to purge more or less freely, passing liquid or semi-liquid fæces (often accompanied by flatus) in small quantities and frequently. In some cases feeding exclusively on dry food will prevent the trouble, but in others it will not. Such horses are hard to keep in condition, require the best of food and very careful feeding, and are unpleasant to drive. If used for slow work they usually give fair satisfaction. Some horses become "washy" as the result of swallowing imperfectly masticated feed, due to faulty teeth. Such can be successfully treated by having their teeth attended to. Others may be "washy" only when fed some particular food or watered under certain conditions, and of course these, after the cause has been ascertained, can be successfully treated by removing or avoiding the cause.

Acute Diarrhœa is that condition in which an animal not "washy" from predisposition or acquired conditions, purges freely without suffering acute pain. The fæces are voided freely in liquid or semi-liquid form, often of a dirty brown color, and usually without offensive odor. In other cases the excretions are foul smelling and often of a dirty clay color. In some cases a spontaneous cure results in a few hours, indicating that the trouble was caused by some irritant in the intestine, which was expelled with the excreta, and a rapid recovery took place. In other cases the trouble continues, the animal loses appetite, but thirst is usually excessive, he drinks large quantities of water, regardless of its quality, he fails rapidly in strength, and, if the trouble be not checked he will become unable to stand, and death will soon take place.

Treatment.—If possible, ascertain and remove the cause. If this can be done in the early stages it is often all that is required. If it be suspected that the disease is due to some irritant in the intestines, and the patient is not showing weakness and loss of appetite, a laxative of 1 to 1½ pts. of raw linseed oil should be given. This, of course, temporarily increases purgation, and is given with the hope that this increase will cause the removal from the intestine of the irritant that is responsible for the trouble. In fact it is good practice in all cases of acute diarrhœa in which the patient still retains a reasonable appetite and reasonable strength to give a laxative.

After giving the laxative nothing should be given to check the diarrhœa for at least twenty-four hours, as it requires that length of time for the laxative to establish and complete its action. If astringents be given earlier they will counteract the laxation, and there will be practically a negative result from each, hence no good will result. If after this length of time the diarrhœa still continues, means should be taken to check it. Also, if the patient has lost appetite and is becoming dull and weak, even in the early stages, he is not in condition to withstand the still further weakening effects of a laxative, and prompt means of checking the diarrhœa should be taken, even though we suspect the presence of some movable irritant in the intestines.

While, upon general principles, we say that "diarrhœa should not be too quickly checked," experience teaches us that in cases of acute diarrhœa, presenting the symptoms noted, prompt measures to check it are necessary. For a horse of ordinary size we recommend 2 ozs. of tincture of opium, and ½ oz. each of powdered catechu and prepared chalk in a pint of cold water, given as a drench every four hours until diarrhœa ceases. The dose for small or larger animals should, of course, be in proportion to size. If appetite remain dry food, as oats and hay, should be given. If appetite be lost and weakness well marked the patient should be drenched every few hours with raw eggs and ½ pt. whiskey or 2 ozs. sweet spirits of nitre, or with oatmeal gruel to which has been added the stimulant. If the excretions have an offensive odor the administration of ½ oz. hyposulphite of soda every few hours usually gives good results.

As already stated, the patient is usually very thirsty, and, if allowed will drink excessive quantities of water. It is not wise to allow large quantities of water to be taken at once, but the patient's thirst should be satisfied by allowing small quantities—say a gallon at a time, and given every half hour or even oftener if necessary. To the water add one-quarter of its bulk of lime-water, that is, four parts water and one part lime-water. This, in most cases, gives good results.

We are often impressed with the idea that the lime-water gives more marked results than the drugs. Lime-water is made by slacking a lump of lime, then adding considerable water, stirring well, then allowing to settle. The undissolved lime precipitates and the clear liquid on top is lime-water. It cannot be made too strong, as the water will dissolve and hold in solution only a certain quantity of lime and the remainder precipitates. In other words lime-water is a saturated solution of lime in water, that is, the water contains all the lime that it will hold in solution.

SUPERPURGATION.

Superpurgation, or over excitement of the intestines from undue action of purgative medicine, is a condition of the bowels frequently seen. The susceptibility of horses to the action of purgatives and other medicines vary greatly. While in a majority of cases this is governed to a great degree by size and breeding (hot blooded horses being more susceptible than those of cold blood, hence require smaller doses in proportion to age, weight, etc.), we find that horses of like breeding exhibit various degrees of susceptibility. It is not possible to tell with certainty by the general appearance of a horse just how large a dose of aloes or other purgative medicine it will require to give the desired action, which usually is moderate purgation. In some cases where an ordinary dose has been given, one that is in proportion to the size and breeding of the animal, practically no purgative action is produced, while in another case of apparently the same nature, in a horse of apparently similar characteristics, severe purgation may be the result. Hence we can readily understand that the most observant and skilful may be disappointed in the operation of a purgative. Some horses, without showing any indications, are particularly susceptible, while others are the reverse. Then again, the susceptibility of a horse varies at different times, owing largely to the general condition of the digestive tract, which may not in any way be indicated by his general appearance. At the same time in cases where reasonable care and intelligence is exercised in regard to the size of the dose and after treatment it is seldom that serious results occur. It is possible that untoward results may occur in any case. The results of a purgative depend, not only upon the size of the dose and condition of the animal, but largely upon the quality of the drugs and upon the treatment of the animal both before and after administration.

When the necessities of the case permit, the patient should be prepared by not allowing anything but a little bran to eat for twelve to eighteen hours before administration. Afterward no solids but bran should be allowed. Water should be given often and in small quantities (if the weather be cold the chill should be removed from the water) until purgation commences. After this solid food should be given in small quantities. Gentle exercise the first few hours after administration hastens the action of the purgative, but on no account should the horse be exercised or worked severely, nor should he be given any exercise during the action of the dose. It is customary, and good practice to allow perfect rest after the administration of the dose until the action has ceased and the bowels become normal.

While there are, in most cases, more or less nauseation and distress, caused just prior to, and during the visible action of the drugs, these are often so slight as to escape observation. But irrational treatment such as allowing solid food, copious drinks of water, fatiguing exercise, etc., increase the irritation and distress. It is good practice to administer a little ginger with the purgative, especially with aloes, as this tends to prevent griping.

The usual symptoms associated with the actions of a purgative are slightly hurried breathing and impaired appetite (not always noticed), when purging is about to commence, and the patient usually becomes more or less nauseated and suffers from slight griping pains. If the purging, however, does not proceed to an undue extent, these symptoms soon subside, and the nausea is succeeded by a desire for food. Should the patient be constitutionally weak, or be driven or ridden for a considerable distance, or worked while the purging continues or too soon after purgation ceases, or if the dose was too powerful in the first place, or if two or more of these circumstances operate, the purging will probably become excessive and long continued, and the life of the animal will thereby be endangered. While under ordinary conditions purgation should commence in eighteen to twenty-four hours after the administration of the dose, and continue for a like period, it is not unusual for a longer period to elapse before its action is noticed, and its duration may also be extended beyond the normal time. A purgative dose should not be repeated (except in exceptional cases) for at least thirty-six hours, and then only a small dose given when the first has not operated. We are assuming that the drugs given are of good quality, as, of course, no dependence can be placed upon the action of drugs of inferior quality. Purging may continue for a long time, but as long as the patient is kept quiet and the appetite remains good, the pulse normal or nearly so, little or no danger need be apprehended. If, however, the appetite fails, the pulse becomes thready, and the animal weak, prompt treatment is necessary. The symptoms indicating too violent and long continued action of a purgative are: staring, glassy eyes, frequent indistinct or intermittent pulse, voiding foul smelling or bloody fæces, distended abdomen, with or without evacuations of gas, well marked loss of appetite, and general weakness. The patient usually stands still, or paws and wanders about, but seldom lies down. Horses suffering from any acute disease of the respiratory organs are particularly susceptible to the action of purgatives, and in such cases even reasonable doses act violently.

Treatment.—As stated, when the appetite and strength remain practically unimpaired, even though purgation continue an abnormal length of time, it is not necessary to interfere; but should the serious symptoms noted be observed, means must be taken to check the purgation. This, however, should not be done too quickly. Care should be taken not to allow water to be taken in large quantities at a time, as the thirst is usually great, and the horse will drink inordinately. He should be given water in small quantities and often. The addition to the water of about one-quarter of its bulk of lime-water gives good results. He should be allowed small quantities of anything he will eat. Dry food, as hay and oats, are preferable. If very weak, stimulants as 4 to 6 ozs. of whiskey or brandy should be given every few hours. If purging continues treat as for diarrhœa, viz., give 1½ to 2 ozs. of laudanum and 4 drs. each of powdered catechu and prepared chalk in a pint of cold water as a drench every four or five hours until purging ceases. Care must be taken to not continue the latter treatment after purging ceases, as there would be danger of causing constipation.

AZOTURIA.

While azoturia is not a disease of the digestive organs it is a dietetic disease and quite a common and serious ailment, hence we may be excused for discussing it in this connection.

It is a disease peculiar to the horse and the mule, especially the former. It is characterized by partial or complete arrest of the power of locomotion caused by partial or complete paralysis of the posterior or anterior limbs (usually the former) with a morbid change in the character of the urine. While in all cases the kidneys become involved it is not primarily a disease of these organs. Some authorities call it a disease of the blood, while others class it as a disease of the nervous system. As it occurs after a period of idleness accompanied by high feeding we feel justified in classifying it as a "Dietetic disease." It would not be wise to discuss the various views as to the nature of the disease here, as a knowledge of this is valuable only from a scientific standpoint. Besides, as opinions of scientists differ we would gain nothing by the discussion. We shall confine our discussion to the conditions under which the disease occurs, the symptoms and treatment, both preventive and curative.

Causes.—It is a disease of the well kept horse. It does not appear in poorly kept and neglected animals. The predisposition to the disease is produced by idleness and good food. An attack is always preceded by a period of idleness, the period varying to a considerable extent—some say from two days to two weeks or longer. A few days' idleness is more likely to be followed by an attack than a longer period of rest. We cannot call to mind a case that occurred following a rest of less than three or more than ten days. Just why this is a fact cannot be satisfactorily explained. During a period of complete rest and good feeding the equilibrium between repair and waste is altered or partially suspended and plethora is established. The various excreting organs in some cases become more or less inactive. Certain products of the food which should be eliminated by said organs accumulate in large quantities, but no physical symptoms are noticeable that will lead the attendant to suspect danger until the animal is put in motion. Then these products, which are supposed to be of a nitrogenous nature, are converted into various substances, chiefly uric and hippuric acids, and are thrown upon the kidneys for elimination or excretion. The kidneys being unable to perform the increased function these materials are practically thrown back upon the system, causing a form of blood-poisoning of the muscles. This produces paralysis, either partial or complete of the muscles involved, depending upon the severity of the attack. It is probable, if the period of rest be extended beyond ten days or two weeks, that the system becomes accustomed to this condition. The excretory organs then regain their activity and eliminate the materials which at an earlier stage in the period of idleness would have caused the disease, had the animal been subject to exercise.

We cannot tell why some animals suffer from the disease under conditions to which several have been subjected, and the others go free. Neither can we tell why a horse may be subjected to such conditions many times with impunity and another time be attacked with the disease. We know that such are the facts, but cannot explain them.

We notice that horses accustomed to spasmodic exercise, or, in other words, accustomed to standing idle for a few days at a time and then worked or driven, seldom suffer from azoturia. Most victims are those that are accustomed to regular work and good food, and from some cause spend three days or more in idleness, and receive their usual amount of grain, and are then given exercise. Exercise following rest is necessary to cause the trouble. Cases have been caused by horses becoming halter-cast after a few day's rest, the exertion during the efforts to rise having the same effect as exercise or work. It is seldom that a horse that stands in a box-stall is attacked. In most cases he takes sufficient voluntary exercise to keep the excretory organs active, hence prevents an accumulation of the products noted. As the disease is always serious (especially in heavy horses) and in severe cases often fatal, it is obvious that preventive treatment is advisable. This, of course, consists in giving daily exercise to well-fed horses, even if for only a few minutes. If conditions make this impossible the grain rations should be reduced and largely supplemented by bran, or, if possible, the horse given a roomy box-stall during the period of idleness.

Symptoms.—After a period of rest the horse is hitched and, of course, is usually feeling in higher spirits than usual and anxious to go. After being driven a variable distance, from a few hundred yards to several miles, (the symptoms have been noticed very early in some cases, and in rare cases not for a few hours), he begins to lose ambition, hangs back, suddenly goes stiff or lame, either in a hind or fore leg (usually the former). It is often thought that he has picked up a nail. He perspires freely; the muscles of the loins or croup, or in the fore leg, those of the forearm and shoulder, become enlarged and hardened. The respirations become labored, the expression becomes anxious, the pulse frequent and strong, he trembles, looks around at his sides, apparently suffers pain, and he may lie down, roll and regain his feet. His back becomes arched, he staggers, knuckles at his fetlock joints, he is losing control of his limbs, the whole body shakes, he tries hard to retain the standing position, but eventually falls. He may rise on his forefeet, and rarely regains the standing position, or drag his hind part along upon flexed fetlocks, and fall again. He generally struggles violently, often becomes delirious, and frequently uncontrollable. If he voids urine, or if it be drawn with a catheter, it is noticed to be thick in consistence and very dark in color, very strongly resembling strong, thick coffee in appearance. He is totally unable to rise or stand if lifted by the use of slings or in other ways, but his power to struggle is very well marked, and it is often difficult to prevent him injuring himself and his attendants.

These are the symptoms of a severe case, and, of course, are more or less modified in cases of less severity. In mild cases the patient is able to retain the standing position, but the partial or complete loss of power to control the limbs is noticed. The lassitude, enlargement and hardening of the muscles, anxious expression, and apparent colicky pains, and the marked change in the appearance of the urine, are more or less marked in all cases.

Treatment.—In most cases, when the first symptoms appear, if the horse be allowed to stand still for a few hours and is made as comfortable as possible he will recover without treatment. Hence, as soon as the slightest symptoms of the disease are noticed in a horse that is being driven, ridden, worked or exercised in any manner after a period of idleness, the driver should not attempt to get him home or to a veterinarian, but quietly lead him to the nearest comfortable quarters (if in fine weather a field or fence corner will do) and send for the nearest veterinarian. If the patient has trouble in standing, care should be taken to support him, if possible, for a few hours, when he will probably have regained sufficient power to support himself. It is good practice to administer a purgative of 7 to 10 drs. of aloes (according to the size of the patient) and 2 or 3 drs. of ginger. If the weather is cold, clothe heavily and keep warm. If he can be kept on his feet for a few hours a recovery will take place, and he can be moved to his own or other comfortable stable in twenty-four to forty-eight hours or in some cases sooner; in rare cases it requires a longer period of complete rest. If the patient falls and is unable to rise he should be loaded on a boat or truck and moved to some roomy and comfortable place and made as comfortable as possible.

If the services of a veterinarian can be procured it is always wise to do so in severe cases of this disease, as he will follow treatment that can be given only by a veterinarian who has the proper instruments and understands the use of the drugs that are used in treatment.

When such cannot be procured it is good practice to administer a purgative and follow up with the administration of 1 to 1½ drs. of iodide of potassium every five hours for about twenty-four hours. Injections of warm, soapy water per rectum should be given every few hours to hasten actions of the bowels. The urine should be drawn off with a catheter every six to eight hours, and if the kidneys become inactive ½ oz. of the nitrate of potassium (saltpetre) should be given three times daily. It is necessary for an attendant or two to remain with him, and in some cases it is necessary to hobble his feet to prevent injury to himself or attendants. If the bowels and kidneys can be kept active, and delirium does not increase, there will be reasonable prospect of recovering, but if the symptoms continue to increase in intensity death will result, usually in from two to three days.

When recovery is about to take place and the patient attempts to rise, he should be assisted. In some cases it is wise to use slings to get him on his feet, but if he cannot stand when raised he must be let down again.

During treatment he should be allowed water frequently, but should not be allowed to drink large quantities at a time, and, if he will eat he should be given bran and a little good hay, or grass if it can be procured. At any time during treatment, if colicky pains be shown, it is good practice to give an anodyne as 1 to 2 ozs. tincture of belladonna or 1 to 1½ ozs. chloral hydrate.

As stated, in all, except very mild cases, it is wise to employ a veterinarian, as complications are liable to arise which he will probably be able to combat, and which would not be understood by an amateur.

THE OX

When we use the word "ox" we refer to cattle in general, regardless of sex. The stomach of the ox, being such a complex organ, is more liable to digestive derangement than his intestines. In order that the reader may more readily understand and appreciate the different diseases, their causes, symptoms and treatment, it may be wise to describe the anatomy of the œsophagus and stomach.

The œsophagus or gullet, passing from the posterior portion of the pharynx or cavity posterior to the root of the tongue, is a tube composed of mucous membrane surrounded by muscular fibres. These fibres surround the mucous membrane, and, like other muscular fibre are contractile. When a bolus of food is passing down the tube the fibres expand, and immediately contract after the bolus has passed. The œsophagus, after passing through the thorax or lung cavity, pierces the diaphragm (the division between the thoracic and abdominal cavities) then expands and enters the stomach as a somewhat funnel-shaped dilation ; the mucous membrane is plentiful, somewhat folded, and continuous with the mucous membrane of the stomach.

The ox is usually spoken of as having four stomachs, but this is not strictly correct, as there is but one organ; but it is more or less completely divided into four compartments, called for convenience the first, second, third and fourth stomachs. Technically these are called, the rumen, reticulum, omasum and abomasum. The rumen, paunch or first stomach is a very large compartment, occupying about four-fifths of the adbominal cavity, situated principally on the left side, extending well back to the pelvis and having an average capacity of probably about thirty-six gallons. The reticulum or second stomach is situated to the front and right of the rumen. It is a comparatively small compartment and not well divided from the rumen. In fact, the division is so imperfect that it would be difficult to distinguish one from the other if it were not for the arrangement of the mucous membrane; that of the rumen being smooth like that of the œsophagus, while that of the reticulum strongly resembles an empty honey-comb with the top of the cells cut off. On this account the compartment is frequently referred to as "the honey-comb." The omasum or third stomach is to the front and right of the reticulum. It is a small organ with a capacity of about 1 to 1½ gallons. The mucous membrane of this compartment is formed into leaves of different depths. In fact, when it is empty it appears as a compartment of leaves of mucous membrane, on which account it is often referred to as "the many-plies." These leaves are thickly studded on each side with elevated epithelial cells, which grind the food as it passes through. To the right and posterior to this compartment is the abomasum or fourth stomach, which is the true digestive stomach and contains the gastric glands. This is comparatively small, its capacity probably being between three and four gallons. At the posterior portion is a constricted orifice called the pylorus or pyloric orifice, with which the small intestine is continuous.

Digestion in the ox (with the exception of that which takes place in the small intestine) is supposed to be carried on as follows : He eats large quantities of bulky food, eats it rapidly, hence does not take time to masticate it well. It enters the rumen, the muscular coat of which has both transverse and longitudinal fibres. the contraction of which lessens the calibre of the organ in all directions, and, of course, their relaxation correspondingly enlarges it. During the time the animal is eating this contraction and relaxation is continuous, producing a somewhat churning motion which thoroughly mixes the contents with each other and with the liquids that are present. When the animal has satisfied his desire for food the process of rumination or chewing the cud commences. This is supposed to be performed somewhat as follows: The muscular fibres mentioned contract firmly, this compresses the contents of the organ and forces it forward, the dilated end of the œsophagus closes and, in closing grasps a portion of the ingesta and by a regurgitative or anti-peristaltic action it is returned to the mouth for re-mastication. This process being performed the bolus is swallowed. If there still be any imperfectly masticated portions they are supposed to again enter the rumen, while the finely masticated and the fluid portions pass directly to the omasum by what is known as "the œsophageal canal," which consists of two double leaf-like folds of mucous membrane which extend from the œsophagus (hanging downward) to the omasum. When a bolus of re-masticated food is being swallowed the lower edges of the folds approach each other and when they meet a canal is formed which carries the ingesta to the omasum. Then another bolus is regurgitated, re-masticated and swallowed, and this continues until the process of rumination is completed. It will be seen that the cud is simply a portion of the contents of the rumen returned to the mouth for re-mastication, hence the too-common idea that cattle suffer from a disease known as "loss of the cud" is false. In most cases of digestive troubles the process of rumination ceases, but when the disease is cured it will again be performed.

It must not be thought that all the contents of the rumen undergo this process at any time. Only a limited amount is operated upon at once; hence, in health the rumen always contains a large amount of ingesta.

The re-masticated food having entered the omasum it fills the spaces between the leaves, which press upon it, and, having a slight motion, one upon the other, still further grind it and press the fluids into the abomasum. These gradually pass into the abomasum, where true digestion really commences. It will be seen by the above that the functions of the first three compartments are simply to prepare the food for digestion which takes place in the fourth stomach.

When from any cause any of the functions mentioned are checked, suspended, interrupted or materially altered, digestive derangement will be noticed, the causes, symptoms and treatment of which we will discuss.

TYMPANITIS, BLOATING, HOVEN OR BLOWN.

Causes.—This condition known by many names consists of distension of the rumen with gas. The most fruitful cause is a sudden change from dry food to an unlimited supply of green food of any kind, principally to the different varieties of clover, and more particularly when the clover is in flower. It frequently occurs from the voracity with which cattle that have been kept on dry food all winter consume green fodder. Hence, it is more prevalent in the spring than at other seasons. It results from feeding too freely on green food of any kind, especially on that upon which dew or rain is present, and more particularly when frosted: hence is not uncommon in the fall when cattle are allowed to consume clover, rape, turnip tops, etc., when frosted. Any food that readily ferments, if taken in sufficient quantities to temporarily check digestion, will quickly form gases and cause bloating. It is often a complication in cases of choking, the mechanical impediment being the cause by preventing the escape of gas through the gullet. Sudden changes of diet of any kind may cause the trouble, or insufficient secretion of saliva may have the same effect. While some of the above-mentioned causes usually precede an attack, it is not uncommon to notice a well-marked case for which no well-marked cause can be traced. Such cases are doubtless due to some unsuspected and not well understood temporary derangement of the digestive glands and muscles of the rumen. Any condition that causes torpidity of the rumen may cause bloating, even though no change of food of a dangerous nature has taken place. Torpidity of the rumen occurs in debilitating diseases, in fact in most diseases of the ox, also from the introduction of excessively cold material as frosted fodder, into the organ.

Symptoms.—The patient commences to exhibit signs of uneasiness, lying down and rising frequently, and kicking at the belly. Rumination is suspended and food refused. There is general depression, protrusion of the muzzle, projection and congestion of the eyes, increased flow of saliva, and generally moaning during expiration. The back is arched and there is more or less marked swelling of the abdomen especially marked on the left side, especially between the point of the left hip and the last rib. If this be pressed with the finger it will yield, but at once regain its former condition when pressure is relieved. If tapped with the fingers a resonic, tympanic or drum-like sound will be heard, hence the name "tympanitis." Distension of the rumen causes forward pressure upon the diaphragm (the division between the abdominal and lung cavities), hence lessens the space of the lung cavity and causes difficulty in respiration in proportion to the degree of bloating. In many cases forcible ejection of fæces per rectum is noticed. In most cases there are eructations of gases of a special odor. The bowels soon cease to act and breathing becomes more difficult as the tympany increases. The brain frequently becomes involved to some extent, the patient becoming blind, staggering and falling. Death may occur quickly from rupture of the rumen, rupture of the diaphragm, suffocation, or absorption of gases.

Treatment.—Preventive treatment consists in avoiding sudden changes of food, especially from a dry to a moist or green ration. All changes should be made gradually. When cattle that have been accustomed to dry fodder are to be turned out on grass, especially any variety of clover, it is good practice to give a moderate meal in the stable then turn on grass for a few minutes, say twenty to thirty minutes. Next day leave on grass for a longer period, say forty to fifty minutes, and continue to gradually increase the period in order that the animals will become less inclined to engorgement and the digestive organs gradually acquire the power to perform their new functions. In a few days it will be reasonably safe to allow the cattle to remain on the pasture. Much greater danger exists at any time in allowing cattle that are not accustomed to green fodder to partake of it when frosted, or damp with either dew or rain. Frosted grass, rape, turnip tops, etc., are very dangerous under any conditions.

Curative treatment must be directed to remove or neutralize the gases that are present and to prevent the formation of more. It will depend upon the severity of the attack and the extent of the distension of the rumen whether it will be wise to attempt the immediate removal of the gases or to administer drugs to neutralize them. When bloating is not excessive, with little danger of death occurring quickly, the administration of any drug that will neutralize the gases may, and should, be effective. For this purpose oil of turpentine (commonly called spirits of turpentine) is probably the best simple remedy. This is given in

2 to 4 oz. doses, according to the size of the patient, and the state of distension. It is wise to administer it in some vehicle to prevent irritation of the mucous membrane. The best vehicle is raw linseed oil 1 to 1½ pts. When oil is not on hand melted butter or lard or whole milk answers the purpose well, but turpentine will not mix with water; at the same time when oily vehicles are not readily obtainable it may be given in water if the bottle be constantly shaken. Hyposulphite of soda in 1 to 1½ oz. doses mixed with about a pint of warm water also gives good results. Carbonate of ammonia in 4 to 6 dr. doses, or bicarbonate of soda (baking soda) in 1 to 1½ oz. doses also acts well, but none of these act so well or so promptly as oil of turpentine. The Kentucky Experimental Station highly recommends the administration of about ½ oz. of formalin in a quart of water and cite many cases in which it has given excellent results. The writer has not experimented with this drug in this connection, having had good results from oil of turpentine. At the same time the use of formalin is worthy of a trial, but it must be remembered that it is a very strong astringent and irritant, hence must be diluted with at least a quart of water.

In addition to administering the dose (whatever we select) it is good practice to put a hay rope, a piece of wood or other material about two inches in diameter, into the patient's mouth and fasten it there. This tends to cause a working of the jaws and facilitates the escape of gas through the œsophagus. If the desired results be not obtained in an hour the dose may be repeated.

In cases where bloating is extreme there is danger of death resulting quickly from rupture of the organs mentioned from suffocation or from absorption of gases. In such cases we cannot wait for the action of medicines given by the mouth. Relief must be prompt and the gases must be removed by mechanical or surgical means. In some cases the passing of a rubber tube down the œsophagus to the stomach will give immediate relief. The mouth must be kept open by an ordinary gag, a mouth speculum, a small clevice or other device; the tube (5 or 6 ft. of ordinary ½-inch garden hose serves the purpose well) is oiled, carefully passed until the end enters the rumen. If that part of the rumen be not blocked by semi-solid contents the gas will immediately escape through the tube, but if it is the gas cannot enter the tube.

In such cases an opening must be made into the rumen on the left side at the most prominent part between the point of the hip and the last rib through the skin, muscles and wall of the rumen through which the gas will escape and give practically immediate relief. The hair should be clipped off and the seat of operation, the instruments, and the hands of the operator thoroughly disinfected with a five per cent. solution of carbolic acid, one of the coal tar antiseptics or other good disinfectant. An instrument called a *trocar* and *canula* is the proper one to use. It consists of a metal tube with a sharp pointed metal rod passing through it, the point of the rod extending some distance longer than the tube. An incision may be made through the skin with a knife or the instrument forced through without an incision. It is forced well into the rumen, the trocar then drawn out, which leaves the canula or tube inserted through which the gas escapes. When this instrument cannot be procured in time an opening may be made with a knife and the lips of the wound held apart to allow escape of the gas. Unless the opening be quite large no after treatment is required other than keeping the wound clean and dressing regularly with an antiseptic. When the proper instrument is used after-treatment of any kind is seldom necessary.

In all cases it is good practice, after bloating has disappeared, to administer a laxative of about 1 lb. of Epsom salt or 1½ pts raw linseed oil, and feed lightly on laxative food for a few days.

IMPACTION OF THE RUMEN.

Cause.—Impaction of the rumen is one of the most common diseases of the stomach of the ox. It consists in distension of the rumen with solid matters. It is a pathological condition somewhat similar to tympanitis, but differing in the urgency of its symptoms and the method of treatment. It depends upon introduction of solid matters to such an amount as to partially or wholly paralyze the organ by over distension. Some foods appear more liable to cause the disorder than others, as grain, chaff, or potatoes, but anything particularly palatable to the animal may be consumed in such quantities if opportunity presents itself. Sudden changes of food, especially if the change be to a food particularly palatable, over-feeding on grain without allowing the animal to take exercise, indigestible food such as over-ripe hay, food of poor quality even if consumed in only moderate quantities, may cause the trouble; the animal continuing to eat, but not ruminating sufficiently, the amount of ingesta gradually increases in the rumen. This distends its walls until they become partially paralyzed; hence the normal contraction and relaxation does not take place, and the normal churning motion is absent. We frequently notice a case of impaction without appreciable cause, which, no doubt, is due to a temporary suspension of the action of the walls of the organ, or a failure in action of the glands, for which we can give no cause.

Symptoms.—The animal becomes dull and suffers pain, which is often expressed by stamping of the feet, striking at the abdomen with the hind feet, switching the tail, etc. The pulse is frequent, and respirations usually accelerated. Appetite is lost and rumination suspended. The bowels are usually constipated. The abdomen is enlarged, especially on the left side, but this does not occur so quickly as in tympanitis; neither is it of the same nature. When tapped between the point of the left hip and the last rib a dull sound is produced, and when pressed it has a doughy feel, and the imprints of the fingers do not quickly disappear—it "pits on pressure." There is often a grunt during expiration, more evident when the animal is lying down—especially if lying upon the left side, a position that is seldom maintained for any considerable time. In the later stages tympanitis often sets in as a complication, when the respiration becomes more labored, the grunt during expiration more pronounced, in some cases resembling a groan rather than a grunt. The patient often grinds his teeth and persists in standing with protruded muzzle and arched back. In some cases inflammation of the rumen results, when there will be well-marked increase of the temperature and the patient will manifest pain if pressure be made on the left side.

The foregoing symptoms are more or less well-marked in severe cases, but in cases of less severity the patient occasionally appears to have periods of ease and expresses a desire for food. If food be allowed he will eat a variable amount with apparent relish, but the symptoms of illness soon become more marked than before. This is of necessity the case, as the walls of the rumen are more or less inactive and the mucous glands also are in a state of partial inactivity: the organ is not performing its proper function and the introduction of a fresh supply of food must intensify the trouble.

Treatment must be directed to the removal of some of the impacted food mass and the restoration of activity to the over-distended walls of the rumen. When the distension is not excessive a brisk purgation of 2 drs. Epsom salts, ½ oz. gamboge and 2 ozs. ginger in about 1½ qts. of warm water should be given as a drench. This is a fair dose for an ordinary sized cow, the dose for smaller or larger animals should be in proportion to size. In order that the purgative may act it is necessary that the paralysis of the walls of the organ be overcome. For this purpose nerve tonics, as nux vomica in 2 dram doses (for an ordinary sized cow) should be given every six or seven hours. It is not wise to allow the patient any solids to eat until there is a free action of the bowels. If he expresses a desire for food a little bran mash may be allowed. If purgation has not commenced in 36 hours more purgative medicine should be given. About 1½ pts. of raw linseed oil should be given and alternated every twelve hours with 1 lb. Epsom salt and 1 oz. ginger, until purgation is established. The administration of nux vomica should be continued in the meantime. The patient should be allowed all the water he will drink. If the weather and surroundings be cold it is well to remove the chill from the water.

It is remarkable how stubborn some cases are, the length of time an animal will suffer and the quantities of purgative medicines it is necessary to administer before an improvement is noticed. If the disease is not yielding to treatment after the second day it is necessary to give the patient something to sustain strength. Probably for this purpose nothing acts as well as boiled flax-seed administered as a drench in about quart doses four or five times daily. This is laxative, soothing and nutritive.

So long as tympanitis does not occur the probability of successful treatment may be looked upon as hopeful. If it occurs the usual treatment for bloating must be followed in addition to that already noted. In cases where the early symptoms of the disease are extreme an operation called "rumenotomy" is necessary. This consists in cutting through the skin, muscles and walls of the rumen and removing a large portion of the contents by hand. The operation can be successfully performed only by a veterinarian.

What is commonly called "Grain Sick" is simply impaction of the rumen with grain. When an animal is known to have had the opportunity of eating excessive quantities of grain, the usual custom of shutting him in a stable, allowing him neither food nor water, and awaiting developments is absurd. The owner should anticipate trouble by at once administering a brisk purgative, as for impaction. Allow him nothing to eat, but allow all the water he will drink in small quantities and often, in the hopes that purgation will commence before the grain swells and causes paralysis of the walls of the rumen. Of course, in cases of "grain sick" where the early symptoms are severe, rumenotomy should be performed at once.

FARDEL BOUND.

Causes.—Fardel bound is the name given to a pathological condition which consists in impaction of the omasum or third stomach. It is also known as maw bound, vertigo, staggers, etc. The ingesta becomes impacted between the leaves of the organ. It is sometimes followed by inflammation of the stomach. It is a much more serious condition than impaction of the rumen. The contents of the omasum are normally drier than those of any other compartment of the stomach, but when this disease is present they become very dry, so dry that in some post mortems it has been observed that they will burn if lighted with a match. The disease is caused by introduction into the stomach of food of an indigestible character, particularly that of a dry, woody nature, as autumn grass that has been allowed to remain in the field until spring, and is consumed in greater or less quantities by the cattle along with the fresh grass ; over-ripe hay, poorly saved hay, straw, coarse and indigestible herbage sometimes found in old pastures, especially where considerable shade is found. Like other diseases of the stomach, it is often met with when no well-marked cause can be traced. It is difficult to treat and often proves fatal.

Symptoms.—The symptoms of fardel bound are not as typical as those of bloating or impaction of the rumen. In many cases, in the early stages, fæces are passed frequently and in small quantities, in some cases in a fluid or semi-fluid state, and in others quite dry and hard. In either case obstinate constipation soon follows, the appetite becomes impaired or entirely absent, rumination ceases, the secretion of milk is more or less suspended (if the patient be milking), the muzzle becomes dry, and the eyes usually dull but in some cases wild looking. In rare cases delirium is noticed in the early stages, the patient becomes wild, more or less furious, and hard to control. A short grunt is often noticed during expiration, especially when the patient is lying. This symptom is often noticed in cases of impaction of the rumen, but the condition of the abdomen, especially on the left side, is sufficient to enable a man to differentiate between the disease. Respirations are usually frequent and short. The patient often persists in standing, but in some cases lies considerably on his left side with the head turned towards the flank. Pressure on the right side under the false ribs often causes pain. After a variable time there is usually more or less tympanitis, caused by fermentation of the contents of the rumen, in which digestion is also suspended. As stated, delirium may be noticed in the early stages, in other cases it may occur later on, while in still others there is drowsiness and stupor or partial paralysis more or less marked during the whole progress of the disease. The patient suffers acute abdominal pain.

Treatment.—Some recommend bleeding. Where the brain appears markedly affected the extraction of 4 to 6 qts. of blood from the jugular vein is good practice, but when the brain symptoms are not well marked blood letting is seldom practised. It must be understood that there is paralysis, either partial or complete, of the muscular walls of the viscus and also of the muscular fibres of the manyplies, and that laxatives or purgatives will not act satisfactorily until this paralysis is overcome. The actions of purgatives are often very peculiar and disappointing. In a reasonable time after the administration of a purgative there generally are two or three slight liquid evacuations and the attendant thinks that free purgation has commenced, but these symptoms are often quickly followed by a return of the constipation. The administration of a brisk, saline purgative (as for impaction of the rumen) at first, is considered good practice by most practitioners. While in a general way the purgative action of aloes is very slightly marked in the ox, it is supposed to have a special action on the contents of the third stomach; hence it is good practice to add 6 to 8 drs. of aloes to the ordinary purgative, all dissolved in water and given as a drench, care must be taken to not use hot water, as it will cause the formation of a waxy mass out of the aloes, which interferes with the administration and also lessens the purgative action of the aloes. Follow up with 2 to 3 drs. of nux vomica three times daily to overcome the muscular paralysis. Also give a stimulant of 2 to 3 ozs. sweet spirits of nitre, or a cupful of whiskey in a pint of cold water as a drench every four or five hours, and allow the patient all the cold water he will drink. If free purgation has not commenced in twenty-four hours give 1½ to 2 pts. of raw linseed oil, continue the administration of nux vomica and stimulants, and about every twelve hours until free purgation is established, give 1 lb. Epsom salt and 1 oz. ginger, and 1 to 1½ pts. raw linseed oil alternately, i.e., give the saline dose and the oil alternately at intervals of twelve hours. If the patient will take a little food, allow reasonable quantities of bran mash with a little linseed meal, but no solid food. If he will not eat, some nourishment must be given after the second day in order to keep up his strength. For this purpose some practitioners recommend ale or stout, some recommend oat meal gruel, and some boiled flaxseed. Probably the last mentioned, given in 1 to 2 qt. doses every six hours, gives the best results. This has a soothing effect upon the irritated and more or less inflamed mucous membrane of the stomach, and also a laxative as well as a nutritive action. Treacle or black strap molasses is highly prized by some for the treatment of this and other diseases of the stomach, and is worthy of a trial. Treatment should be kept up until the patient improves or death results.

CHOKING.

Choking is more of an accident than a disease, but as it is a pathological condition of the digestive organs it may be considered correct to classify it as a disease of the digestive organs. It consists in the blocking or the packing of the œsophagus (the gullet) with some foreign body. Symptoms somewhat similar to those of choking, however, arise from other causes, as injuries to the œsophagus from sharp bodies swallowed, and also from some nervous diseases. Blocking of the tube by foreign bodies frequently occurs in the ox, but not nearly so frequently now as formerly, as most feeders pulp the roots instead of feeding them whole as was once done. Choking is usually caused by the lodgement in some part of the œsophagus of a portion of a turnip or other root or a whole apple, potato, etc., but may be by impaction of other food too greedily swallowed. When stricture of the œsophagus from any cause exists, choking is quite common, the bolus of food or piece of solid matter not being able to pass through the constricted tube, on the other hand, where dilatation of a portion of the tube exists, choking is also common, as the bolus, when being swallowed, lodges in the dilated portion. This is followed by the lodgement of other boluses until the symptoms of choking becomes well marked. When no abnormal condition of the œsophagus exists, and reasonable care be taken to properly prepare solid foods, choking is of rare occurrence. The foreign body that causes the trouble may be lodged in the pharynx (the cavity just behind the root of the tongue) or in the cervical portion of gullet (the region of the neck) or in the thoracic portion (that portion that passes through the thoracic or lung cavity).

Symptoms.—The symptoms are readily recognized. The patient stands with muzzle protruded, makes ineffectual attempts to swallow, coughs, champs his jaws and there is a profuse flow of saliva from the mouth. Appetite and rumination are suspended, but gulping efforts to swallow are made. The eyes project and become bloodshot, the patient is uneasy and in many cases fæces and urine are frequently voided in small quantities. When any matter is swallowed, or given as a drench, it is returned through the mouth and nostrils. If the impaction be in the pharynx, coughing is the best marked symptom, and respiration is interfered with; if in the cervical region an enlargement can generally be located by sight or by manipulation on the lower margin of the neck in the channel. This latter may be large or small, hard or soft, movable or immovable, according to the bulk and nature of the material and condition of the œsophagus. If in the thoracic region, of course, the obstruction can be neither seen or felt. If fluid is given it appears to pass to the stomach, but it simply fills the passage from the obstruction to the pharynx and is then regurgitated. Bloating is often soon noticed, except in cases in which, on account of the shape of the obstruction, the whole calibre of the tube is not filled, hence liquid or gaseous matter may be able to pass it.

Treatment.—This must be directed to the removal of the obstruction, either by the mouth or by causing it to pass downwards to the stomach. If bloating be excessive it should be relieved by puncturing as in a case of ordinary tympanitis. Then, if possible, the seat of the obstruction should be located. If in the pharynx it can usually be removed by hand. The patient's mouth must be kept well open by the use of a mouth speculum, a clevice or other device, an assistant holds the animal and the operator passes his hand into the pharynx, grasps the object and removes it. If in the cervical region the operator should endeavor to move it by manipulation. If it can be worked a little either upwards or downwards the exercise of a little patience will usually cause it to be swallowed or coughed up. If it be grain, either whole or chopped, or hay or straw too greedily swallowed, the mass may be broken up by manipulation and will pass down to the stomach. If relief cannot be given as above or the obstruction be in the cervical region, efforts must be made to force it down. For this purpose an instrument called a "probang" should be used. The too common habit of using a fork handle, broom handle, whip, harness trace, etc., cannot be too strongly condemned. The opposing surface of the obstruction is usually irregular in shape and as that of the instrument mentioned is either round or oval, the latter is very liable to pass to one side of the former and rupture the œsophagus. In this case it is often thought that the object has been forced to the stomach, but the patient does not get ease, will neither eat nor drink, and in a few hours the neck and throat commence to swell by reason of the gases that the animal may swallow and that are formed in the gullet, filling up the areolar tissue, and the patient usually dies in a few hours longer.

A probang usually is made of about five or six feet of spiral wire, covered with leather or gum elastic, and having attached to each end a metal or horn disk of a cup shape, so that when it meets the obstruction, instead of passing alongside of it, it practically grasps it or encircles it, and when force is applied it is exerted upon the obstruction in the desired way. Many probangs have stillets of whalebone or cane to strengthen them. When a probang is not procurable a piece of ordinary garden hose answers the purpose fairly well, the hollow in the hose acting as the cup-shaped disk of the probang. The hose can be strengthened by using a whip-handle or other material for a stillet, care being taken that the stillet be not passed quite to the end of the hose.

In order to pass the probang a wooden gag with a hole through the centre or other device is necessary to hold the mouth open. The gag extends a few inches on each side of the mouth and has straps attached to it, which pass over the head and buckle behind the horns to hold the gag in the mouth. The probang should be oiled. An assistant on each side of the animal catches the gag with one hand and the horn on the other, and hold the head in such a position as to make the mouth and œsophagus in as nearly a straight line as possible. The operator then passes the probang through the hole in the gag and gently backwards until it enters the œsophagus through which it passes until the end reaches the obstruction. Then steady pressure should be applied to force the obstruction down into the stomach. In some cases the obstruction is so firmly implanted that it cannot be forced down in this way, in which case, if in the cervical region, an operation called "œsophagotomy" may be performed. This consists in cutting through the skin and walls of the œsophagus and removing the obstruction, then stitching the wound in the œsophagus with carbolized catgut or silk sutures, then stitching the wound in the skin and feeding on sloppy food only for ten to fourteen days. None but a veterinarian should attempt the operation. When the obstruction is in the cervical region and cannot be forced down all that can be done is leave the animal alone. If necessary to prevent bloating leave the canula in the stomach and await developments. In many cases the animal gets relief after several hours, the obstruction evidently becoming partially cooked and passing to the stomach. As choking is liable to recur if care be not taken, the animal should not be fed on food liable to cause the trouble for a week or ten days after the occurrence, in order to allow time for the inflamed and dilated portion of the œsophagus to regain its normal condition.

COLIC.

Causes.—The ox is not nearly so liable to the different forms of colic as the horse, but at the same time cases are not unusual. Colic, defined as "any abdominal pain not due to inflammation" is capable of more exact limitation. It is distinguished by certain symptoms, which are more or less marked in other abdominal disorders, and are known as "colicky pains." While food of poor quality, of an indigestible nature, food improperly prepared, sudden changes in food, etc., usually cause disease of the stomach of the ox, we find that in some cases they cause painful disorders of the intestines, and such attacks are known as "colic."

Symptoms.—The animal ceases to feed and ruminate for a time, the pulse becomes full and bounding; there is moaning, grinding of the teeth, striking at the abdomen with the hind feet, extreme restlessness, indicated by frequently lying down and rising, turning the head around and placing the muzzle against the seat of pain; there often is sweating and frequent passing of urine in small quantities, or of portions of small dry fæces. Rupture of various kinds, strangulation of the bowels, impaction of the bowels, as well as certain disorders of the liver, stomach or urinary apparatus, may be cause of symptoms simulating those of colic. In such cases other symptoms are usually present which assist in diagnosis. But, failing these, we may usually attribute the symptoms of disorder to simple or spasmodic colic, spasms of a portion or portions of the small intestine. Then the pains are paroxysmal, that is, a period of pain is followed by a period of ease, during which the patient appears perfectly normal, the pulse becomes normal, all excitement ceases, the patient will eat or ruminate and appear normal in all respects for a variable time. This is again followed by a period of well marked pain, etc. The periods of paroxysm vary in length and severity, but the pain is always well marked. The trouble may be induced by changes in diet, the passage of imperfectly prepared food from the stomach, and some claim, by drinking large quantities of very cold water.

Treatment.—As it is a spasmodic disease medicines that relieve spasms (called antispasmodics) should be given promptly, as 2 fluid ozs. each of sweet spirits of nitre and tincture of belladonna and 1 fluid oz. of laudanum for an ordinary sized cow; smaller or larger animals should be given a dose in proportion to their size. The patient should not be allowed to eat anything during the periods of ease, as this is very liable to increase the intensity of the trouble. The dose may be repeated in one and one-half to two hours if necessary, and at like intervals as often as required; but after the second dose it is wise to omit the laudanum as it tends to constipate. On the assumption that the trouble has been caused by the presence of indigestible food or of food imperfectly prepared in the intestine, it is good practice to administer a purgative after the symptoms of colic have disappeared in order to remove the cause. For this purpose the ordinary saline purgative of 1 to 2 lbs. Epsom salts and 1 oz. ginger should be given in a quart or more of warm water. It is also good practice to give an injection of warm soapy water per rectum, as this not only removes the contents of the rectum but tends to stimulate the general actions of the bowels, hence hastens the action of the purgative, as in any case after the administration nothing but sloppy food, in small quantities, should be allowed until free purgation commences.

FLATULENT COLIC.

Colic in which there is the formation of gases in the intestines, principally in the large intestine, is known as "flatulent colic." This form may be diagnosed from the spasmodic form by the symptoms being less alarming and violent but of a more persistent character; there are practically no periods of ease. The symptoms of pain are constant, but vary in intensity. Emission of gases per rectum is often noticed, and, particularly if the small intestine be involved, there may be eructations of gases and in reasonably well marked cases a more or less well marked distension of the right side of the abdomen. In such cases treatment should be directed to neutralize the gases or cause their expulsion, and at the same time keep up the heart's action. For this purpose 2 to 3 fluid ozs. each of oil of turpentine and the aromatic spirits of ammonia, in 1½ pts. of raw linseed oil, should be given. If more than one dose be given it is wise to use new milk instead of the oil. Rectal injections as for spasmodic colic should also be given. It is also good practice to force the patient to take walking exercise and to apply friction to the right side of the abdomen. The acute symptoms should be followed by the administration of a saline purgative, as in cases of spasmodic colic, and as the patient already has been given oil the amount of the saline should be less than under other circumstances. In all cases of colic in the ox it is good practice to explore the rectum by hand, remove its contents and follow by injections.

DIARRHŒA.

Diarrhœa is the term applied to that condition in which there is a frequent passage of liquid or semi-liquid fæces without co-existent inflammation. It may be a spontaneous effort to discharge from the intestines something that is obnoxious to them and to the system generally.

Causes.—Any irritant in the digestive canal may give rise to the disorder, as coarse or badly saved food, acid plants in the pasture or hay, indigestible food, sudden changes of diet, particularly from a dry to a moist one, medicinal substances, parasites, derangement of the liver, foreign matters in the intestines, etc. Sometimes when an animal is turned out on grass, after being kept in the stable for a considerable time, an attack is noticed. Exposure to cold is also a cause. A fruitful cause is water of poor quality. This is frequently noticed in dry seasons where cattle obtain water out of stagnant pools. Sometimes chronic diarrhœa results from long-continued improper dieting, whereby the mucous membrane of the ailementary canal becomes organically deranged and its secretory functions perverted. Unsanitary surroundings and poor care predispose to the disease. Some animals appear particularly predisposed and will suffer from it from causes that have little or no effect upon others under the same conditions. This is more marked in horses than in cattle.

SYMPTOMS.—The symptoms cannot readily be mistaken. There is a more or less frequent evacuation of greater or less quantities of liquid or semi-liquid fæces. In the early stages the temperature, pulse and respirations remain practically normal. The appetite usually becomes lessened and rumination irregular. In some cases the appetite becomes capricious. The symptoms vary greatly according to the severity and duration of the attack. In many cases, even though the early symptoms may have been well marked, a spontaneous cure results in a few hours, while in others, acute diarrhœa continues. In the latter cases the appetite becomes greatly diminished or altogether suspended, rumination is materially interfered with, but thirst is usually excessive. The animal loses strength quickly, the pulse becomes weak and frequent, the general debility becomes well marked. In other cases a form of chronic diarrhœa, without alarming symptoms continues for a long time, the patient gradually but surely losing flesh, ambition and strength. The evacuations frequently have a foul odor, but this is not always the case. Cases of long continued chronic diarrhœa sometimes result in a disease known as dysentery, which we will discuss later on.

TREATMENT.—First remove the cause, if possible. In many cases if the cause can be located and removed, and the animal well cared for and carefully fed, no other treatment is necessary and a recovery will take place in a few days. Upon the assumption that all cases are due to an irritant in the intestines, which must be removed before a cure can result, some claim that the first treatment in all cases should be administration of a brisk purgative in order to still further increase the activity of the bowels, and cause the removal of the irritant. Our experience has taught us that in advanced cases where appetite is materially lessened or wholly suspended, and the animal shows well marked signs of weakness, and practically in all cases of acute diarrhœa in quite young or weakly animals, this practice is unwise. It often proves fatal in cases that might have recovered had less heroic treatment been given. In cases where the patient is still strong with a fair appetite, even though diarrhœa be acute, it is good practice to administer a laxative as 1 to 2 pts. of raw linseed oil (according to the size of the patient), but we do not consider it good practice to administer a drastic purgative in any case. When a laxative or purgative is administered no treatment to check the diarrhœa should be given for twenty-four hours in order to allow the medicine already given to establish its action. In cases where it is not considered wise to administer a laxative, or in other cases where one has been given and diarrhœa continues beyond twenty-four hours after its administration, means of checking it should be adopted, as the administration of 1 to 2 fluid ozs. of laudanum and 2 to 4 drs. each of powdered catechu and prepared chalk in a quart of cold water as a drench every four or five hours until diarrhœa ceases. In addition to this add to the drinking water one-quarter of its bulk of lime-water; give a little at a time and often, as a gallon every hour if the patient will take it. The food should be of a dry nature, as hay or grain. In cases where weakness is well marked and appetite gone, stimulants and nutrients as 2 fluid ozs. of sweet spirits of nitre or a cupful of whiskey mixed with milk and a few raw eggs may be given as a drench every few hours.

DYSENTERY.

Dysentery, commonly called "bloody flux," is the inflammation of the lining membrane of the intestines, accompanied by ulceration. It occurs as a sequel to protracted diarrhœa, or may originate as a disease of itself from exposure to cold, feeding on coarse innutritious food, and almost any debilitating influence which acts slowly but persistently. It may occur as an after-effect of poisonous agents.

Symptoms.—In some cases the disease is acute, but is more often chronic. In acute cases there is increase in temperature and more or less well marked abdominal pains in the early stages. The patient stands with arched back and strains almost constantly, passing only a small amount of watery matter tinged with blood. Sometimes little vesicles or blisters may be seen on the mucous membrane of the nostrils. As the disease advances signs of abdominal pain increase in intensity, rapid emaciation takes place and the patient sinks and dies from exhaustion.

In the chronic form the symptoms are those of extreme debility. The patient becomes hide-bound, emaciation is generally soon well marked, the coat is dry and staring, the mucous membranes become pale, eyes sunken, ears pendulous, the anus is relaxed and constantly discharging small quantities of a bloody substance, and the rectum generally protrudes a little. The back is arched, the gait is staggering, and in many cases pressure upon the loins appears to cause pain. When fæces are passed in quantity the odor is highly offensive, and they are glairy, bloody and viscid in consequence of the amount of mucous present. The animal may remain in this state for a long period, with the appetite almost gone but thirst sometimes excessive.

When at length death occurs or the patient is slaughtered, a post mortem often reveals that the stomach as well as the intestines have been involved. The fourth stomach has its lining membrane reddened, with a gelatinous effusion into its substance and into the sub-mucous tissue. The small intestines are sometimes somewhat similarly affected, but not infrequently present only a slight congestion of the mucous membrane. The large intestines are usually the main seat of the disorder. They show highly congested spots, and congestive streaking giving them a bluish color, ulcerations are also generally present, penetrating the mucous coat more or less deeply. The contents have an offensive smell and are tinged with blood.

Treatment.—This is often very unsatisfactory, which perhaps is due to the fact that the diseased mucous membrane of the intestines is in such a state that absorption of medicines cannot readily take place. Treatment should be largely that recommended for acute diarrhœa, except that in no case should a purgative or laxative be administered, even in the early stages. Large doses of opium, as 2 drs. of the powdered opium or 2 fluid ozs. of the tincture (laudanum) with 4 drs. each of catechu and prepared chalk, should be given 3 or 4 times daily. It is good practice to give astringent injections per rectum as alum water, 1 oz. of alum to a gallon of warm water. The patient's strength should be kept up and the heart's action stimulated by the administration of nutrients and stimulants, as a quart of boiled flaxseed and 2 fluid ozs. of sweet spirits of nitre or ½ pt. whiskey every few hours. Careful nursing is absolutely necessary though some cases are so tedious that the attendant is liable to become discouraged and inclined to allow matters to take their own course. The food must be of first-class quality, dry and nutritious.

While a large percentage of cases prove fatal, even under the most careful and skilful treatment cases of recovery are not rare, hence efforts to cure should always be adopted.

ENTERITIS.

Enteritis, inflammation of the bowels is not a very common disease in the ox, but is occasionally seen. Either the mucous or muscular coat may be primarily involved, but the inflammation usually extends and involves all the coats of the intestine involved. This disease is more frequently seen in working cattle. Adults in high conditions are most liable.

Causes.—It is due to exposure to rough, cold weather, especially if the animal has been subjected to severe exercise of any nature, and is in a state of perspiration. It may be caused by drinking freely of cold water when overheated and by consumption of irritant substances; it also results from the extension of inflammation of other organs, and may result as a sequel to other diseases of the intestines.

Symptoms.—There are general symptoms of disorder with symptoms of pain when pressure is made upon the abdomen or over the loins, frequent passage of small quantities of dry fæces, and in some cases slight abdominal distension or bloating. Acute febrile disturbance soon takes place, the temperature rises a few degrees and the pulse becomes full and frequent. The patient usually stands obstinately in one place, with muzzle protruded and the hind limbs seeming inclined to give way. Thirst is usually excessive, but all inclination for food is lost; the patient groans, grinds his teeth, looks around to the right flank, and flinches if the abdomen be pressed. The pain is continuous, which, with acute fever, serves to distinguish the disease from colicky disorders. In fatal cases, shortly before death, the patient usually becomes unconscious and falls, moaning continuously. The passage of fæces becomes suppressed and a small stream of liquid excrement is often forced through the hardened mass, by which action the rectum becomes distended, and that which is voided has a fœtid and putrid odor. Often death is preceded by cessation of pain, but the animal looks anxious, the extremities are cold, the pulse very frequent, weak and often imperceptible at the jaw, and the general temperature gradually falls. This indicates the occurrence of gangrene. While in the early stages the pulse is strong and frequent it soon loses its strength, but increases in frequency, and the rectum, when examined by hand, is evidently much increased in temperature. The torpidity of the bowels is due to cessation of peristaltic action, as an inflamed muscular coat soon loses its power of contraction.

Post Mortem Appearances.—Soon after death the intestines become filled with gas. The outer covering is congested, inflamed and gangrenous over the parts especially involved. The abdominal cavity contains a considerable quantity of serum. Both small and large intestines are usually involved. The walls of the intestines are thickened and vary in color in different parts, from the redness of a simple congestion to the greenish dark condition of gangrene. There is often effusion and blood extravasation between the muscular fibres, and the contents of the bowels are principally blood and mucous.

Treatment.—The animal must be made as comfortable as possible and carefully nursed. Rugs or blankets wrung out of hot water should be kept to the abdomen. The contents of the rectum should be removed by hand and followed by the injection of warm soapy water. Purgatives must be avoided, as the muscular coats of the intestines have become inactive; hence they will simply irritate, not being able to cause any action. In the early stages, when the pulse is full and strong, the abstraction of 6 to 8 qts. of blood from the jugular vein is good practice, but blood-letting cannot be tolerated after the pulse begins to lose its force.

Large doses of opium should be administered, as 2 to 3 drs. of powdered opium in a pint of cold water as a drench every two or three hours. The thirst should be relieved by giving water with a little saltpetre dissolved in it in small quantities and often.

CONTENTS

Diseases of Digestive Organs of Horses:

Chronic Indigestion 6
Acute Indigestion 7
Constipation 9
Impaction of the Colon 9
Spasmodic Colic 11
Flatulent Colic 13
Intussusception (Intestinal Indigestion) 14
Volvulus or Twisted Bowel 15
Enteritis (Inflammation of the Bowels) 16
Diarrhœa 17
Superpurgation (Over Action of Purgatives) 19
Azoturia (Paralysis caused by Faulty Feeding) 21

Diseases of Digestive Organs of Cattle:

Tympanitis or Bloating 25
Impaction of the Rumen (First Stomach) 28
Fardel Bound (Impaction of Third Stomach) 29
Choking 31
Colic 33
Flatulent Colic 34
Diarrhœa 34
Dysentery 36
Enteritis (Inflammation of the Bowels) 37

LIST OF BULLETINS

Published by the Ontario Department of Agriculture, Toronto.
Available at Date of Issue of Latest Bulletin

Serial No.	Date.		Title.
138	Feb.	1905	The Composition of Ontario Feeding Stuffs.
156	May	1907	Tillage and Rotation.
164	March	1908	Legume Bacteria.
167	Oct.	1908	Mitchell-Walker Moisture Test.
170	March	1909	Mitchell-Walker Test Bottle.
174	Dec.	1909	Farm Underdrainage: Does It Pay?
175	Dec.	1909	Farm Drainage Operations.
184	Nov.	1910	Uses of Vegetables, Fruits and Honey.
187	Jan.	1911	The Codling Moth.
188	April	1911	Weeds of Ontario (No. 128, revised).
195	Jan.	1912	Insecticides and Fungicides (No. 154 revised).
198	Feb.	1912	Lime-Sulphur Wash.
205	Sept.	1912	Dairy School Bulletin (No. 172 revised).
			Part I. Cheese-making and Butter-making in Factories.
209	March	1913	Farm Forestry (No. 155 revised).
211	March	1913	Fruits Recommended for Ontario Planters.
213	April	1913	Bee Diseases in Ontario.
216	Oct.	1913	Box Packing of Apples.
218	Dec.	1913	Birds of Ontario (No. 173 revised).
219	Jan.	1914	The San José and Oyster-Shell Scales.
221	April	1914	Food Value of Milk and its Products.
222	April	1914	Currants and Gooseberries.
223	May	1914	Fertilizers.
224	Sept.	1914	Greenhouse Construction.
225	Dec.	1914	Swine.
226	Dec.	1914	Plum Culture in Ontario.
227	Jan.	1915	Cherry Fruit-Flies.
229	Feb.	1915	Smuts and Rusts of Grain Crops.
230	March	1915	The Cherry in Ontario.
231	April	1915	Vegetable Growing.
232	April	1915	Field Beans.
237	March	1916	The Grape in Ontario.
238	May	1916	Lime and its Use in Agriculture.
239	May	1916	Potatoes.
240	June	1916	Bacterial Diseases of Vegetables.
241	July	1916	Peach Growing in Ontario.
242	Dec.	1916	Diseased Mouths a Cause of Ill-health.
243	Dec.	1916	Nature Study, or Stories in Agriculture.
244	Dec.	1916	Hints for Settlers in Northern Ontario.
245	Dec.	1916	Food Values.
246	Jan.	1917	Suggestions on Feeding Stock.
247	April	1917	Farm Poultry (No. 217 revised).
248	April	1917	Pruning.
249	May	1917	The Pear in Ontario.
250	July	1917	Insects Attacking Fruit Trees.
251	July	1917	Insects Attacking Vegetables.
252	July	1917	The Preservation of Food: Home Canning.
253	Aug.	1917	Dairy Cattle.
254	Aug.	1917	War Breads.
255	Oct.	1917	Tuberculosis of Poultry in Ontario.
256	Oct.	1917	Wintering Bees in Ontario.
257	Dec.	1917	Diseases of Fruit Trees.
258	Jan.	1918	Diseases of Vegetables.
259	Feb.	1918	Books on Agriculture and Household Science.
260	Feb.	1918	Co-operative Experiments with Farm Crops.
261	Mar.	1918	Wheat and Rye.
262	Mar	1918	Sugar Beets.
263	June	1918	Mushrooms.
264	July	1918	Diseases of Digestive Organs of Horses and Cattle.

BULLETIN 265] [AUGUST, 1918

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

Bacteria—Friends and Foes

By D. H. JONES, B.S.A.

Nature of Bacteria.

Bacteria are microscopic plants. They are the smallest forms of life known, and in order to see them it is necessary to use the highest power microscope, together with other bacteriological apparatus. Some species of bacteria are so infinitely small that they can be only just discerned even with the highest magnifying microscopes, and it is considered that there are some which are even still smaller, being too small to come within our range of vision with all the aids known to science. The average size of the more common species of bacteria is about 1-10,000 of an inch in length and 1-20,000 of an inch in breadth.

In addition to being the smallest of living things, bacteria are the simplest of living things in their structure. They are unicellular, that is, their whole body consists of only one cell. The bacterial cell is composed of protoplasm enclosed in a membrane and the whole cell is transparent.

Shape of Bacteria.

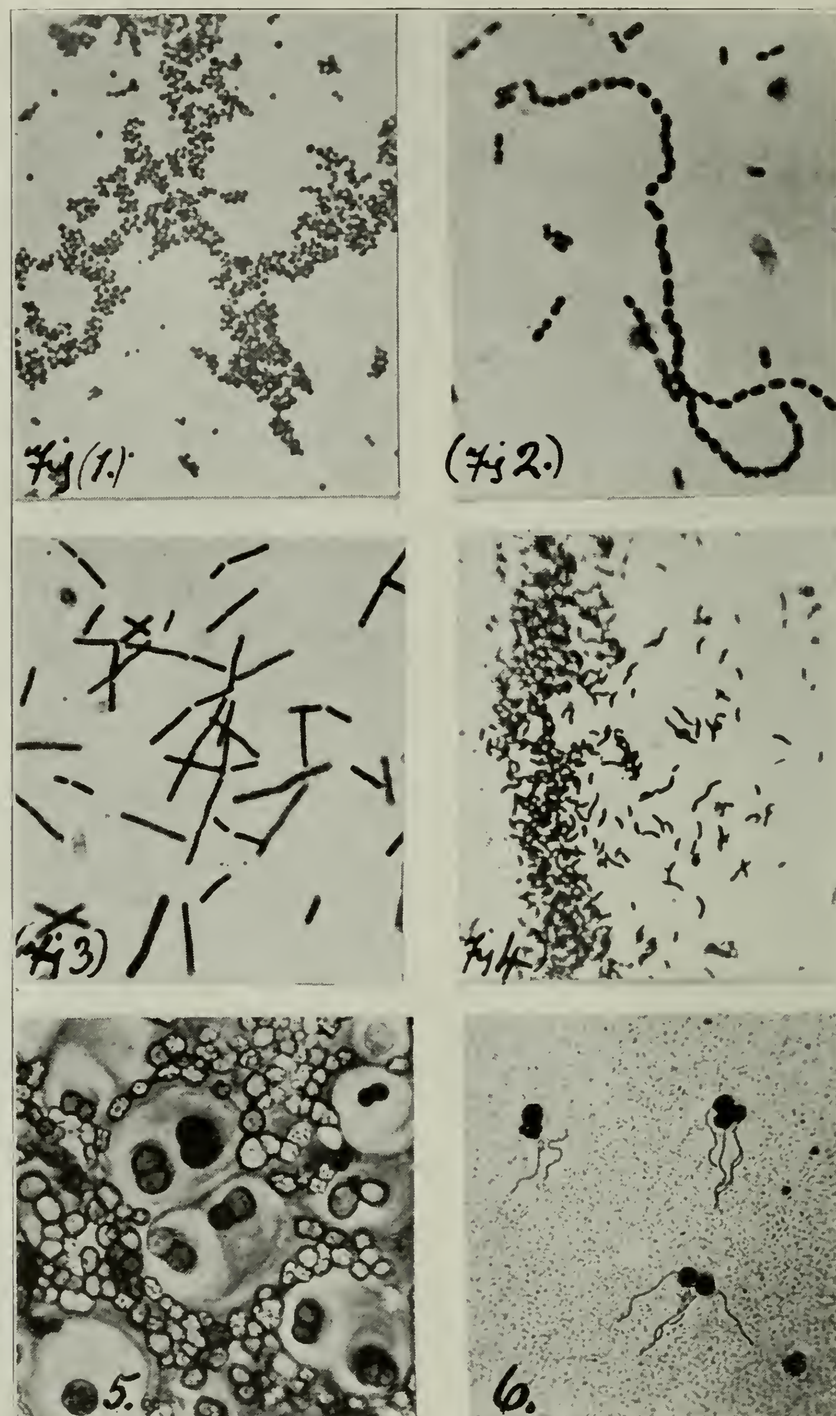
There are four typical shapes of bacteria: (1) spherical forms known as cocci; (2) straight rod forms known as bacilli; (3) spiral forms known as spirilla; and (4) thread forms known as thread bacteria. Bacteria of any one of these four types never change to either of the other types. There are many species of each type.

Method of Bacterial Growth and Multiplication.

Bacteria absorb their food in solution through their cell membrane. The food so absorbed is utilized by the internal protoplasm of the cell, which thus increases in quantity, and following this increase in substance the cell divides in two, each cell being a complete bacterium. These two bacteria continuing to feed, again divide, and thus produce four, and so the development and multiplication goes on. Under favorable conditions of moisture, food and warmth this growing and dividing takes place about every twenty minutes or half hour, so that in twenty-four hours we may get a progeny of ten millions to twenty millions of bacteria, all developed from one bacterial cell. It is this power of rapid multiplication inducing as it does changes in the material in which the bacteria are growing that makes bacteria so important in the economics of life, some of them being beneficial and some injurious.

Bacterial Movement.

Some species of bacteria have the power of motion when placed in liquids. Some of them move about like fish, others wriggle like mosquito larvæ, others glide along with a snake-like motion. These movements can readily be observed when a satisfactory preparation is viewed under the high power microscope. The



Various Types of Bacteria. (Original.)

1. *Micrococcus albus*, magnified 1,000 diameters.
2. *Streptococcus lacticus*, magnified 1,000 diameters. (Lund.)
3. *Bacillus Bulgaricus*, magnified 1,000 diameters. (Lund.)
4. *Spirillum rubrun*, magnified 800 diameters.
5. *Azotobacter chroococcum*, showing capsules, magnified 1,000 diameters.
6. *Azotobacter chroococcum*, showing flagella, magnified 1,000 diameters.

bacteria which have this power of motion are furnished with delicate little whips called flagella. These flagella project from the body, sometimes from the end and sometimes from the sides, and by waving or lashing these flagella the bacteria are propelled forward or backward.

Bacterial Spores.

Some species of bacteria, when the food supply fails them or becomes otherwise unfavorable, go into what is known as the spore condition. That is, the protoplasm within the cell membrane contracts and condenses and around this condensed protoplasm another membrane is produced, which is very tough and resistant. This condensed protoplasm, enclosed in its tough membrane, is the bacterial spore. These bacterial spores are very resistant to drying, heat and disinfectants. Some of them may be boiled for an hour or two without being killed. It is the presence of such bacterial spores on meat and vegetables such as corn, peas, beans, etc., which makes it so difficult to "can" these materials satisfactorily. The spores remain dormant until the conditions around them are satisfactory for germination. Moisture, warmth and food are the conditions which induce germination of the spores. When a spore germinates, the membrane around it breaks open and the protoplasm emerges and forms a growing bacterial cell. This bacterial cell grows and multiplies until conditions again become unfavorable for further multiplication and then the bacterial cells thus formed go into the spore condition. These bacterial spores are very common in soil, dust and on the surface of anything that is exposed to a dusty atmosphere.

Bacterial Capsules.

Some species of bacteria produce soft, gelatinous capsules around the outside of their membrane. It is these bacteria which produce the so-called ropiness in milk and bread. This ropiness is due to the development in the milk or bread of large numbers of bacteria with their capsules, and it is the sticking together of the capsules that makes the milk or bread ropy, slimy and sticky. The gelatinous substance which grows on vinegar and known as mother of vinegar is simply a mass of millions of vinegar bacteria, each one with its gelatinous capsule sticking to its neighbors.

Places Where Bacteria Are Found.

Bacteria are found in large numbers wherever any other forms of life exist. One ounce of cultivated soil will contain millions of them in an active, growing condition. In dust they are present usually in the spore or dormant condition. In natural waters, such as rivers, lakes, ponds, wells, etc., they will be present in varying numbers according to the amount of contamination from soil surface washings and seepage. They are present in immense numbers in all decaying or putrefying organic material, whether of vegetable or animal origin, manure piles, garbage heaps, etc. It is their presence and activities in such material which induces the fermentation, decay or putrefaction which takes place. They are present on dry hay and straw, in considerable numbers, usually in the spore condition. They are present on the hands, face, head and surface of the human body generally, and in immense numbers on the bodies of all animals, flies, and other insects. Any food material, whether cooked or uncooked, which is exposed gets contaminated with them. As a result of this contamination the food is apt to spoil unless used before it has time to spoil. Milk becomes sour or putrid as a result of the development and multiplication of the bacteria which get into it during the milking operations and subsequent handling. Bacteria are thus practically omnipresent.

Kinds of Bacteria.

Just as there are many kinds or species of plants and animals so there are many species of bacteria. The great majority of species are beneficial in their action; some, however, are injurious and amongst these latter are those species which produce the infectious diseases of men and animals, such as tuberculosis, typhoid fever, anthrax, black leg, contagious abortion, etc., and those which produce such diseases of plants as "fire blight" of apple and pear trees, crown gall, soft rot of vegetables and bacteriosis of beans. A different species of bacteria is necessary for each of these diseases.

In addition to those bacteria which cause disease being injurious, there are some which are beneficial in one place but injurious in another. For instance, many of the species of bacteria beneficial in the soil are injurious when they get on to food material, as they bring about the decay or putrefaction of the food, rendering it unfit for use if they are allowed to develop and multiply on or in it. Hence, we refer to some bacteria as friends and others as foes.

For the purpose of further discussion we will group the different kinds or species of bacteria under the following heads:

Group I. Bacteria of the Soil and Manure Pile.
" II. Bacteria of the Water Supply.
" III. Bacteria and Sewage Disposal.
" IV. Bacteria and Food Preservation.
" V. Bacteria of Milk and Milk Products.
" VI. Bacteria of Infectious Diseases of Man and Animals.
" VII. Bacterial Diseases of Plants.

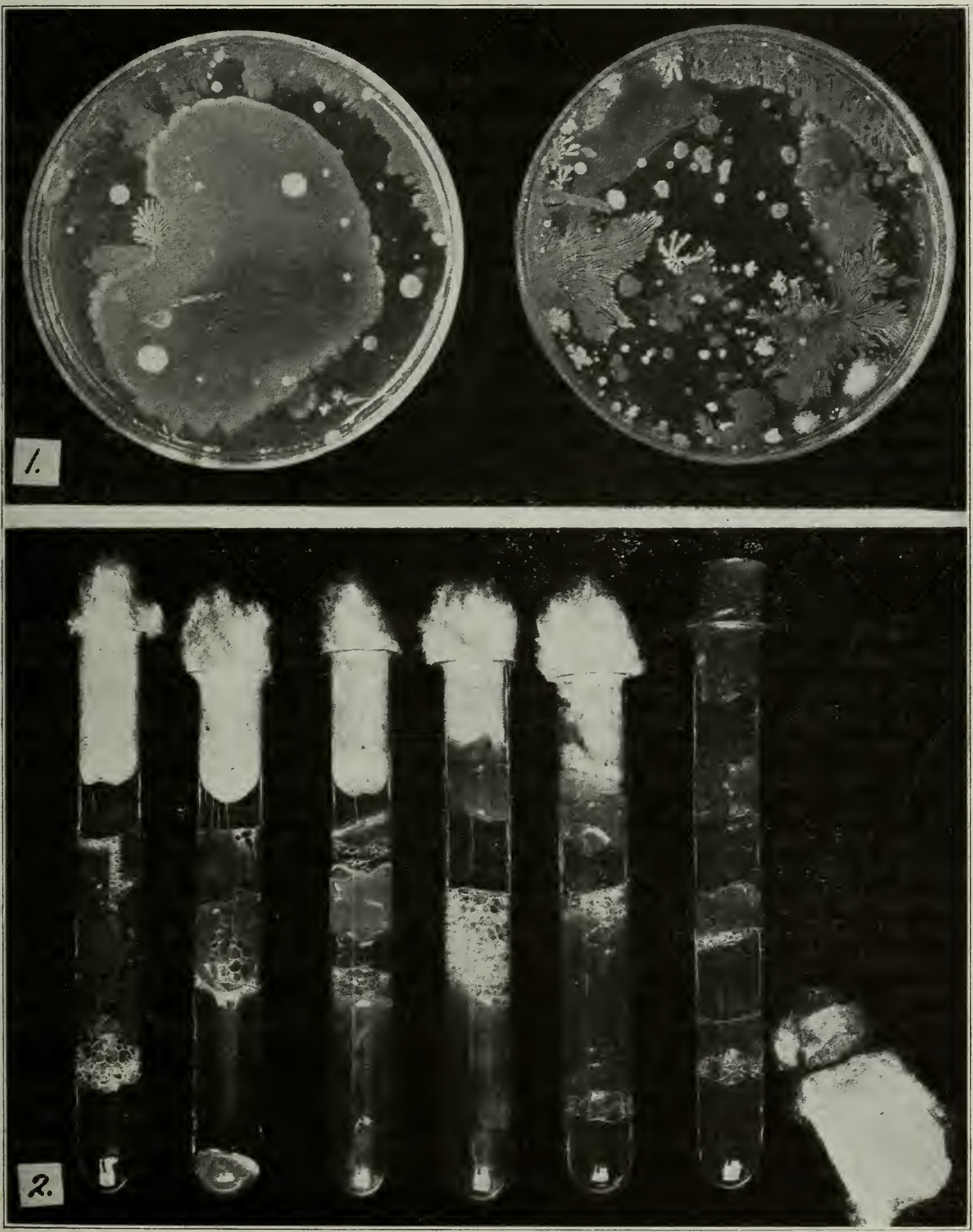
GROUP I. BACTERIA OF THE SOIL.

As previously stated, one ounce of good soil will contain millions of bacteria. They are more numerous in the first foot of soil than at greater depth, their numbers rapidly diminishing below two feet until at four feet very few are found. The function of the soil bacteria is to prepare the plant food present in the soil so that it can be assimilated by the growing plants.

Plant Food Digesting Bacteria.

When fresh manure, green manure, stubble or sod is ploughed in, the plant food which these contain is in a crude condition, and has to be prepared or digested before the growing crop can use it. This preparation or digestion is brought about by various species of the soil bacteria. These soil bacteria may be likened to the digestive juices in the stomach and intestines of man and animals, which prepare the food for assimilation by the body. Unless these digestive agents are present and active, the food is not assimilated. This digestive proceess in the soil is a very complicated one, taking place in different stages, and different species of bacteria are necessary for each of the different stages.

First, there are the species of ammonifying bacteria which digest or break down the proteid substances and liberate ammonia. The ammonia thus liberated is seized upon by the nitrifying bacteria, one kind of which (nitrous bacteria) changes it to nitrites, and another kind (nitric bacteria) change the nitrites to nitric acid which on combination with sodium or potassium gives nitrates; these nitrates can then be used by growing plants.



Soil Bacterial Cultures. (Original.)

1. Colonies of bacteria of various types growing on solid gelatin medium inoculated from garden soil highly diluted.
2. Test tube cultures of a gas-producing soil bacillus growing in solid sugar gelatin medium.

Notice how the solid gelatin has been split up by the gas produced by the growing bacteria.

In addition to this action on manures, green and otherwise, there is a bacterial action on the minerals of the soil. Growing plants require small quantities of mineral food, and this has to be set free from its combinations in the soil and rendered available before the plants can use it. This action is induced by certain of the soil bacteria, the same species which act on the manures being largely responsible for this work.

Nitrogen-Fixing Bacteria.

In addition to the species of bacteria which prepare the plant food contained in or added to the soil there are other species which add plant food directly to the soil. These are principally the *azotobacter* or nitrogen-fixing bacteria which are able to use the free nitrogen of the atmosphere for their own bodily needs, and as a result of their activities some of the atmospheric nitrogen becomes added to the soil in such a condition that growing plants can use it. Approximately four-fifths of the atmosphere is nitrogen and while plants require considerable quantities of nitrogen in their food supply they cannot use the free nitrogen of the air directly. They can take their nitrogen only in the form of nitrates. In common practice these nitrates are usually added to the soil in well-rotted manures or in nitrate fertilizers, or they are prepared from green and fresh manures by the action of the previously-mentioned classes of bacteria. But the nitrogen-fixing bacteria take the free nitrogen of the atmosphere and so combine it that eventually it becomes incorporated in the soil in such a condition that growing plants can use it.

Legume Bacteria.

There is another class of nitrogen-fixing bacteria that do their nitrogen-fixing when developing in combination with leguminous crops such as all the clovers, alfalfa, vetches, peas and beans.

It has been known for centuries that the soil of fields in which there has been grown a good clover, pea or other leguminous crop is richer after the crop than it was before. Hence the practice of having a clover or other leguminous crop in the crop rotation. Just why a good leguminous crop was beneficial to the soil was not known until a few years ago. It was then found that certain species of bacteria, which came to be known as the *legume bacteria*, entered the roots of the legumes and produced on them little swellings or nodules. Wherever these nodules are present in large numbers on the roots or legumes a good crop is assured. The combination of the legume bacteria with the plant results in fixation of the atmospheric nitrogen which becomes incorporated in the plant tissues, root, stem and leaf, giving a larger and more vigorous plant than is the case where the bacteria are not present.

It has been found that different varieties of legume bacteria are necessary for most of the different legumes. The variety of bacteria good for red and white clover is no good for alfalfa or sweet clover; the variety good for field peas is no good for field beans, and the variety good for field beans is no good for soy beans, and so on with other legumes.

If any particular legume crop has not been growing satisfactorily in any particular field, it is questionable if the right kind of legume bacteria is present in the soil of that field. So, before a satisfactory crop can be grown the right bacteria have to be introduced. For instance, the cultivation of alfalfa is a new practice in many sections. If sweet clover is common in the district it is probable that the right bacteria are there for alfalfa, as the variety good for sweet clover

Legume Plants Showing Influence of Inoculating Legume Seeds with Nitroculture (Legume Bacteria). (Edwards and Barlow.)

1. (A) inoculated and (B) uninoculated alfalfa plants from a farm in Grey County, Ontario. Regarding the field from which these plants were taken, an Agricultural Representative of the Department of Agriculture who saw the field, writes as follows:—"A part of the field was seeded with seed treated with culture obtained from the Bacteriological Department at the Ontario Agricultural College, Guelph; while the rest of the field was seeded with a better grade of seed, which, however, was not inoculated. There is a good catch of seed all over the field, but that which was from uninoculated seed has not made a very vigorous growth, while that from inoculated seed has made a luxuriant growth. In digging, many nodules could be found on the roots of the inoculated alfalfa, but none were on the roots of that which was not inoculated."
2. Red clover seedlings (A) from inoculated seed and (B) from seed not inoculated, both samples grown on the same field at the same time.

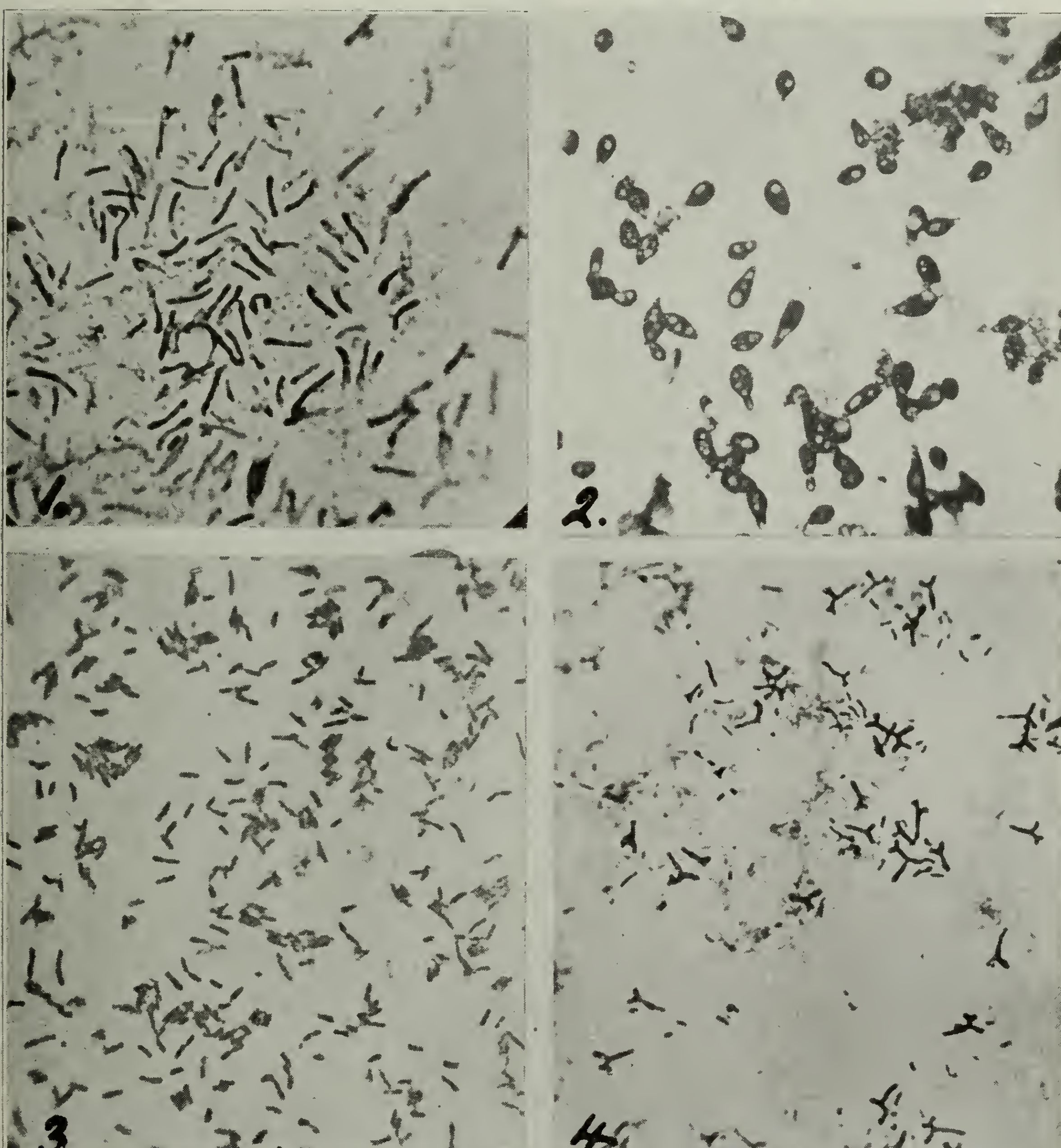
Beneficial Nodules on Roots of Leguminous Plants produced by the Legume Bacteria. (Photo by Barlow.)

1. Nodules on a portion of alfalfa root.
2. Nodules on field pea root.

is good for alfalfa. If it is not present, it is doubtful if a good crop will be grown; hence the difficulty often met with in getting alfalfa established in a new district unless the bacteria are first introduced. There are various ways of introducing the bacteria. One is to take a few loads of soil from a field in which the bacteria are present and scatter this over and work it into the field to be treated. This method was the first adopted. It is not practicable, however, in most cases.

Legume Seed Inoculation.

Another way is to inoculate the seed of the legume crop to be sown with a pure culture of the right variety of bacteria. When this is done, the bacteria are



Different Varieties of Legume Bacteria. (Stained and magnified about 1,000 diameters. (Original.)

1. Bacteria from an alfalfa nodule.
2. Bacteria from a red clover nodule.
3. Bacteria from a field bean nodule.
4. Bacteria from a field pea nodule.

on the surface of the seed when it germinates in the soil and so get into the young roots. These cultures of legume bacteria are prepared in bacteriological laboratories and sold so much per culture. They are known as *nitro-cultures,* or *legume bacteria cultures,* and various other trade names have been given them. The Bacteriological Laboratory of the Ontario Agricultural College was the first to produce these cultures satisfactorily for distribution on the American continent. They are sold from the laboratory for the nominal sum of 25c. each, to cover cost of material, container and postage. Each culture is sufficient for one bushel of seed. Thousands are sent out annually to all parts of Canada on application for the same. Many letters have been received showing that very beneficial results have been obtained from their use, more particularly from those districts where the crop to be inoculated was new. For further information regarding these legume bacteria cultures, apply to the Bacteriological Laboratory, Ontario Agricultural College.

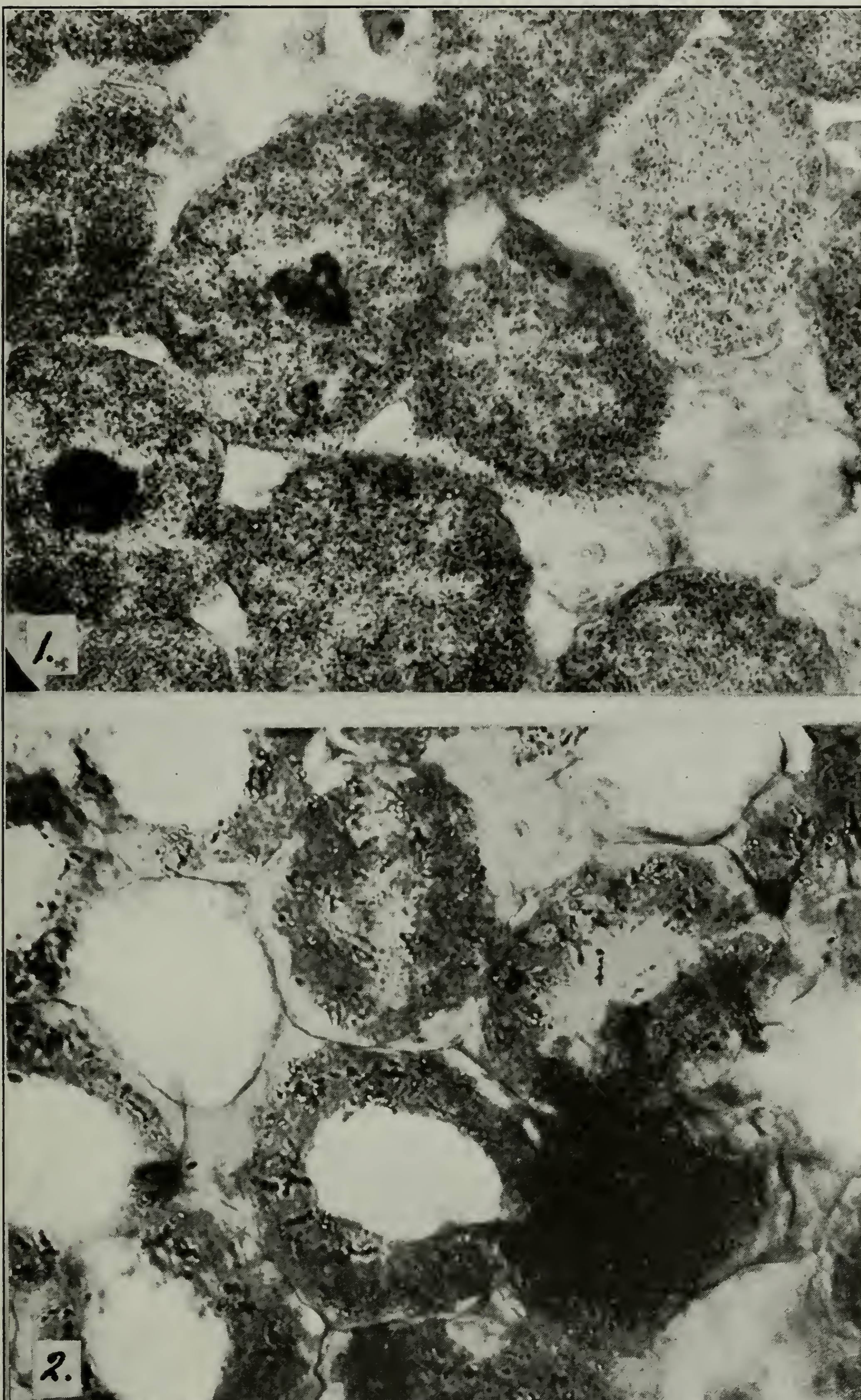
What Soil Bacteria Need to do Their Best Work.

From what has so far been said about the various soil bacteria, it will be gathered that they are friends and not foes of the farmer. They are not only useful but are absolutely essential, and the more there are of them in the soil and the more actively they are working, the better will be the crop returns. We are faced then with the problem of how to encourage their development and activities. To solve this problem we must know the conditions favorable to their development.

1. Oxygen.—First, the beneficial soil bacteria need oxygen, as many of the changes which they bring about are oxidation processes. There is an unlimited supply of oxygen in the air, and if the soil is well drained there will be plenty present in between the soil particles to a depth of two feet for the use of the bacteria. If, however the soil is caked or waterlogged, the necessary oxygen is not available for the bacteria, therefore their development and activity is checked and their elaboration of plant food is prevented. To supply the soil bacteria with their necessary oxygen we must therefore keep the soil well drained and the surface loosened up and pulverized by cultivation.

2. Moisture.—The second requirement of the soil bacteria is moisture. This does not mean saturation or free water such as would induce a waterlogged condition in the soil. So long as the soil is just moist there will be plenty of moisture for the bacteria. Two-thirds saturation is as much moisture as should be present. This moisture should exist as a thin film of water around the individual soil particles, and it is in this film of water that the bacteria live and do their work. There should, however, be no free water between the soil particles, as this would keep out the oxygen. Hence, to have right moisture conditions for the bacteria in the soil it should be well drained to carry off all excess moisture in wet periods, and in dry periods it should be shaded or cultivated where practicable so as to keep a soil mulch on the surface to prevent excessive evaporation.

3. Neutral of Slightly Alkaline Reaction.—A third requisite for the soil bacteria is a neutral or slightly alkaline reaction in the soil. That means that there should be no free acid in the soil, in other words, the soil should not be "sour." The beneficial soil bacteria will not develop where acid is present. The work of some of the soil bacteria includes the production of acid, and if this acid is allowed to accumulate it interferes with further bacterial activities. This acid as it is produced must be neutralized and if sufficient lime or potash is present



Nodule Sections 5 microns thick, stained with analin safranin and gentian violet. Magnified 1,000 diameters. (Original.)

1. Section of a nodule from soy bean root, showing the bacteria as small black specks within the plant cells.
2. Section of a nodule from field pea root, showing the bacteria as irregular-shaped rods within the plant cells.

in the soil, the acid is neutralized as fast as it is produced. If the acid in question is nitric acid and it is neutralized by potash, we get as a result potassium nitrate, which is one of the most valuable nitrate fertilizers, and readily assimilated by the growing plants. If lime is not present in the soil in sufficient quantities to neutralize the acid, then it should be added.

4. ORGANIC FOOD SUBSTANCES.—A fourth requisite of the soil bacteria is organic food substances. These are supplied by the sod, stubble, manures, straw, etc., that are ploughed in, and these should be present in fair quantities to feed the bacteria. It is this process of the bacteria feeding on these crude plant food substances that breaks them down or digests them, making them suitable for the growing crop to use them. This action of the bacteria in digesting the crude organic material added to the soil results in the production of humus, which it is so essential should be present in cultivated soils.

BACTERIA OF THE MANURE PILE.

The action of various species of bacteria in manure is just as necessary to prepare it for plant assimilation as is the action of bacteria in the soil. The changes that take place in manure from its fresh to its well-rotted condition are due almost altogether to the action of bacteria aided to some extent by molds.

When fresh manure is added directly to the soil, the plant food which it contains is not so readily available to growing plants as is the case with well rotted manures. The bacteria contained in the fresh manure aided by those present in the soil have to break down the complex organic compounds of the manure into simpler forms, or, as previously described, digest them before the growing crop can use them.

In the case of well-rotted manure, however, most of this digestive process has been completed by the bacteria, and the plant food present is largely in the right condition to be readily used by the growing crop. The rotting or ripening of the manure is mainly the digestive action of the bacteria contained in the manure.

The kinds of bacteria which bring about this action in the manure pile are the same as those which bring about the digestive processes in the soil. But the conditions which prevail in the manure pile are different from those which prevail in the soil, and as a result we are just as liable to have injurious action, resulting in loss, induced by these bacteria as we are to have beneficial action. Consequently, the bacterial action in the manure pile has to be controlled if we are to get best results.

There are large numbers of bacteria in manure when it is produced. These numbers rapidly increase and are added to from the stable floor, the air and surroundings generally, and a rapid fermentation of the manure results. Everyone is familiar with the sharp, pungent, ammoniacal odor which is given off from an occupied horse stall if it has not been cleaned out for a day. This odor is due to the free ammonia which is given off from the manure, liquid and solid, through the rapid action of the ammonifying bacteria. When the ammonia is given off into the atmosphere it is lost, and so this action should be prevented as far as possible.

If the fresh manure is thrown into a pile and the pile is kept well packed and moist the production of ammonia will not be so rapid as to be readily given off into the atmosphere. Most of it, as it is produced, will be seized upon by the nitrous bacteria and changed to nitrites and these nitrites will be changed by the nitric bacteria into nitric acid and finally result in nitrates. It is the presence of these nitrates in well rotted manure that is largely responsible for well rotted manure giving quicker returns than fresh manure when added to the soil.

Fire Fianging in Manure.

Everyone who has had anything to do with horse manure will be familiar with the condition known as fire fianging. This fire fianging means loss, as it destroys the plant food in the manure by a slow burning. The condition of fire fianging is due to a rapid oxidation in fresh manure induced primarily by the digesting bacteria. In order for this to occur, there must be abundant oxygen within the fresh manure pile. This condition exists when the fresh manure is loosely packed and strawy. In such manure the bacteria will induce rapid oxidation which causes a rise in temperature. The temperature will continue to rise until eventually the bacteria which have started it are destroyed by the heat and much of the manure rendered worthless. Therefore to prevent fire fianging the manure pile should be kept well packed and moist for the purpose of excluding excessive quantities of air.

There is not the danger from fire fianging in cow manure or pig manure that there is in horse manure, as these manures are naturally wet and compact. Mixture of these with horse manure, providing the whole is well packed, will thus reduce loss by fire fianging.

GROUP II. BACTERIA AND THE WATER SUPPLY.

All natural drinking waters, such as rivers, ponds, lakes and wells contain many species of bacteria. Other micro-organisms 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.

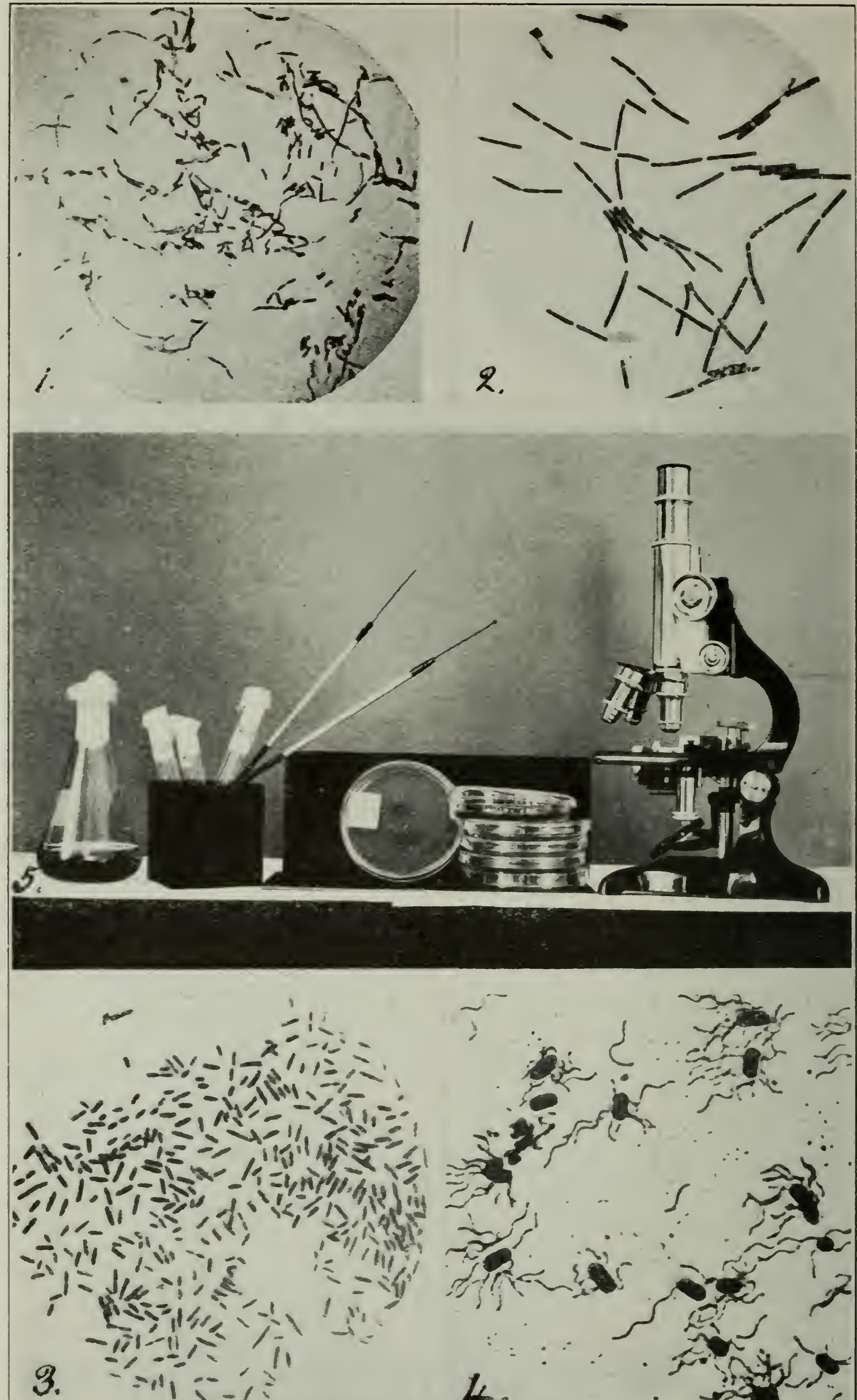
The species of bacteria found in drinking waters are divided into three more or less distinct groups, as follows:

Group 1. 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 2. Soil Bacteria Found in Water.

In the soil, as previously stated, there are many different species of bacteria. These find their way into rivers, lakes, wells and springs, during rains, particularly 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 the water. They do not produce disease, hence their presence alone in water is not sufficient to condemn the water for drinking purposes, though if they are present in any quantity they



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 cul- high-power microscope. (Edwards.)

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 3. Intestinal Bacteria Found in Water.

In the intestines of man and animals there are certain species of bacteria normally present in very large numbers. These are passed out by the million in the bowel discharges. The most common of these species is the *Bacillus coli.* These bacteria do not multiply to any great extent in natural waters, as the food and temperature conditions are not 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 is 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* 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. Water, milk, or any kind of food that gets contaminated from such discharge 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 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.

Treatment of Polluted Water.

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.

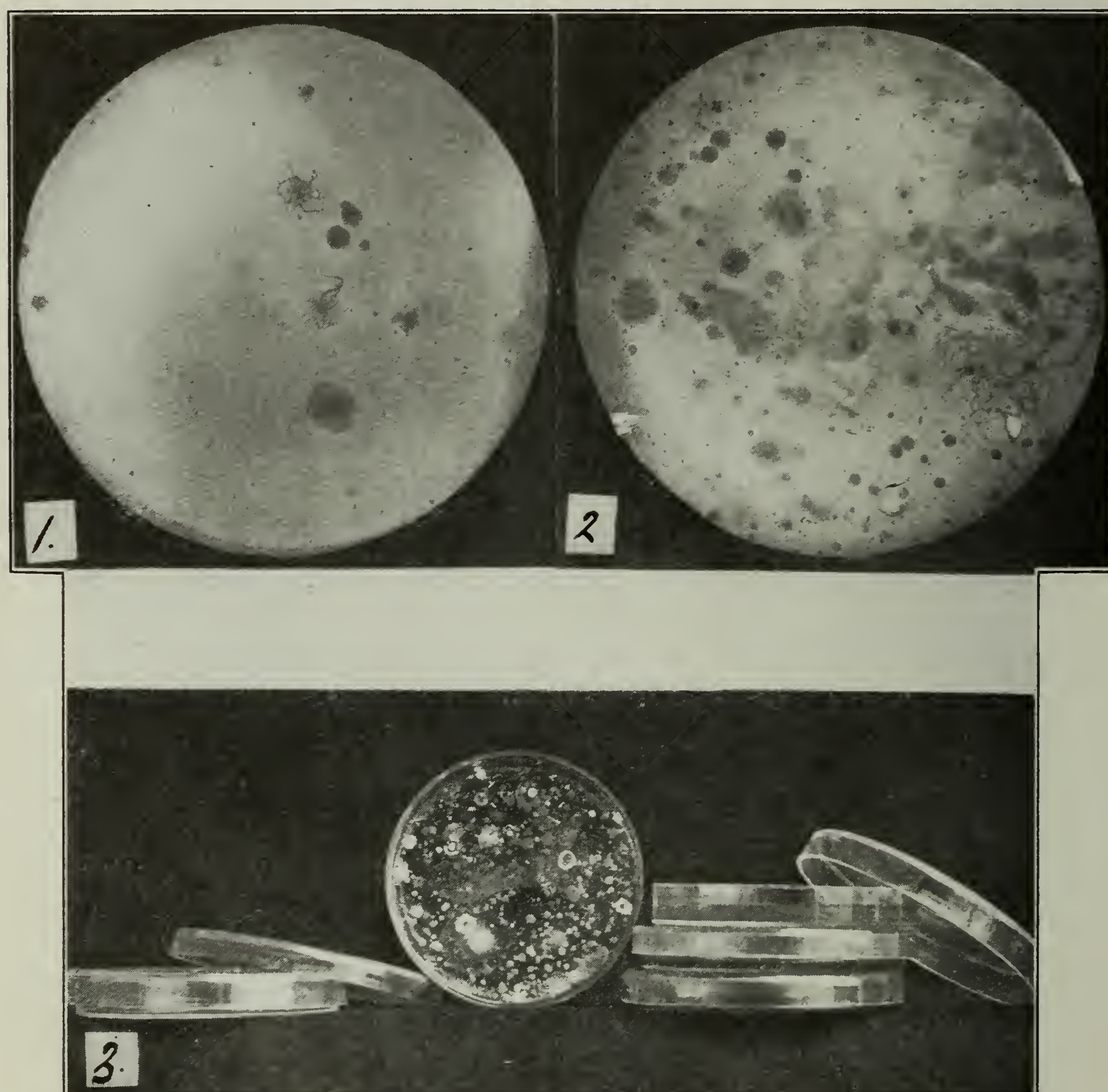
The water so polluted should be sterilized before being used for drinking purposes. Sterilization may be accomplished either by boiling the water or by the addition of a suitable disinfectant. The disinfectant most suitable for this purpose is a hypochlorite solution. This hypochlorite solution may be prepared and applied as follows:

Stock Hypochlorite for Water Purification.

1. Mix one half pound of chloride of lime (33 per cent. available chlorine) with one pint of water.
2. Add sufficient water to make one gallon.
3. Dissolve 13 ozs. of sal soda crystals in two quarts of luke-warm water.
4. Add sufficient water to make one 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 3 per cent. of chloride of lime or 1 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.



1. A few colonies of bacteria growing on a gelatin plate culture from 1 c.c. of a sample soil bacteria. This sample of water was good and fit for drinking purposes. (Original.)
2. A large number of colonies of various species of bacteria growing on a gelatin plate culture from 1 c.c. of a sample of well water submitted for examination. In addition to the ordinary water and soil bacteria, there are many sewage bacteria present indicating that the water was badly polluted and unfit for drinking purposes. Such drinking water is liable to cause typhoid fever. This sample of water was condemned as dangerous. (Original.)
3. Petri dish cultures of bacteria showing bacterial colonies growing on solid gelatin culture medium. (Edwards.)

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 or cistern may be estimated and the necessary amount of the solution poured direct into the well and stirred in.

Farm well waters in Ontario suspected of being polluted will be tested upon application to the Bacteriological Laboratory, Ontario Agricultural College.

NOTE.—For further discussion on water supply, see Bulletin 267.

GROUP III. BACTERIA AND SEWAGE DISPOSAL.

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 odors 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 gases, 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 odors and its full manurial value is recovered in the soil.

The best and most up-to-date method of sewage disposal for separate houses is by the installation of water-closets and septic tanks, the effluent from the septic tank to be carried to the soil by means of a sub-irrigation tile system, as outlined below.

The septic tank is built of brick or concrete beneath the surface of the ground and is composed of two sections. The first section is known as the settling tank and the second as the discharge tank. The sewage from the house is conveyed by tight-jointed, glazed tile to the settling tank. This tank remains always full of sewage and the solids present gradually settle to the bottom. As more sewage enters, the liquid from this chamber overflows to the discharge tank and collects there until a certain depth has been reached, when the whole contents of the tank are discharged by the working of an automatic valve fixed at the bottom. This discharged liquid is conveyed through tight-jointed tile to the sub-irrigation system of open-joint tile spread out in the soil of the garden, lawn or other convenient area.

In the settling tank there is a very complicated bacterial action. The crude fresh sewage contains many millions of bacteria, some species of which soon die. Others multiply and bring about great changes in the sewage through their digestive action, breaking down the complex chemical substances of the organic material present into simpler substances that are soluble and breaking down the soluble substances to water and gases.

The class of bacteria which do most of this work in the setting tank is composed largely of the so-called anaerobic bacteria. These are certain species which multiply and do their work in the absence of oxygen. They accumulate in large numbers near the bottom of the tank, and it is their function to partially digest the solid materials that settle to the bottom, changing them from the solid to the soluble condition, when they are ready to pass over into the discharge tank in liquid form. In this action, gases such as CO_2 and H_2S are produced, which bubble up to the surface.

In the discharge tank the bacterial action is not so decisive as in the settling tank, for the simple reason that the contents of this tank 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 class of bacteria most prominent in this tank is composed of aerobic species, *i.e.,* bacteria that require oxygen for their activities. The action of these bacteria is largely a further breaking down or digestion of the organic matter both solid and soluble still present in the sewage. Their action, however, is not completed in this tank as their maximum oxygen requirement is not possible and the liquid does not stay long in the tank.

Septic Tank Construction for Sewage Disposal. (Original.)

This tank was built to accommodate the sewage from two adjoining houses. It was built of one course of brick, reinforced with concrete outside and a concrete top.

1. Settling chamber, partly covered, into which the inlet tile from the two houses can be seen entering.
2. Discharge chamber, showing the syphon valve and outlet tile leading to a sub-irrigation tile system in the garden.

Note.—This tank has been in service three years at time of writing, and has given perfect satisfaction.

As soon, however, as the contents of the tank are discharged into the sub-irrigation 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 the breaking down of the complex organic substances of the sewage into simple substances. Then the soil bacteria, principally the nitrifiers and members of the same class present in the sewage itself, recombine these elements and simple compounds into other compounds as nitrates, when they may be utilized by growing plants.

The strong soapy water from the laundry should not be discharged into the septic tank, as this would interfere with the action of the bacteria. The water from the bath and wash basins, however, may be discharged into it without unfavorable results.

For details regarding construction and instalment of water-closet and septic tank system, see Bulletin 267.

The Kaustine System of sewage disposal, recommended by the Board of Health, Toronto, for places where a water-closet is not installed, involves chemical treatment of the excreta which destroys the bacteria and dissolves the solids. As this method is not one in which bacterial action is involved, it does not come within the scope of this bulletin. For particulars regarding the instalment of the Kaustine System, apply to Kaustine Co., 858 Dupont Street, Toronto.

GROUP IV. BACTERIA AND FOOD PRESERVATION.

It is a universally known fact that foods not properly preserved will spoil. They will ferment, decay, putrefy or become moldy. These changes are brought about by the development of bacteria, yeasts and molds on or in the food. If these micro-organisms can be prevented from growing on or in the food it will not spoil. Therefore, the question of food preservation resolves itself into the problem of preventing these bacteria, yeasts and molds from growing and multiplying on or in the foods. This is done in various ways as drying, use of antiseptics or preservatives, and "canning" according to the nature of the food to be preserved.

Bacteria are the micro-organisms mostly responsible for the spoilage of vegetables, cereals, meats and milk, while yeasts and molds are mostly responsible for the spoilage of fruits and fruit juices.

As stated in the early pages of this bulletin, the surface of everything which is exposed to the atmosphere is more or less contaminated with these invisible micro-organisms. But before these micro-organisms can multiply and thus become active in the spoiling of the foods on which they are present, the conditions for their development must be satisfactory.

Preservation of Food by Drying.

The first requisite for the multiplication of these micro-organisms is moisture. Hence, if food materials are sufficiently dried and kept dry they will not spoil. The preservation of certain foods by drying has been practised for centuries, and is a common means of food preservation at the present time. Some foods, such as the cereals, wheat, oats and barley, ripened peas and beans, are naturally dry and do not have to be subjected to any drying process except that common in the harvest fields. The flour, meal and other preparations made from them are also sufficiently dry to prevent bacterial development in them, providing they are kept in a dry place. If, however, they are exposed to much dampness and allowed to get wet they soon begin to spoil, as the moisture enables the bacteria that are present to develop and multiply, causing the material to ferment, heat and sour or become sticky. Flour, meal and other uncooked cereal preparations all contain bacteria of different species in considerable numbers. These get into the flour from the exterior of the grains during the milling operations and from the dusty atmosphere. These bacteria remain dormant so long as the material is kept dry, and most of them are destroyed in the baking or other cooking operations to which the material is finally subjected before it is used as food. Sometimes they are not all destroyed in the cooking operations, and then if the material is not used soon it is liable to spoil. This is the principal reason for bread occasionally becoming sour, ropy or moldy.

Dried Vegetables.—The preservation of vegetables by drying has developed in recent years into a large business. The vegetables are cleaned and sliced and the moisture is evaporated in suitable drying chambers. Care has to be taken that sufficient moisture is removed or the material will spoil through the development of the various micro-organisms that will be on the individual pieces. The slicing and drying process kills the vegetable tissue. and so the common decay bacteria can readily grow on it if sufficient moisture is present. This drying process decreases the bulk and weight of the vegetables, thereby facilitating transport.

Stored Roots.—Some healthy roots such as turnips, beets, carrots, parsnips, salsify and potato tubers keep satisfactory if well stored at a low temperature even though they are always covered with the common soil bacteria. If such roots are exposed to dampness and warmth they have a tendency to grow rather than to decay. This is due to the fact that they are composed of living tissue, the root or tuber being simply a store chamber of food material and the common decay bacteria present on such roots cannot affect the sound living tissue. If, however, the life of the roots is destroyed by freezing, or too much heat, then decay will set in as the common soil bacteria will readily develop on the dead root tissues, and there will be plenty of moisture present in the roots to enable the bacteria to grow.

Again, if the roots are not sound, but affected with a disease, such as the bacterial soft rot, at the time they are removed from the soil, then the disease will be likely to spread from the diseased specimens to those touching them until the whole pile is rotted as a result of the development and multiplication of the plant disease bacteria, which have the power to attack living plant tissue when once they gain entrance through the skin.

Dried Fruits.—With dried fruits, such as raisins, prunes, currants, figs, etc., another factor besides dryness enters into consideration. It is not necessary to have these fruits bone dry, as in the case of the cereals, a fair percent of moisture being allowed to remain within them. This is because there is a high percentage of sugar in the fruit, and it is only necessaray to evaporate sufficient moisture from the fresh fruit to ensure this sugar being present in a satisfactory density. When this satisfactory density is obtained, yeasts and molds cannot make use of the moisture present, and therefore cannot grow. If these dry fruits, however, are kept in a damp place they absorb moisture, and this brings about a dilution of their sugar content which enables the yeasts and molds to grow, thus spoiling the fruit by producing fermentation and moldiness.

Dried Meat and Fish.—Preservation of meat and fish by drying has been practised for ages. The Indians preserved their meat (Pemmican) by cutting the deer flesh into strips and exposing it to the sun to dry as much as possible. It is the modern practice, however, to augment the drying of meats and fish by the use of certain antiseptics, such as smoke containing creosote fumes and salt. When these antiseptics are used, it is not necessary to dry up all the moisture present, as the antiseptic used should prevent bacterial development, though it does not kill the bacteria.

PRESERVATION OF FOODS BY CANNING.

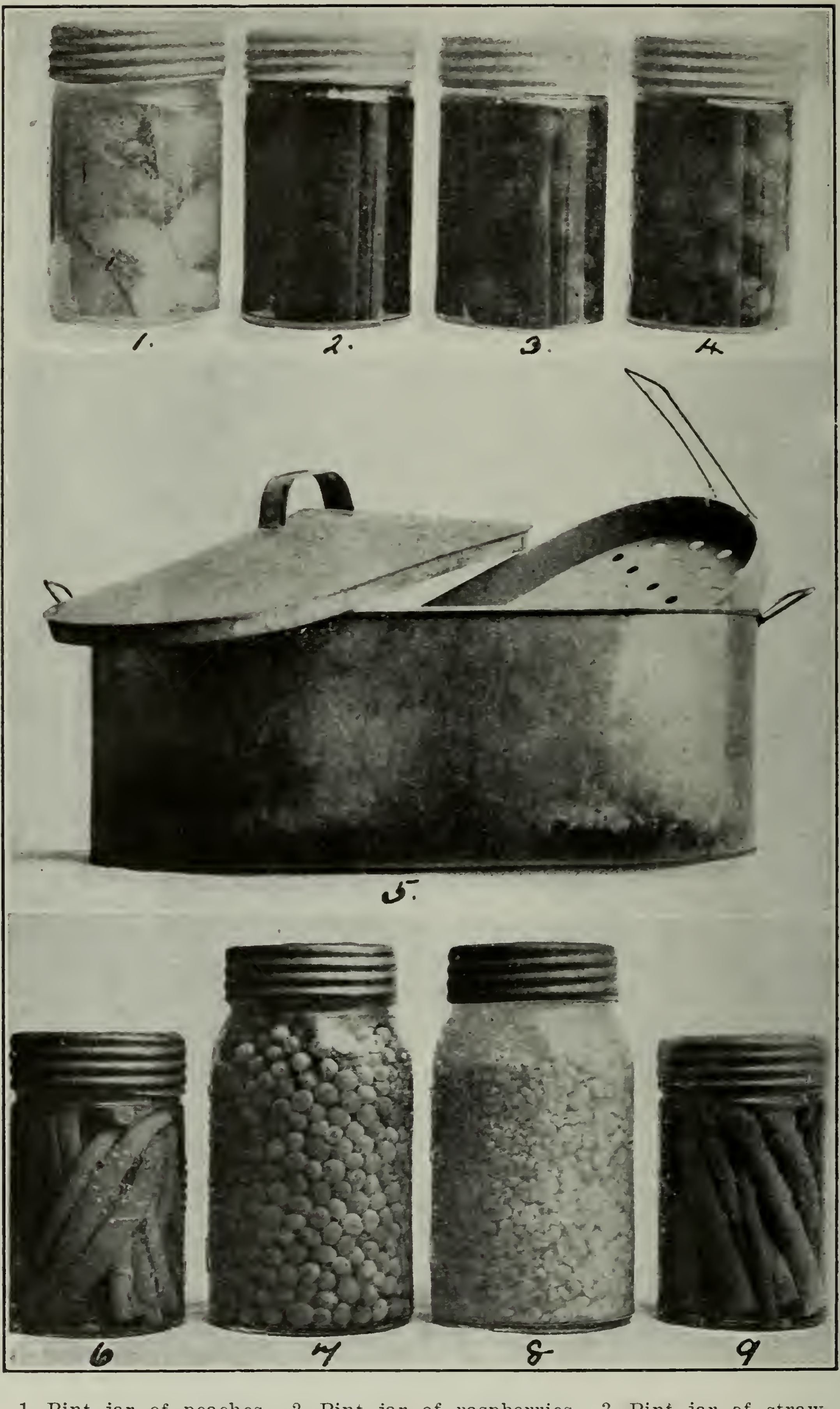
Foods are canned for the purpose of preserving them in their fresh, juicy condition as near as possible. Not only is the moisture originally present in them allowed to remain, but more moisture is frequently added in the shape of syrups.

This method of preservation depends altogether upon two factors; first, killing all the micro-organisms that are present on the foods, and second, preventing other micro-organisms from gaining access to the food after all those present have been destroyed. Fruits, vegetables, meats, fish, and milk, are preserved in great quantities in this way.

Canning Fresh Fruits.—The micro-organisms to contend with in the preservation of fruits are mostly, if not altogether, yeasts and molds. With very few exceptions, bacteria cannot grow in fruit juices, owing to the fruit acids that are present. Invisible yeast cells and mold spores are always present on the surface of fruit. They get there mostly from the soil of the orchard where they multiply rapidly, being fed by the juices of the fruit that drops to the ground and is allowed to rot. During cultivation and wind storms many of these yeast cells and mold spores are stirred up into the atmosphere with particles of dust, and so get deposited on the fruit while it is growing.

If soft fruits are allowed to stand for a few days after picking, particularly if some of them have been damaged and the juice extruded, there will be fermentation and molding. This is due to the development of the invisible yeast cells and mold spores that were on the surface of the fruit. These feed on the plant juice and rapidly multiply, and the result of this multiplication is fermentation in case of the yeasts, and moldiness in case of the germination of mold spores. If the fruit is to be preserved any length of time, all the yeast cells and mold spores present must be destroyed and others be prevented from gaining access to the fruit. The destruction of the yeast cells and mold spores present is brought about by the proper application of heat (sterilization) and others are prevented from getting on the material by hermetically sealing the fruit in glass jars, tin cans or other satisfactory containers. Fruit to be preserved should be sound, fresh, not over-ripe, clean, and in case of stone fruits, the stones should preferably be removed. Sterilization may be effected either before or after the fruit is filled into the containers, whether these be sealers or tin cans.

Sterilization of Fruit Before Canning.—If the fruit is to be sterilized before filling into the containers, the sterilization process implies cooking or boiling the fruit in a kettle, adding sugar to taste, and then while hot, filling it into hot sealers which have been previously cleaned and sterilized in water heated to boiling, then sealing immediately with rubbers and caps taken direct from scalding water.



1. Pint jar of peaches. 2. Pint jar of raspberries. 3. Pint jar of strawberries. 4. Pint jar of cherries. 5. Wash boiler fitted with perforated false bottom, used for sterilizing jars of fruit and vegetables. 6. Pint jar of butter beans. 7. Quart jar of green peas. 8. Quart jar of young corn. 9. Pint jar of asparagus. (Original.)

If the cooking process of the fruit and the sterilization of the jars, caps and rings has been thorough, and the closure joint is air-tight, the fruit should keep indefinitely until it is opened. After a jar of fruit so preserved is opened, yeast cells and mold spores are liable to get in and so induce fermentation or moldiness, if the contents are not soon used.

The requisite amount of sugar may be added as a syrup after being dissolved in water, equal parts of each, or may be scattered over the fruit in the kettle, mixed in, and allowed to stand over night, by which time sufficient juice will usually be present in the kettle to make boiling satisfactory. The latter method of course ensures a thicker and richer fruit juice than if water were added to the sugar to make a syrup.

The sugar used in the above method is simply for improving the flavor. It does not act as a preservative in the quantities used. If the sugar is to serve as a preservative it must be present in the proportion of at least 40 per cent. of the mass, and the result is jam or thick preserve. When sugar is present in this proportion and well mixed in, yeasts and molds cannot readily grow in the substance, as such a proportion of sugar renders the water unsuitable for absorption by the yeasts and molds. It prevents osmosis.

Sterilization of Fruit After Filling: Cold Pack.—If it is not desired to cook the fruit before sealing up, the fruit may be very satisfactorily sterilized after it is put into the jars. When preserved in this way, the finished product more nearly resembles the fresh fruit than is the case with the fruit that is cooked before filling into jars.

Needless to say, the better condition the fruit is in at the time it is packed. the better will be the finished product. The fruit should be well picked over, not overripe, stems, pits, and unsound specimens discarded, and the fruit rinsed with clean, cold water, and drained. The skin should be removed from peaches and apricots.

The jars, rubbers and caps should be well washed and rinsed. The fruit is then filled into the jars. A syrup of sugar dissolved in water, equal parts of each, is then added to fill up the jar to the brim, the rubber cap and ring put on and closed, but *not* screwed or clamped down tightly, but left a little loose to allow for expansion during the heating process. If the tops are screwed on tightly they are liable to be sprung as a result of expansion of contents when heated.

The jars and their contents are then ready for sterilization. This process implies standing them in cold water, bringing this to a boil, and allowing the jars to remain in the boiling water for 15 to 20 minutes, or placing them in a steamer and steaming for half an hour. An ordinaray wash boiler is a very satisfactory boiling apparatus for this purpose. A false bottom made of strips of wood or perforated sheet iron should be placed inside the boiler so as to raise the jars off the boiler bottom. The jars should then be placed on this false bottom and the boiler about a third or half filled with cold water, the top put on and heated as above described.

Immediately after the heating process, the tops of the jars should be tightly clamped or screwed down, and the jars stood away. If the jars have been properly heated and the caps well screwed or clamped down immediately after so as to make an air-tight joint, the fruit should keep indefinitely, until the jar is opened, as all the yeast cells and mold spores will have been killed and no others will be able to get in.

Canning Vegetables.—Bacteria are the micro-organisms that we have to contend with mostly in the canning of vegetables. It is these which cause putrefaction and decay of green vegetables that are not properly preserved. They are always present on the surface of the vegetables until they are destroyed by heat or some other agent. Yeasts and molds are also liable to be present, but they are much more easily destroyed than the bacteria.

The spores of bacteria, as previously stated, are much more difficult to kill than are yeast or mold spores. Boiling them for one or two hours does not always kill them. Hence it is that more difficulty is experienced in the canning of vegetables than in the canning of fruits. All species of bacteria do not form spores, but there are usually, if not always, some of the spore-bearing species of bacteria on the surface of vegetables.

The vegetables commonly preserved by canning are green peas, beans, corn, asparagus and tomatoes. These should be fresh, sound, clean and not over-ripe.

The cold pack method of putting up gives best results with vegetables, except possibly with tomatoes.

Have jars, rubbers and tops all thoroughly clean and well rinsed.

Green Peas are shelled and blanched (directions for blanching see below) and then filled into the jars, and clean water, salted to taste, is poured in to fill up all spaces. The rubbers and tops are next put on but not screwed down tightly. The jars and their contents are then ready for sterilization. (Directions for sterilization see below).

Green Beans may be packed whole or cut, as most convenient. They should first be picked over, stemmed and blanched, then filled into jars, water, salted to taste, added to cover, rubbers and tops put on but not screwed down tightly. They are then ready for sterilization, as below.

Green Sweet Corn should be cut from the cob and filled direct into the jars. Water, salted to taste, added to cover, rubbers and tops put on, then the jars and contents sterilized, as below.

Asparagus should be picked over and cut to suitable length, then blanched and filled into jars, water, salted to taste, added to cover, rubbers and tops put on, then sterilized, as below.

Tomatoes differ from most vegetables in being very pulpy, having a high water content and considerable acidity. On account of the high water content it is desirable not to add more water than is absolutely necessary.

The tomatoes should be fresh, sound, and fairly ripe. Scald, skin and pack directly into jars. If the juice expressed is sufficient to fill all spaces in the jar when the tomatoes are packed in, so much the better. They will pack better if cut. If sufficient juice is not present to fill all spaces add sufficient water, salted to taste, to cover. Put on rubbers and tops but do not screw down tightly, then sterilize.

Owing to the fact that tomatoes have a fairly high acid content some of the spore-forming bacteria common on vegetables cannot readily grow in the tomato pulp. For this reason it is sometimes easier to sterilize tomatoes than other vegetables. There are, however, some species of spore formers liable to be present that can grow in the pulp, and it is owing to the presence of these that it is advisable to sterilize tomatoes in the same way as recommended for other vegetables, rather than in the way recommended for fruits.

Another way for canning tomatoes is to sterilize them before filling into the jars. This is, perhaps, the most common method practised. It implies cooking the tomatoes and filling hot into hot sterilized jars in the same way as used for fruit.

For canning this way the tomatoes are scalded, skinned, placed in a kettle and boiled for an hour or so with occasional stirring. In addition to destroying the micro-organisms present, this process will drive off some of the water content. The jars, rubbers and tops are sterilized as described for fruit, and the hot pulp is transferred direct to the hot jars, which are then topped and screwed down tightly and placed away.

If all the micro-organisms in the pulp have been destroyed in the cooking process and the jars and tops effectively sterilized, and the joint is air-tight, the tomatoes will keep indefinitely. Otherwise the tomatoes will spoil.

NOTE 1.—*Blanching* implies washing the material in clean, cold water, then placing it in boiling water for two or three minutes and stirring carefully. This removes substances from the exterior of the vegetables that otherwise would tend to give a slimy precipitate in the canned goods. On removal from the boiling water the vegetables should be placed in cold water to cool and get firm before filling into the jars.

NOTE 2.—*Sterilization of Vegetables put up by the Cold Pack Method.*—There are three ways of sterilizing vegetables that have been put up by the cold pack method.

Method 1.—Place the filled jars with loose tops in a boiler half full of cold water, as described for sterilizing fruit. Bring the water to a boil and keep it boiling for two to three hours. Then screw or clamp the tops down tightly while hot, and place the jars away. Occasionally there are bacterial spores present that will resist boiling for two or even three hours. When such are present, the goods will spoil. For this reason we cannot guarantee this method, although it is commonly practised.

Method 2. Place the filled jars in the boiler, half-filled with cold water, bring to a boil and boil for half an hour. Then tighten down the tops, remove from boiler and put on one side to cool. Twenty-four hours later, loosen the tops slightly and return the jars to the boiler and heat for half an hour, as on the previous day. Then tighten down the tops again and remove jars from boiler to cool. Repeat this operation for the third time after another twenty-four hours and then the sterilization should be complete. Tighten down the tops and store away the jars.

This method entails quite a lot of labour, but it is the best and surest method for sterilizing vegetables. The reason for giving three heatings is as follows: The first heating destroys all the mold spores, all the yeast cells, and all the bacteria that are not in the spore condition. It does not kill the bacterial spores, however. During the twenty-four hours that elapse between the first and second heatings many of the bacterial spores present will germinate. After germination the second heating will kill them. Usually all the spores present do not germinate between the first and second heatings, but these will nearly always germinate between the second and third heatings, then these are destroyed by the third heating. These three separate, half-hour heatings, are more effective than the one three-hour heating.

Method 3. For this method steam under pressure is necessary. A strong steam-tight chamber, known as the autoclave or "canner" is used. Into this the filled jars or tins are placed, some water is put into the bottom of the canner and heat applied sufficient to generate steam. When the top is screwed down tightly the steam enclosed under pressure rises to a temperature of 240° to 250° F. This high temperature is maintained for 30 to 45 minutes, by which time all forms of life, including bacterial spores, should be destroyed.

The jars or cans are then removed and hermetically sealed.

The "National Junior No. 1 Canner" has proved itself satisfactory for this method of sterilizing vegetables, meats and fruits.

VINEGAR BACTERIA.

Vinegar is made from alcoholic liquids, such as wine, hard cider, fermented honey, malt and fruit juices by the action of the vinegar or acetic acid bacteria, *Bacterium aceti,* commonly called "mother of vinegar." Wine and cider vinegars are considered the best.

The mother of vinegar is a slimy gelatinous layer that forms on the top of acidifying alcoholic liquids. This layer is composed of millions of vinegar bacteria sticking together by means of their gelatinous capsules.

Vinegar or acetic acid is produced from fermented liquids, as a result of the oxidation of the alcohol present in the liquid. This oxidation may be produced by chemical means, but in usual practice it is due to the action of the vinegar bacteria in the presence of the oxygen of the atmosphere. There are several species of vinegar bacteria, each species producing a somewhat different kind of film from that of the others.

Home Manufacture of Cider Vinegar.—Good hard cider is necessary to make a good sample of cider vinegar. The hard cider may be made from apples by pulping them and straining out the juice and allowing it to ferment in barrels or other convenient receptacles.

The fermentation of the apple juice may be hastened and improved by adding some yeast, as Fleischman's or Royal Yeast, as soon as the apple juice is expressed from the apples.

When the fermentation is complete, that is, when the sugar of the apple juice has all been changed to alcohol, the liquid is ready for the mother of vinegar to change the alcohol to acetic acid.

As the acetification is an oxidation process there must be plenty of air available to the vinegar bacteria. Consequently, the barrel or other receptacle in which the vinegar is to be made should not be filled too full of hard cider.

The best way to proceed is to lay an empty barrel on its side and fix it so that it will not roll. Then bore a hole at each end near the top and one in the middle on the top. The holes in the ends are for the purpose of aeration and the hole in the top is for filling in the cider. At one end near the bottom a tap should be fitted from which to draw off the vinegar when it is ready.

Fill the barrel about a third full of hard cider, using a funnel with a long shaft, through the hole in the top. Then add some mother of vinegar as a starter. If preferred, the mother of vinegar may be added to the barrel before the cider is filled in. The mother of vinegar will then develop as a gelatinous film over the top of the liquid. Care should be taken not to disturb it by shaking the barrel, as the film will fall to the bottom where it will not do good work. After a few weeks a sample should be drawn from the tap to test for strength of vinegar. If the vinegar is sufficiently strong draw off about half of the quantity and then fill in more cider through the funnel. The shaft of the funnel should be long enough to reach down through the film of mother so that when cider is added it will not disturb the film. The barrel should preferably not be more than half full at any time, as this allows the maximum of surface for the film to develop on and so gives the maximum of aeration to the bacteria that constitute the film.

The vinegar may be drawn off from time to time and more hard cider added.

When the vinegar is drawn off, if it is to be kept any length of time it should be filled into bottles and pasteurized. Filtering and clarifying with isinglass improves its appearance, making it bright and clear

Rapid Method (Commercial).—A more rapid method of making vinegar is to have a vat filled with beech shavings. The top and bottom of the vat are filled with perforations. The shavings are first covered with a coating of mother of vinegar slime by running mother of vinegar slowly through the vat from above down and then passing and repassing hard cider through, simply by allowing it to trickle slowly down over the shavings. In course of time the shavings become covered with the mother, then as the hard cider slowly trickles over their surface in a thin stream the bacteria are able to change the alcohol into acetic acid or vinegar by the time it reaches the bottom. If the vat is not working its best, however, it will be necessary to repass the liquid through the vat several times.

The reason for the rapidity of action in this method as compared with the barrel method previously described, is that the hard cider as it trickles slowly over the surface of the shavings is in direct contact with the mother in a very thin stream, and air is present right throughout the vat in between the shavings, so that the oxidation process which the mother induces can be induced at its maximum rate.

GROUP V. BACTERIA OF MILK AND MILK PRODUCTS.

Bacteria play a very important role in the milk and dairy industry. Practically all the natural changes either good or bad that take place in milk from the time it is drawn until the time it is consumed, or otherwise used, are due to the action of the various species of bacteria that get into it, though sometimes yeasts and molds are involved.

If the milk is to be consumed as milk, then most of the changes that take place in it as a result of bacterial action are injurious. Exceptions to this are found in the prepared fermented milk, as Kephir, Koumiss and Bulgarian Milk; in these, however, the bacterial action is controlled and cultures of certain species of bacteria are added to the milk to bring about the desired changes.

Bad Milk.—Everybody knows that if a sample of ordinary milk is kept for a few days, particularly if it is not kept cold, it will sour or become gassy or ropy or putrid. This souring, ropiness, gas production and putrefaction, is brought about by different species of bacteria in the milk. As the changes in the milk which these bacteria produce are injurious and undesirable, everybody who has anything to do with the handling of milk should know how to prevent their occurrence.

In the ordinary methods of obtaining and handling milk it is impossible to prevent some bacteria from getting into it. With proper care, however, a large percentage of the bacteria that ordinarily get into the milk can be prevented from getting in, and with proper handling of the milk the few that do get in can be prevented from producing any marked changes within a reasonable time. It is desirable, then, that those who have to do with the production and handling of milk should know how to prevent, as far as possible, the bacteria from getting into the milk and also how to prevent those that do get in from bringing about the changes which result in the spoiling of the milk.

How Bacteria Get Into Milk.

1. Bacteria from the Udder.—When milk is drawn from a clean, healthy udder it is practically free from any injurious bacteria. A few bacteria are usually present in the teat ducts and also in the milk cisterns of the udder, and so during milking operations some of these pass out into the milk. The varieties of bacteria that are found here, however, do not as a rule bring about any noticeable change in the milk after it is drawn. Consequently, contamination of the milk by bacteria from the interior of the udder, unless the udder is diseased, is usually negligible.

With the exterior of the udder, however, the case is different. Various species of contaminating bacteria are constantly present all over the surface of the udder and considerable numbers of these are shaken off during the milking operations and drop into the pail unless steps are taken to prevent them. One way to prevent these bacteria from getting into the milk is to wipe the udder over with a clean damp cloth immediately before milking. This does not remove many of the bacteria, but largely prevents their falling off during milking. Another method of prevention is to use covered or sanitary milk pails. These prevent many of the bacteria which fall from the udder or other part of the cow's body during milking from getting into the pail.

2. Bacteria From Cow Hairs.—Hairs from the cow's body are heavily infested with contaminating bacteria. Hundreds or even thousands may be present on a single hair. It is seldom that a few hairs from the cow's body, particularly the flanks, do not get into the milk pail during the milking operations unless care is taken to prevent them. An examination of the strainer through which the milk is poured from the pail to the can usually shows a few hairs at least. It is commonly thought by milkers that, providing these hairs are removed from the milk by the strainer, their getting into the milk does not matter. Such an idea, however, is wrong, for most of the contaminating bacteria present on the hairs when they drop into the milk are washed off into the milk during the milking, and these are much too small to be caught by the strainer. Hence care should be taken to prevent cow hairs from falling into the milk. Grooming and clipping the cow's flanks and hind quarters is helpful in this regard, also wiping them with a damp cloth immediately before milking. Such practices, together with the use of the covered or sanitary milk pail should prevent most of the contamination of milk from cow hairs.

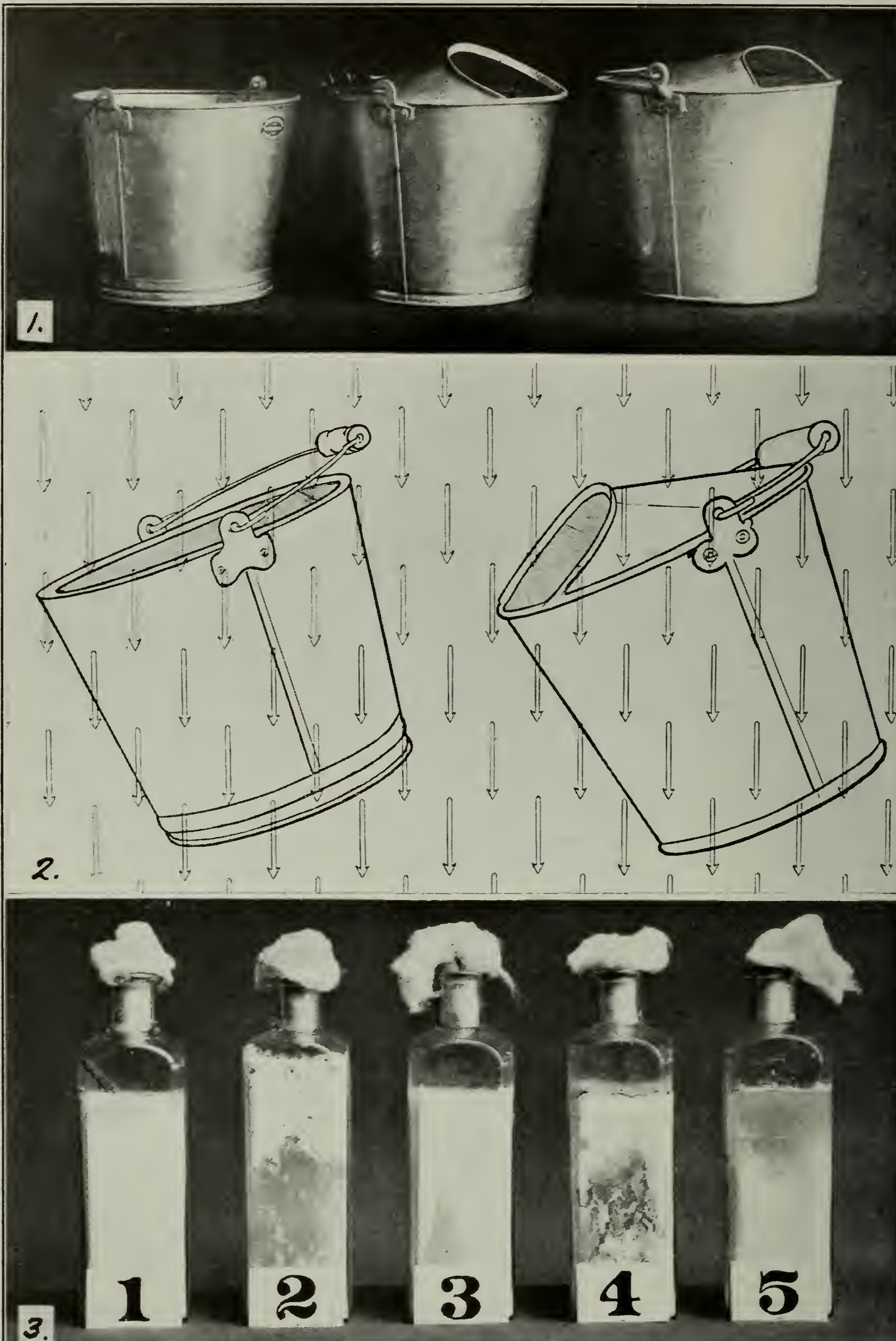
3. Bacteria from Bits of Hay, Straw and Manure.—Every particle of hay, straw and manure will have on it many serious contaminating bacteria, even though the hay and straw appear absolutely clean. These bacteria do no injury to the hay or straw so long as it is kept dry. But as soon as it gets damp

or wet, then they cause it to rot. When bits of hay or straw or particles of manure get into the milk during the milking, the contaminating bacteria are washed from them into the milk, just as in the case of cow hairs, and whilst the bits of hay and straw are removed from the milk by the strainer, the bacteria are not, as they readily pass through the finest strainer used. In this way little bits of hay and straw or bits of manure that drop into the milk from the body of the animal or when feeding or bedding is being carried on, bring about a more or less serious bacterial contamination of the milk.

4. Bacteria from Dust.—As stated in an earlier page of this bulletin, particles of dust in the atmosphere will have on them various species of bacteria, usually in the spore or resting stage. As soon as these get on to any moist food material, they germinate and multiply, feeding on the food material and causing in it various kinds of fermentation. When these bacteria on particles of dust get into milk, they find the most ideal food for their rapid development, and it is this development and multiplication of the bacteria in the milk that changes its character from a desirable to an undesirable condition. Hence care must be taken to prevent dust from getting into the milk. Such stable operations as feeding, bedding and sweeping should not be carried on either during milking or shortly before milking, as they stir up the dust. They should be attended to either after the milking is over or at least an hour before milking, thus giving a chance for the dust to settle before any milk is exposed.

5. Bacteria from Flies.—House flies and stable flies are great carriers of putrefactive and other contaminating bacteria. Hundreds of thousands of these bacteria may be found on one leg of a fly. Flies breed and feed on manure and filth of all kinds, and from these sources they get heavily contaminated with the putrefying bacteria present in such substances. Unfortunately, flies will also feed on good human and animal foods, and when they settle on or fall into such material they naturally contaminate it with the bacteria that they have picked up from manure or filth on which they have previously been. In the summer time they are present in great numbers around stables and manure piles and milk houses, and it is very common for a number of them to get into milk. Hence, as each fly is liable to have hundreds of thousands of bacteria on its legs, mouth and body, when a number of flies get into milk during the milking or handling process, the milk becomes badly contaminated. So every care should be taken to keep flies out of the milk. Manure piles, the breeding place of flies, should not be allowed near the milk house. Windows and doors of milk houses and stable should be screened, milk cans should be kept covered and every other precaution necessary to prevent flies getting into the milk should be taken.

6. Bacteria from Strainers, Milk-Pails, Cans, Bottles and Other Milk Utensils.—Milk strainers, pails, cans, bottles or other utensils that have had milk in them will have a thin film of milk left on their inner surfaces or wherever the milk has been in contact. This thin film of milk, if allowed, will dry on pretty hard. Within this thin film of milk bacteria will be present in large numbers and unless the greatest care is taken to thoroughly wash and then scald such utensils, any milk that is put into them will get contaminated with bacteria from this film. It has been shown many times that milk pails, cans, bottles, and strainers that have not been properly washed and then sterilized either by scalding or steaming are responsible for more bacterial contamination of milk than most other sources of contamination put together. Therefore, the greatest of care



Milk Pails and Milk Contamination. (Photo by Lund.)

1. Ordinary wide-topped milk pail and two covered sanitary milk pails.
2. Diagram showing how the ordinary wide-topped milk pail allows dust, cow hairs, flies, etc., to get into the milk during milking, while the covered sanitary milk pail tends to prevent such contamination.
3. Samples of sterilized milk spoiled by contamination as follows:
   1. By adding a bit of hay.
   2. By adding a pinch of road dust.
   3. By adding a particle of cow manure.
   4. By adding a bit of straw.
   5. By adding a fly.

should be taken to thoroughly wash all milk utensils with brush, warm water, soap, soda or washing powder and then rinse out with clean hot water and follow by scalding or steaming and allowing them to air dry in a dust-free atmosphere. If cheese-cloth strainers are used these should be well washed and boiled after each time of use.

7. Bacteria from Milking Machines.—Milking machines were introduced largely as a labor-saving device. It was also thought that they might reduce the bacterial contamination of milk, as they offered no chance for the bacteria of the atmosphere, dust, hay, straw, flies, hairs, etc., to get into the milk during milking. General experience has shown that however much they may reduce labor in milking they do not reduce bacterial contamination of the milk unless they are properly attended to. Frequently machine-drawn milk is worse contaminated than hand-drawn milk. As a matter of fact, in some districts of Ontario, creameries and cheese-factories have refused to take in milk drawn by milking machines, as they found they could not make good products from such milk on account of its high bacterial content.

An investigation carried on in one of these districts by Mr. T. H. Lund, of the Bacteriological Department of the Ontario Agricultural College, showed that the trouble was due to the improper care of the milking machine, particularly the tubes and cups which were not being properly cleaned and sterilized. The trouble was found to be largely in connection with the disinfectant solution in which the tubes and cups were placed after use. In a number of cases the solution was found to have no disinfectant properties whatever; in fact there were large numbers of living contaminating bacteria present in the solution which resulted in the tubes being worse when taken out than when put in. The milk that was next drawn through these tubes would be very badly contaminated. In some cases it was found that the so-called disinfectants used in preparing the solution were not satisfactory. In other cases it was found that though the disinfectant might have been satisfactory at first, the solution had been used so long that it had lost its disinfectant power. In some cases simply a salt brine was used. This is by no means effective, as it will not kill bacteria and will only prevent their growth when in very high concentration. In other cases a handful or two of hydrated lime had been thrown into the vat. In these samples the bacteria content was very high, as this lime had no disinfectant power. Milking machine tubes and cups placed in this supposed disinfectant solution came out worse contaminated with bacteria than when put in.

In caring for the tubes of a milking machine it is necessary to have a satisfactory disinfectant solution in which to place them between milkings. This is necessary because the interior of the tubes during milking gets coated with a thin film of milk in which bacteria will multiply unless it is removed. It is not so simple a matter to remove this film of milk from the interior of the tubes as it is to remove the film of milk from milk pails or cans in the washing and scalding process to which they are subjected. Hence, after the tubes have had a good washing, as it is not possible to scald them satisfactorily, they must be sterilized some other way. This is done by placing them in a vat containing a suitable disinfectant.

The following method of preparing a disinfectant solution and caring for milking machines is recommended after having been thoroughly tried and proven to be reliable:

Chloride of Lime Solution for Disinfecting Milking Machine Tubes, Teat Cups, Etc.—One lb. chloride of lime (full strength 33 per cent. available chlorine).

Ten lbs. (1 gallon) water; mix in enamel pail, crock or wooden tub.

Allow to stand two to three hours with an occasional stir.

Pour or syphon off the clear supernatant liquid and add sufficient water to make 100 lbs.

Immerse tubes and teat cups in this solution. It will be good for about two weeks in summer and three weeks in winter. As long as there is available chlorine it is effective.

Cleaning and Sterilizing the Milking Machine.—The metal parts of the machine should be thoroughly washed and scalded each time after use. and then be put in a clean place.

The teat-cups and tubing should be fitted on to the machine and well rinsed out before and after use every time.

Warm water should be used for rinsing before milking to remove all traces of the chloride of lime.

Warm water and washing powder should be used first after milking, and then hot water before putting the tubes in the sterilizing solution again.

All teat-cups should be taken apart at least once a week and given a thorough scrubbing with hot water and washing-powder, and the tubing well scrubbed out with the brushes provided. They should then be rinsed in hot water before putting together and returning to the chloride of lime. If this could be done twice a week, so much the better, but it must be done at least once a week if satisfactory results are to be obtained.

8. Bacteria from Hands and Clothes of Milker.—The hands of the milker should be well washed and dried before milking, otherwise gross contamination of the milk from the hands is liable to occur. Clean dustless clothes should be worn during milking. Washable overalls and jackets in case of men and washable dresses or overalls in case of women milkers are strongly recommended.

The foregoing eight sources of contamination of milk are the most common. There are others, as for instance, the water in the cooling tank may be badly contaminated, though this should not be the case. Drops of this water getting slopped over the open tops of the cans of milk would cause contamination of their contents. This is how many cases of ropy milk get established.

How to Prevent Bacteria from Spoiling the Milk.

Even after all reasonable care has been taken to prevent bacterial contamination of the milk as outlined above, some contamination will occur, that is, a few bacteria will have got into the milk in some way or other. If these are allowed to multiply in the milk they will spoil it.

The best way to prevent their rapid multiplication in the milk is to chill it immediately in the cooling tank and keep it cold until used. A small amount of bacterial multiplication will take place, even at refrigeration temperatures, and this will show itself in the condition of the milk in course of time. But milk that has been obtained under clean conditions and has been kept cold should be in excellent condition even after forty-eight hours.

Summary of Milk Contamination Preventive Measures.

Prevent dust, cow hairs, bits of hay, straw, and manure, flies and drops of dirty water from getting into the milk during milking operations as outlined above. Thoroughly clean and sterilize all pails, cans, bottles and other utensils. Cool the milk at once down to refrigeration temperature and keep it cool and covered until used.

Bacteria and the Different Fermentations in Milk.

Lactic Acid Curdling.—The lactic acid fermentation of milk is brought about by the action of the lactic-acid-producing species of bacteria on the milk sugar. As a result of this action lactic acid is produced and this combines with the calcium, leaving the casein free and thus producing the curd.

There are quite a number of lactic-acid-producing species of bacteria. The most common is the one usually referred to as the lactic acid bacillus, known also as *Bacterium lactis acidi* and *Streptococcus lacticus.* This is the species that gives a desirable curd and is used in the culture starters for butter and cheese-making. It is a small oval or round bacterium sometimes occurring in chain formation.

Bulgarian Milk.—Another species is the so-called bulgarian bacillus, or *Bacillus bulgaricus.* This is a large rod bacillus and produces a very high acidity in milk if cultivated properly. It is used to produce the so-called Bulgarian milk which is often recommended for certatin digestive troubles.

Gassy Curd.—Another type of lactic-acid-producing bacteria is represented by the colon bacillus known as *Bacillus coli,* being found in large numbers in the intestines, particularly the colon, of man and warm-blooded animals. This bacillus produces gas as well as acid. *Bacillus lactis aerogenes* is another acid and gas-producing species common in manure. These bacteria that produce gas as well as lactic acid are undesirable types in milk.

Sweet Curdling of Milk.—Sometimes milk will coagulate or curdle with a sweet or soft curd, something like the curd which is produced by the action of rennet. There are several common species of bacteria found on hay, straw, dust, manure, flies and cow hairs, that have the power to produce this soft curd. These bacteria produce an enzyme very similar to rennet that acts directly on the casein and albumen of the milk, causing the so-called sweet curd. Unfortunately, these bacteria produce another kind of enzyme which induces putrefaction of the milk, consequently this type is very undesirable.

Slimy Fermentation—Ropy Milk.—The condition of milk known as ropiness or sliminess is due to the development in the milk of certain species of bacteria that produce gelatinous capsules. The most common of these species in milk is *Bacterium viscosis,* and this is responsible for most of the trouble met with in outbreaks of ropy milk. This bacterium is quite common in water, wells, cisterns, and cooling tanks, particularly in the summer time. Anything on which this water gets splashed will thus get contaminated with the ropy milk bacterium. This bacterium will readily grow in milk at low temperatures, so that milk that is contaminated with it, even if kept cold, will be liable to become ropy. Consequently, care should be taken to prevent contamination of the milk from any of the sources of milk contamination previously referred to, as these may be contaminated with the ropy milk bacterium as well as with other bacteria.

Alcoholic Fermentation of Milk.—The alcoholic fermentation of milk is induced mostly by certain varieties of yeast which have the power to ferment the milk sugar and from it produce alcohol and carbon dioxide. The common varieties of yeast used in breadmaking, beer, wine or cider manufacture cannot ferment milk sugar, and so will not cause an alcoholic fermentation in milk unless some other sugar, as ordinary cane sugar, is first added.

There are a few species of yeast, however, that have the power to ferment milk sugar, and these occasionally get into milk from the air and contaminating substances, with very undesirable results to the milk unless a fermented milk is wanted.

Kephir is a fermented milk drink made by putting the so-called Kephir granules into a sample of milk, corking it up tight and allowing it to stand in a warm place to ferment. The Kephir granules are simply masses of milk-sugar fermenting varieties of yeast mixed together with lactic-acid-producing bacteria. The lactic-acid bacteria give a pleasant acid taste, while the yeast produces a small amount of alcohol, thereby modifying the flavour, and also carbon dioxide gas, that makes the liquid effervescent if the container is well corked. Sometimes the Kephir granules get contaminated with other varieties of bacteria and yeasts to such an extent as to spoil the fermentation and produce bad flavors.

PASTEURIZATION OF MILK.

Pasteurization of milk was first instituted to prevent the spread of tuberculosis by milk. It is now used to prevent also the spread of the other infectious diseases that may be carried by milk, also to improve the keeping qualities of milk.

Milk that has been properly pasteurized will have all the common disease bacteria that might have got into it effectively destroyed. Hence, if the process of pasteurization does not interfere with the natural properties and food value of milk, its practice should reduce the outbreaks of infectious diseases.

Unfortunately there is at present no generally recognized or legal standard of pasteurization. The term "pasteurization" is very loosely applied to the heating of milk to various temperatures for varying lengths of time. As wide a range of temperatures as from 140°F. to 190°F. have been variously recommended, and length of time of exposure to heat varying from a moment to two hours. Consequently, so-called pasteurized milk may have a wide range of food values and safety from disease, dependent upon the method of treatment to which it has been subjected.

Milk that is raised much above 150° F. will have something of a cooked flavor, and some of its desirable enzyme properties destroyed. Consequently, so far as the food value of the milk is concerned, it is not desirable to raise the temperature of milk much above 150° F.

It has been repeatedly shown that milk raised to a temperature of 145° F. for twenty to thirty minutes will have all the disease bacteria in it destroyed, and 98 to 99 per cent. of other bacteria also, and the food value of the milk will not be interfered with, and the flavor will be improved rather than injured. Consequently this method of pasteurizing milk is recommended as giving the best results all round.

Milk for pasteurization should be fresh at the time it is pasteurized. If not, the bacterial action that has already taken place in it will have an injurious action on it. After pasteurization, the milk should be rapidly cooled and kept cold until consumed. It should be preferably pasteurized in the bottles or containers in which it is to be kept until consumed, and should be used within forty-eight hours of pasteurization. The bottles or other containers into which the milk is put before pasteurization should have been well washed and thoroughly sterilized before the milk is put in them. Any departure from any of these conditions of treatment will result in an inferior product.

Unfortunately, those who are responsible for our commercial pasteurized milk supply do not always carry out these conditions; consequently, some of the pasteurized milk on the market is not what it is claimed to be so far as safety and quality are concerned. It is very desirable that a legal standard of milk pasteurization be established and enforced.

Milk and the Spread of Infectious Diseases.—A number of the infectious diseases are liable to be spread by milk. The following are the most common of these: tuberculosis, diphtheria, typhoid fever, diarrhœa, summer complaint, infant cholera, dysentery, scarlet fever and sore throat.

In order for the milk to spread any one of these diseases it must first of all be contaminated either directly or indirectly from a case of the disease.

Milk that is drawn from tubercular cattle is liable to have the bovine variety of the tubercle bacterium present in it that may set up tuberculosis in children, also in calves or hogs that are fed on it. Milk that is contaminated as a result of being handled by a consumptive patient is liable to spread the disease amongst humans. *Bacterium tuberculosis,* however, does not multiply in the milk, so that the number of tubercle bacteria found in milk at any time is no more than the original contamination.

With the other diseases mentioned, however, the bacteria which cause them do multiply in the milk. Therefore, any one suffering from, or having anything to do with patients suffering from diphtheria, typhoid fever, diarrhœa, dysentery, scarlet fever, summer complaint, infant cholera, or sore throat, should not have anything to do with the handling of milk, as they are liable to contaminate it with the bacteria which cause these diseases, and when once a few of the bacteria get into the milk they will multiply therein, thus making it very dangerous to the consumers. A large number of outbreaks of these diseases have been traced to a contaminated milk supply where some one individual suffering from one of these diseases has had something to do with the handling of the milk and thus caused its contamination with the bacteria responsible for the disease.

BACTERIA AND BUTTER.

In the manufacture of butter, bacteria are closely associated with the quality of the product, either for good or bad. The flavor or taste of the butter is due very largely to the bacterial action that takes place mostly in the cream before churning, but also to some extent in the butter after it is made.

From what has been previously said about the numbers and kinds of bacteria found in milk, it will be readily understood that there will necessarily be considerable numbers of bacteria in cream whether it be obtained from the milk either by gravity process or by the separator. The number of bacteria in cream is frequently higher than that of milk, particularly in gravity cream, as the fat globules, of which the cream is composed, on rising to the surface, carry with them from the milk considerable of the bacteria.

It is the action of some species of these bacteria that causes the souring or ripening of the cream so desirable for improving its churning properties and also the flavor of the butter. These are the lactic-acid-producing species of bacteria that change some of the milk sugar to lactic acid, and thus bring about the souring of the milk or cream and also produce most of the delicate flavors and odors characteristic of good butter. Other species of bacteria are liable to be present, however, that will give an undesirable flavor to the butter, making it strong or somewhat rancid, fishy, or turnipy in flavor. These latter conditions are usually due to the milk having been badly contaminated before the cream was separated. Thus it will be seen that if we are to get good-flavored butter, the milk from which the cream is obtained must be clean and as free as possible from bacterial contamination.

Cooling Cream.—Another factor that is liable to exert a considerable influence on the bacterial content of the cream is the temperature at which the cream is kept after it is separated from the milk. It is just as necessary to keep the cream cold after it is separated as it is to keep milk cold. Immediately after separation, therefore, the cream should be cooled down in a cooling tank and kept cold until delivered at the creamery. The low temperature will be unfavorable to the development of most of the bacteria present in the cream, particularly the undesirable kinds, and thus prevent the cream from spoiling.

LACTIC CULTURE STARTERS.

In order to control the ripening process of the cream so as to get a uniform product of butter day after day, many creameries use a *lactic culture* for their cream ripening. This is simply a quantity of milk that has first been pasteurized and then soured by the growth in it of a culture of good lactic-acid-producing bacteria. This lactic culture is obtained first from a lactic culture starter, which is a preparation, sometimes in liquid and sometimes in powder form, which may be obtained from the Bacteriological Laboratory of the Ontario Agricultural College for 25 cents, or from commercial bacteriological laboratories such as Ericcson's, Hansen's or Parke Davis' for 50 cents or 75 cents. These lactic culture starters are simply cultures of good lactic-acid-producing bacteria mixed with various substances, as corn starch, that will keep them in a satisfactory condition for some time. To get a lactic culture for use in cream ripening, one of these starters is mixed into a quart of pasteurized milk and placed at 20°-25° Centigrade until the milk curdles. The curd should have a pleasant acid flavor, and have no gas bubbles and very little, if any, extrusion of whey. This curd, if satisfactory, may be propagated further in a larger quantity of milk, such as will be sufficient to act as a starter for whatever quantity of cream is to be ripened. Before adding the culture of sour milk to the cream a portion of it should be set aside in a clean cool place to use as a starter for the next lot of cream. In this way when once a good culture starter has been obtained it may be carried on by such methods of propagation for months or years with proper care. By this method of ripening cream a more uniform quality of butter is obtained from day to day, particularly if the cream is pasteurized before the culture starter is added.

Washing Butter.—After churning, the butter should be well washed to remove, as much as possible, the film of buttermilk from around the butter granules.

as if this is incorporated in the butter it offers a chance for undesirable species of bacteria to develop and thus bring about bad flavors.

Butter fat after it has been well washed is not a satisfactory food substance for bacteria, hence the bacterial content of butter, though very high when the butter is just made, rapidly diminishes on storage. The bacteria which live longest in the butter, however, are mostly the undesirable kinds.

Bacteria and Cheese.

Bacteria play an important role in the manufacture and ripening of cheese. They may have either a beneficial or an injurious effect on the cheese, according to the kinds of them that predominate in the cheese and the conditions under which it is kept during ripening. Molds and yeasts are also much involved, for better or for worse, in the manufacture of the various kinds of cheese found on the market, certain molds being necessary for the production of certain kinds of cheese, particularly the soft cheeses as the Roquefort and Cammembert types. However, it is not our intention in this bulletin to go into a detailed description of the manufacture of the different kinds of cheese with an account of the different micro-organisms that are used in connection therewith. We shall confine our few remarks largely to the part that bacteria play in the manufacture of Cheddar cheese, which is the kind most commonly manufactured in Canada.

Good Cheese.—To get a good Cheddar cheese it is desirable first of all to have milk that is not contaminated with putrefying or gas-producing bacteria. Hence the milk for cheese manufacture should be produced and handled under clean conditions to prevent undesirable contaminations, such as those described previously in connection with milk and butter.

While the milk should be as free as possible from putrefying and gas-producing bacteria, it should contain large numbers of the lactic acid bacteria. These may be added to it in the shape of a lactic culture such as described for butter.

The lactic acid which these bacteria produce is beneficial to the cheese in several ways. First, it helps the rennet in the necessary coagulation of the milk. Second, it has a favorable action on the packing of the cut pieces of curd in the press. Third, its presence is necessaray to aid the pepsin of the rennet to digest, or render soluble, the otherwise indigestible or insoluble proteids of the cheese in the process of ripening. Fourth, it tends to preserve the cheese from putrefaction, as the putrefying bacteria will not multiply in an acid substance. Fifth, it causes the production of much of the desirable flavor to the ripened cheese.

Bad Cheese.—Floating curd or gassy cheese, bitter-flavored, fruity-flavored, or otherwise bad-flavored cheese, is due in practically every case to the milk from which the cheese is made having been contaminated with various species of bacteria and yeasts in any of the different ways mentioned under milk; that is, from dust, or bits of hay, straw, manure, flies, dirty water, unclean hands or utensils. Consequently, those who supply milk to the cheese factories should take every precaution to prevent such contaminations, and those in charge of the factory should see to it that all cans, vats and other utensils be well cleaned and scalded before use.

If the whey is returned to the milkmen it should first be pasteurized, preferably in the whey tank, by turning in live steam. Many cases of bad cheese have been traced to contamination from the whey drawn from the whey tank without its being heated and taken home in the cans used for hauling the milk. Such a practice so heavily contaminates the cans that it is a difficult matter on most farms to effectively clean and sterilize them before the next lot of milk is put into them.

GROUP VI. BACTERIA OF INFECTIOUS DISEASES OF MAN AND ANIMALS.

The bacterial or infectious diseases of man and animals are the worst diseases that we have to contend with. They are transmissible from one person to another, and so spread through the community unless proper steps are taken to control them. Each of these diseases is caused by a different species of bacteria or other micro-organism. When these disease-producing bacteria gain entrance to the system they have the power to grow and multiply there, feeding on the body juices, and the result of this growth and multiplication is the particular kind of sickness characteristic of each different disease.

Typhoid fever, dysentery, tuberculosis, leprosy, diphtheria, smallpox, scarlet fever, mumps, typhus fever, infantile paralysis, epidemic-cerebro-spinal-meningitis, gonorrhœa, syphilis, influenza, cholera, and plague, are some of the most dangerous of these diseases which attack man. Hog cholera, anthrax, blackleg, tuberculosis, infectious abortion, foot-and-mouth disease, glanders, pleuro-pneumonia, chicken cholera, white diarrhœa of chicks, and blackhead of turkeys, are some of the most dangerous of the infectious diseases affecting animals and birds.

Typhoid Fever.

Typhoid fever is an infectious disease affecting man only. It is caused by *Bacillus typhosus* gaining entrance to the intestines usually through contaminated foods or water. On getting established in the intestines the bacillus rapidly multiplies, penetrates the intestinal walls and so gets established in the lymph glands and blood, by which time the fever will be at its height. Millions of the bacilli are produced in the body and many of them are given off in the body discharges, both urine and fæces. It is these discharges which are responsible for the disease being spread as an epidemic. Consequently, the patient should be isolated, and the greatest care is necessary in attending to a typhoid patient to see that all bodily discharges are disinfected immediately, preferably before they leave the sick-room. This may be done by adding a five per cent. solution of carbolic acid in equal quantity to the discharge, well mixing, and allowing to stand for several hours before disposal. In place of carbolic acid a one per cent. solution of chloride of lime (bleaching powder, 25-33 per cent. available chlorine) may be used in the same way. Soiled linen and utensils should be well sterilized by boiling. The attendant should be most particular to wash hands in a satisfactory disinfectant before leaving the sick quarters. The attendant should not prepare foods for other people.

Persons exposed to typhoid fever should be vaccinated with anti-typhoid vaccine. This vaccination requires two treatments. The vaccine is injected into the muscle tissue of the arm or breast with a hypodermic syringe. The vaccine is composed of a culture of typhoid bacilli that have been killed. On being injected into the body a resistance to typhoid is produced. The first treatment is with a dilute vaccine which prepares the body to take the second treatment with a stronger vaccine. The second treatment is given about ten days after the first.

Two other forms of typhoid fever are recognized and these are known as paratyphoid A and paratyphoid B. These are caused by different species of bacilli which are closely related to the *Bacillus typhosus.* Paratyphoid A is common in India and paratyphoid B common in Germany. The antityphoid vaccine prepared from cultures of *Bacillus typhosus* will not protect against paratyphoid. Either a separate vaccine or a mixed vaccine of the different species of bacilli has to be used.

Dysentery.

Bacillary dysentery is caused by the dysentery bacilli, and amœbic dysentery is caused by the dysentery amœba. This is an intestinal disease resulting in acute diarrhœa, pain and weakness, varying in acuteness, and sometimes fatal. It is spread in much the same way as typhoid fever, by contaminated foods and water. The bowel discharges of patients contain large numbers of the causal organism, and so the same care regarding their disposal as described for typhoid fever should be practised.

Infantile Diarrhœa is a very similar disease, and is contracted by bottle-fed infants usually through contaminated milk. This trouble may be guarded against by proper pasteurization of the milk. Unfortunately, commercially pasteurized milk cannot always be depended upon as being satisfactory. Therefore, we strongly recommend that milk for infant feeding be pasteurized in the home daily. The milk to be pasteurized should be fresh. The bottle or can containing it should be thoroughly cleaned and scalded before milk is put into it. The bottle or can of milk should be stood in a pot of cold water, and a clean thermometer placed directly into the milk. The pot should then be placed on the stove, and the temperature of the milk raised to 145° F. This temperature should be maintained for twenty minutes by regulating the application of heat. The temperature of the milk should not be allowed to go over 150° F., and should be kept as near as possible to 145° F. for the twenty minutes. The milk should then be removed and chilled immediately by being stood in cold running water or ice water and kept cold until used. It should be used within twenty-four hours.

Tuberculosis.

Tuberculosis is a slowly-developing disease affecting man, animals and birds. It is caused by *Bacterium tuberculosis* gaining entrance to the body and multiplying in various of the body tissues where it produces the tubercles characteristic of the disease.

Bacterium tuberculosis is a very small microscopic organism, appearing under the high-power microscope as a thin rod, straight or slightly bent, sometimes granular. It varies in length, usually from two to five microns, i.e., from 1/12,000 to 1/5,000 of an inch, and is about 0.3 microns, or 1/17,500 of an inch in thickness. It is present usually in large numbers in tubercular tissues, and can readily be demonstrated by means of proper bacteriological technique.

There are three recognized varieties of *Bacterium tuberculosis*: (1) *Human,* which causes tuberculosis in man; (2) *Bovine,* which causes tuberculosis in cattle, swine and, sometimes, man; (3) *Avian,* which causes tuberculosis in birds, but which has not been proven to be a common cause of tuberculosis in man or the domestic animals.

Formation of Tubercules.—When *Bacterium tuberculosis* gains entrance to the body tissue it feeds on the body juices surrounding it and multiplies sometimes slowly and sometimes rapidly. While so developing, it produces a toxin or poison which acts on the tissue cells surrounding it, thus causing a local disturbance, finally resulting in degeneration and death of the tissue cells affected. A mass of such cells constitutes a tubercle. From such a tubercle the bacteria pass in the blood or lymph stream to other parts of the body and produce more tubercles.

A tubercle is thus a mass of degenerated or dead tissue cells caused by the development of *Bacterium tuberculosis* within the tissue, and as the tubercles enlarge and multiply, following the multiplication of the bacteria, the organ affected is slowly destroyed.

The tubercles thus formed are usually pale yellow in color, sometimes cheesy, sometimes fibrinous, sometimes gritty, and sometimes pus-like in texture. They may occur in any of the body tissues, being commonly found in the lungs, liver, spleen, glands, intestines and bones.

Distribution.—Tuberculosis exists in all civilized countries. In the human race about 15 per cent. of all deaths are due to this disease. It is widely prevalent among cattle and hogs, conservative estimates placing the number at 10 per cent. to 15 per cent. It is increasing in extent in cattle, hogs, and fowls.

Dissemination.

I. Human to Human:

1. Respiration—Dried sputum from a patient. Discharges from the lungs should be received into cloths or paper cups and immediately burned, or into metal or glass cups and disinfected by submerging cups and contents in boiling water, or by chemical disinfectants.
2. Ingestion—Food prepared by a tubercular patient, contaminated by sputum, urine and fæces. Milk handled by a tubercular patient. Drinking cups, table utensils, etc., used by both tubercular and healthy persons.
3. Ante-natal—This occurs rarely.

II. Bovine to Human:

A. By Ingestion.

1. Meat—Infection in this way rarely occurs, unless the meat is consumed raw.
2. Milk—Bovine tuberculosis is transmissible to children or to invalids. It is believed that ten per cent. of deaths from tuberculosis in children are due to bacilli of bovine origin. The germs gain entrance to the milk from the udder of the diseased cow, or through milk contaminated with fæces from cases of intestinal tuberculosis in cows.

B. By wounds, e.g., in post-mortem examinations.

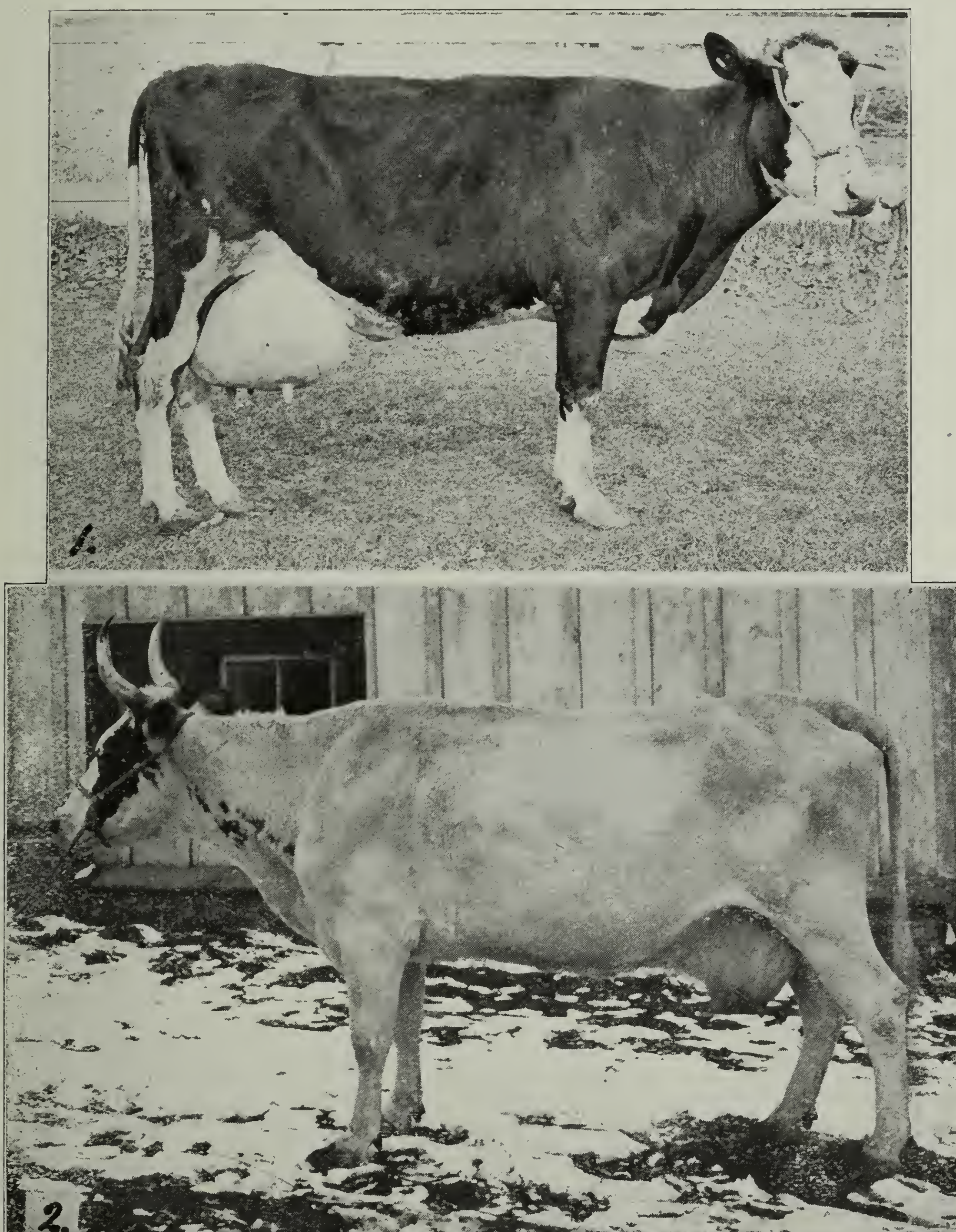
III. Bovine to Bovine.

A. In the Herd.

1. By respiration in infected stables.
2. By ingestion from contaminated mangers, feeding boxes, watering utensils, etc.
3. To calves by feeding infected milk.
4. Ante-natal—This occurs rarely.

B. From Herd to Herd.

1. By transfer of infected animals. Importations, Dispersion Sales.
2. To calves by feeding unpasteurized skim-milk or whey from creameries or cheese-factories.

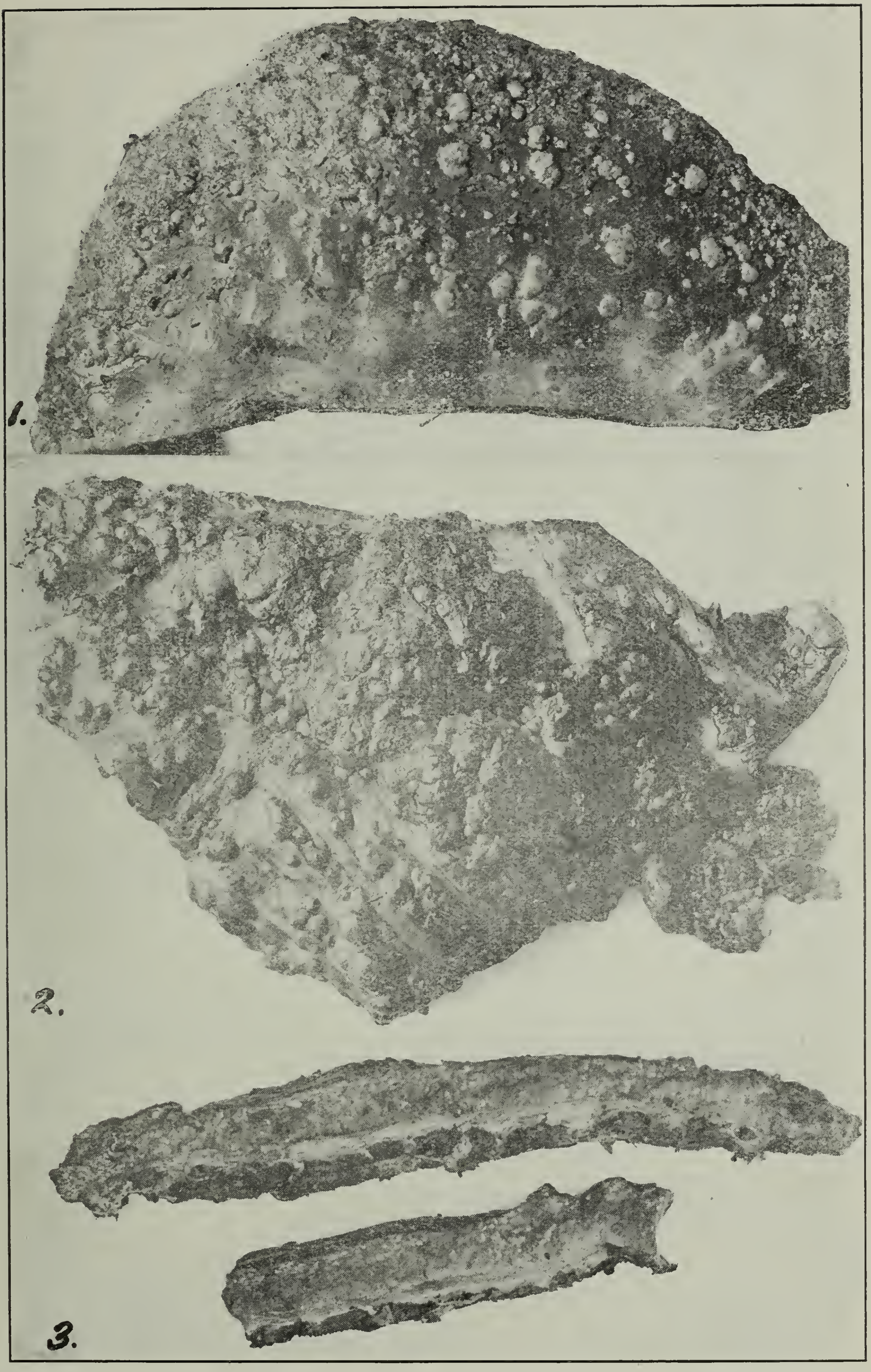


Tubercular Cattle. (photo by Edwards.)

1. Holstein, reacted to test. Post mortem examination showed intestines and udder badly tubercular.
2. Ayrshire in advanced stages of tuberculosis, very thin, skin hard. Post mortem examination showed generalized tuberculosis.

Tubercular Cows. (Photo by Edwards.)

1. Ayrshire cow, did not show noticeable external symptoms of tuberculosis, but reacted to the tuberculin test 5 degrees, and was found after slaughter to have tuberculosis fairly well advanced; lungs badly affected.
2. Grade Shorthorn showed no external symptoms of tuberculosis, reacted to tuberculin test 1 degree. Post mortem examination showed tuberculosis of the lungs, intestines and mediastinal glands.



Tubercular Specimens taken from a Holstein Cow suffering from generalized tuberculosis in an advanced degree. (photo by Edwards.)

1. Portion of the liver covered with tubercles.
2. Portion of the diaphragm covered with tubercles.
3. Sections of stomach wall showing a thick layer of tubercles completely covering the outside of the stomach.

IV. Bovine to Hogs:

1. Feeding infected milk direct from tubercular cows.
2. Feeding unpasteurized factory by-products, skim-milk or whey. Dairymen and packers state that tuberculosis is much more prevalent among hogs in dairy districts than in beef districts.
3. "Following" of cattle by hogs.
4. Feeding offal from abbatoirs.

MANAGEMENT AND ERADICATION IN CATTLE.

Detection of the Disease:

1. By Clinical Symptoms—Not to be depended upon. Cattle may be badly diseased and still appear in good condition.
2. By Post-Mortem Appearance—Detection by this method comes too late. The presence of tuberculosis in the herd should be recognized before it has made such inroads as to cause the death of even one animal. Post-mortem examination should, however, always be made to determine the seriousness of the infection.
3. By the Tuberculin Test—The subcutaneous injection of tuberculin (a product of the growth of Bacterium tuberculosis), causes a rise in temperature in tubercular animals, but has no effect in healthy animals. Tuberculin contains no living germs of tuberculosis, hence cannot cause a case of the disease. The tuberculin test is accurate and reliable. The data from 400,000 tests showed it was accurate in 98.8 per cent. of cases.

TUBERCULIN TEST CHART.

Temperature before injection.	Temperature after injection. Injection at 10 p.m.								Before and after injec. Maximum.	
4 p.m.	6 p.m.	9 p.m.	6 a.m.	8 a.m.	10 a.m.	12 n.	2 p.m.	4 p.m.	Before.	After.
100.2	101.1	101.8	100.1	100.4	100.4	100.3	100.6	100.8	101.8	100.8
101.1	101.0	101.1	100.8	103.5	104.0	104.0	103.6	102.8	101.1	*104.0
101.9	101.7	102.1	102.5	104.5	106.1	106.3	104.4	102.1	102.1	*106.3
102.3	101.9	102.6	103.4	104.9	105.9	105.5	103.2	102.8	102.6	*105.9

*Tubercular.

ERADICATION.

Essential Points:

1. Detection of diseased animals by applying the tuberculin test.
2. Separation of the healthy from the tubercular stock, and prevention of carrying infection on clothing, shoes or in any other ways.
3. Feeding of calves with milk from healthy cows only, or own dam's milk after pasteurization at 185° F. for a minute. Keeping calves entirely separated from the tubercular stock.
4. Cows in advanced stages are best slaughtered. Valuable animals reacting to the test may be kept for breeding purposes. Others may be fattened and sold for meat if slaughtered under competent inspection.

Prevention:

1. Keep tuberculosis out of the herd by buying new animals subject to the tuberculin test; or by keeping newly-purchased animals in quarantine for three months and testing them before they are placed in the herd.
2. Do not feed unpasteurized factory by-products, as skim-milk or whey, to calves or hogs.
3. Test the healthy herd at least once a year (twice is better) to detect cases possibly creeping in.

Tuberculin for testing cattle is supplied free of charge by the Dominion Department of Agriculture. A veterinary surgeon must be employed to make the test and through him the tuberculin is obtained.

Tuberculosis of Poultry.

SYMPTOMS OF THE DISEASE

(A) *Antemortem Symptoms.*

In live fowl it is difficult to detect the diseases in its early stages. As the disease advances, however, the following symptoms are liable to develop:

1. Emaciation.—Notwithstanding the fact that the affected bird's appetite keeps good, and it continues to eat as much or more than the healthy fowl, it will frequently get thin, until eventually it becomes little more than skin and bone. The breast and legs lose all their flesh, and on picking up the bird it will be found to be very light in weight.

This symptom, however, does not always occur; some birds even in advanced stages of the disease will remain fat. Such birds will be very mopy and inactive.

2. Paleness.—The unfeathered parts of the head, around the eyes and mouth, the comb and wattles, become pale and dull and though the eyes usually remain bright and clear, they lack life and fire and are often closed. The feathers become dry and lack lustre of health.

3. Listlessness.—Affected birds gradually lose their vigor and become listless and inactive, being inclined to mope around and lie down when not feeding.

4. Lameness.—When tubercles develop in the bones and joints, lameness occurs.

5. Egg Laying is frequently reduced to a minimum.

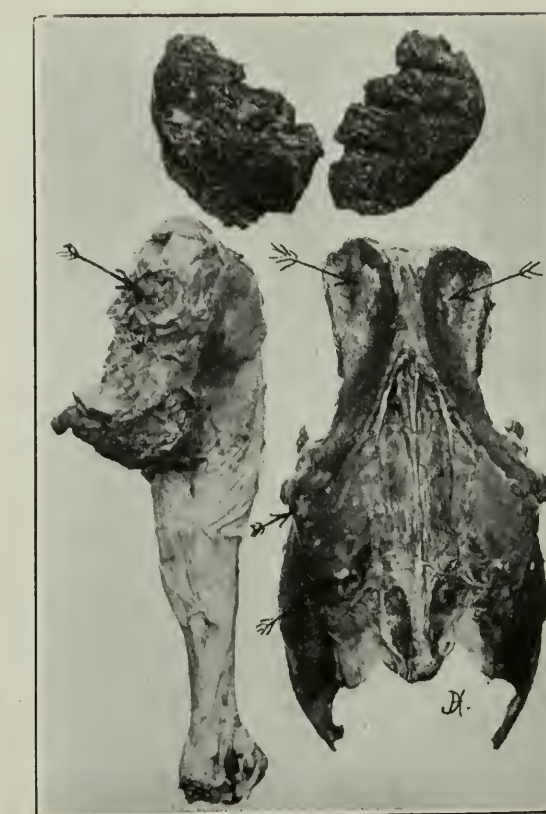
(B) *Postmortem Symptoms.*

Though it may be difficult to determine with certainty whether or not the disease is present in the live bird, it is comparatively easy to determine the presence of the disease in birds suffering from it which have died, or have been killed for examination.

The presence of tubercles in the liver, spleen, intestines or other parts, is indicative of the disease. But as there are other diseases which may cause conditions in the liver, lungs and intestines closely simulating tuberculosis, it is usually

1.

2.



3.

1. Adult hen in advanced stages of tuberculosis, showing extreme emaciation due to the disease. The owner of the bird who sent it for examination stated that it had continued to eat heartily, but had not been laying for some time. The crop was full of grain. Other members of the flock were affected with the disease in all stages, and many died during the previous eighteen months. (Original.)
2. Liver, spleen and intestines of hen badly affected with tuberculosis, showing many small, as well as large, tubercles. (Original.)
3. Tubercular lungs and bones from a hen. (Original.)

necessary, if we are to be certain whether tuberculosis is present or not, to make a bacteriological examination of the affected parts. This examination can be made only by the bacteriologist who has the necessary apparatus. We are prepared at the Bacteriological Laboratory of the Ontario Agricultural College to examine, free of charge, and report upon any suspected cases which are sent in for examination.

Tubercles in the Liver.—The liver is the most commonly affected organ in cases of fowl tuberculosis. The tubercles are readily seen as pale yellow spots or lumps, varying in size, scattered over the surface, and sometimes projecting from the surface, and when the liver is cut open they will be found present throughout the whole mass of the liver tissue.

The tubercular liver is usually softer and more easily torn than the healthy liver, and the tubercles, as little lumps, are easily broken away from the surrounding tissue.

Sometimes an enlargement of the liver accompanies the disease. We have found tubercular livers that were five or six times larger than normal. Such livers were one dense mass of tubercles. In such a case, practically the whole liver tissue was dead, and the enlargement was due to an attempt of the liver to get the better of the disease.

Tubercles in the Spleen.—The spleen is the little purplish red organ situated just under the liver. When the liver is tubercular, the spleen is usually also affected. As in the liver, the tubercles can be easily seen as white or pale yellow lumps varying in size and usually sticking out from the surface, thus making the spleen irregular in shape and frequently enlarged.

Tubercles in the Intestines.—The intestines are the next most commonly affected organ in cases of fowl tuberculosis. Here the tubercles are found within or on the intestinal walls as hard lumps ranging in size from a pea to a chestnut. Their presence here is liable to cause considerable constriction leading to partial stoppage of the bowels. The droppings from a bird so affected are heavily infested with the tubercle bacteria, and readily spread the disease among the flock.

Tubercles in the Lungs.—While tubercular affection of the lungs is common in human tuberculosis, it is not so frequently present in avian tuberculosis. However, the lungs of birds are sometimes affected with tuberculosis, and, as in the case of the liver and spleen, the tubercles are found in the lung tissue as little hard, pale yellow lumps which interfere with the action of the lungs, and gradually destroy the lung tissue.

Similar looking lumps are produced in the lungs of little chicks, often resulting fatally, in the disease known as Aspergillosis, which is caused by the fungus *Aspergillus fumigatus.* The spores of this fungus are ocassionally present on grain and other chicken food. When these microscopic spores get into the chick's lungs they germinate, and the fungus develops, producing tubercle-like lumps, which cannot be distinguished from genuine tubercles except by microscopic examination.

Tubercles in the Bones.—Tubercles are liable to be present in any of the bones of the body of infected birds. They are most commonly found in the leg bones, particularly at the joints. They will appear as pale yellow irregular swellings of the bone. Their presence at the joints causes inflammation, soreness, softening and decay, with accompanying difficulty of movement.

Tubercles in the Ovaries.—Occasionally tubercles are found in the ovaries. In such cases there is danger of the eggs being infected with the tubercle bacteria. Chicks hatched from such eggs are liable to have the disease develop at an early date.

Dissemination of the Disease.

Tuberculosis usually enters a flock through the introduction of a bird suffering from the disease. A bird, as previously described, may be quite seriously affected without showing any marked external symptoms. Such a bird will readily spread the disease through the flock by its contaminated droppings.

The disease is widespread in Ontario. We have received for examination numerous tubercular fowl from twenty-nine different counties in the province during the last five years.

Control and Eradication of the Disease.

Care should be taken in buying new stock that birds are obtained only from flocks known to be free of the disease.

When once the disease gets established in a flock it is difficult to eradicate except by the most drastic measures. The quickest and most effective method is to kill off all the birds that have run with those proven to have the disease and to disinfect the entire premises as thoroughly as possible.

New stock should be obtained from healthy sources, but should not be placed on the runs which had been used by the diseased flock for a year or more. The houses, providing they have been thoroughly disinfected, may of course be used.

The first thing to do in putting the poultry premises in sanitary condition, is to scrape the roosts, walls, ceilings, floors and nest boxes of the houses thoroughly clean with a hoe or other convenient implement. Accumulated manure may be mixed with lime, spread on the land and ploughed under. Loose litter, pieces of boards or other valueless material should be completely burned. When this has been done, the entire inside of the house may be washed down with some good disinfectant such as carbolic acid, one part in twenty of water, zenoleum, lysol, chloronaphtholeum, or other disinfectants, in the strengths indicated by the manufacturers. Any of these may be put on with a spray pump. In place of these, quicklime in the form of whitewash may be used, prepared as follows: Slake the quicklime by adding water in the proportion of one and one-half pints of water to each quart of lime, or by weight, sixty parts of water to one hundred parts of lime. The resulting dry powder is hydrate of lime. For use mix one quart of this with four quarts of water. This must be freshly prepared in small lots and used immediately. It is best applied by means of a spray pump, although it may be put on with a brush or broom. If a spray pump is used, the slaked lime should be put through a fine sieve or strainer in order to prevent clogging of the nozzle. It is important that every crack and crevice and every particle of surface be covered with the disinfectant. After disinfection, clean boards may be placed beneath the roosts to catch the droppings, thus facilitating the work of future cleaning. Slaked lime placed on these boards will absorb the moisture from the droppings besides adding to their fertilizing value. Disinfection of the houses should be carried out at intervals as long as any diseased birds remain in the flock.

To disinfect the runs is a difficult matter, because it is impossible to have the disinfectant come into contact with each minute particle of soil. The best that can be done is to completely cover the ground with freshly-slaked lime and plough under. Sow some quick-growing crop for green manure, lime and plough under again. By this method the soil can eventually be well disinfected. The fact must be kept in mind, however, that any tubercular fowls may be continually reinfecting the soil by voiding the tubercle bacilli with their droppings; consequently, it would be impossible to keep the soil free from infection so long as diseased fowls were kept on that ground.

Detailed information on Tuberculosis is contained in the "Report of the International Commission on the Control of Bovine Tuberculosis." Address the Veterinary Director-General, Department of Agriculture, Ottawa.

Diphtheria.

Diphtheria is a highly fatal infectious human disease, common in many countries. It is caused by *Bacillus diphtheriae* also known as the *Kloebs-Loeffler bacillus,* from the names of the men who first identified it as the cause. The disease is usually an affection of the throat, where the bacillus finds lodgement either through the mouth or nose. As the bacillus multiplies on the mucous lining of the throat, it produces a very strong toxin or poison that is absorbed into the system. In addition to this toxin, a false membrane is produced in the throat consisting of fibrinous exudate, bacilli and dead cellular tissue, the presence of which causes partial suffocation. The toxin, however, is the worst feature of the disease, and it is this which is responsible for the high mortality.

The bacillus is given off in large numbers during expectoration, coughing, sneezing and talking of patients suffering from the disease. Hence the necessity of strict isolation of all diphtheria cases.

To combat the effect of the toxin, subcutaneous injections of diphtheria antitoxic serum are made. These injections should be made as soon as possible after the disease is determined, or even suspected, by a medical man. This antitoxic serum neutralizes the toxin produced in the body by the diphtheria bacilli, providing too large a quantity has not been produced before the injection.

Diphtheria Carriers.—Patients who recover from the disease will sometimes have the bacilli present in their throat, mouth and nose for weeks or months unless every care is given to thoroughly disinfect these parts. Such individuals are known as diphtheria carriers, and are a source of danger to the community in which they mix, as they are liable to spread the disease. Some people are immune to the disease and will not contract it though exposed to infection. These people may have the diphtheria bacillus present in their nose, mouth and throat without suspecting it, and so spread the disease to others who are not immune. These also are known as diphtheria carriers and are more dangerous than recovered patients, as they are not suspected of having the bacilli.

As the diphtheria bacillus will grow and multiply in milk, the disease is readily spread through this medium should it get contaminated with the diphtheria bacillus. Hence the greatest care should be taken that diphtheria carriers, *i.e.,* persons suffering from or recently recovered from diphtheria, or persons coming in contact with cases of diphtheria, should not have anything to do with the handling of milk or other foods.

Small-pox.

The micro-organism responsible for small-pox has never yet been satisfactorily demonstrated. As the virus can pass through the pores of a porcelain filter, it is considered as a filterable or ultramicroscopic virus, the organism being too small to be observed even with the highest magnifying microscope.

Formerly this disease was much more prevalent than it is to-day. The decrease in its occurrence is due to the general practise of small-pox vaccination. The vaccine used in this connection is a mild form of the virus (cow-pox) which is produced with the greatest care to prevent any contamination or injurious effect following its use. Formerly, when sufficient care was not practised in the preparation of the vaccine, there were occasional bad results following its use, due to contamination of the vaccine with other disease-producing micro-organisms.

It is generally known that a person who has had small-pox once and recovered will not, as a rule, take the disease again. Vaccination has the same effect in this particular as an attack of the disease. As the disease is very contagious, the strictest isolation of patients is necessary to prevent the disease spreading.

Epidemic Cerebro-Spinal Meningitis.

Meningitis, that is inflammation of the meninges or membrane that covers the brain and spinal cord, may be induced by a variety of different micro-organisms. such as the pneumococcus, influenza bacillus and the tubercle bacillus, but the so-called *epidemic-cerebro spinal meningitis* is caused by one species of bacteria known as the *Meningococcus* or *Micrococcus meningitidis*.

The meningococcus gains entrance to the body usually at the nose or mouth and from thence gets established at the base of the brain and in the cord where it causes a violent inflammation, frequently fatal. Children and young adults are most frequently affected. Above the age of thirty-five few cases occur.

The meningococcus quickly dies on drying out and so it is considered that the disease is spread mostly by direct contact with individuals suffering from the disease, or carriers, and from particles of sputum, nasal discharges, handkerchiefs, etc., contaminated by such. Hence the necessity for the isolation of sufferers from this disease and careful disinfecting of nasal and mouth discharges and articles contaminated by such.

An antimenigococcal serum is used curatively. This is injected directly into the spinal canal by lumbar puncture.

Influenza.

The disease known as influenza can be traced back to the fifteenth century. At times a few cases occur here and there, but occasionally a great epidemic will spread over the entire civilized world. The last great epidemic reached Russia from the East in the fall of 1889, and gradually spread over Europe and to America, causing much suffering and many deaths. Since then we have had more or less of it, especially during the winter months.

Bacillus influenzae is one of the smallest bacilli that cause disease, except the ultramicroscopic viruses. It enters the body through mouth and nose, develops on the mucous surfaces, thence finding its way to the lungs where it is liable to cause a form of pneumonia. The bacilli will not grow readily outside the human body. The bacilli are present in large numbers in the secretions of the throat, nose and mouth of patients, and it is through these secretions that the disease is spread from person to person.

No serum or vaccine treatment has so far been successful in combating the disease.

Epidemic Infantile Paralysis.

This is an infectious disease affecting mostly young children, 1-2 years old, but older children and even adults are occasionally affected. The chief symptoms of the disease are fever with or without a sore throat, followed in a few days by paralysis. There is usually permanent injury to parts of the nervous system resulting in deformity of the body.

Until recently very little was known regarding the specific cause of the disease. Within the last five years, however, researches conducted during outbreaks in the United States have added to our knowledge of the cause and methods by which the disease is spread.

The micro-organism which causes the disease is very minute, being one of the filterable viruses, but in one stage at least of its life history it can be rendered visible with the high-power microscope.

It is considered that the micro-organism gains entrance to the body through the nose and throat, finally locating in the nervous system, particularly in the brain and spinal cord. The micro-organism is not readily killed by drying, and so it is considered that the disease is spread by inhalation of contaminated dust as well as by fresh material from nose and throat of the patients.

Typhus Fever.

Typhus fever is a highly contagious disease, formely known as "jail fever," "camp fever," and "hospital fever." It used to be common where people were being crowded together in unclean conditions. It has recently been conclusively demonstrated that the disease is most commonly spread by the body louse and head louse. Thanks to modern hygienic conditions, the disease has been practically banished from civilized communities.

The typhus fever bacillus is a small anærobic bacillus, *i.e.*, it will not grow in the presence of air. When it gains entrance to the body through the sucking tube of an infected louse, it multiplies in the blood and produces a high fever and characteristic rash with a high mortality. During the epidemic which raged in Serbia in 1915, it is estimated that 135,000 persons perished of the infection.

Mumps.

Mumps is a contagious disease, the exact cause of which has not yet been satisfactorily determined. A diplococcus has been isolated from the glands of affected individuals in a number of cases, the inoculation of which into the glandular system of a dog resulted in swelling of the parotid gland and fever.

The disease does not produce high mortality. It is an affection of the glandular system which causes enlargements of the glands accompanied by fever and a general low condition. Isolation of patients should be insisted upon.

Scarlet Fever.

Scarlet fever is an acute highly infectious disease, the specific cause of which is not yet known. It produces a high fever, with skin eruption and desquamation and gangrenous inflammation of the throat, with a fairly high mortality.

It is readily spread by contaminated milk, a number of epidemics having been traced to such a source. Consequently, patients or those having the care of patients should not have anything to do with the handling of milk for the public supply. Strict isolation of patients until complete recovery should be insisted upon, followed by thorough disinfection of the isolation chamber.

Measles.

Measles is a highly contagious disease, producing fever and skin desquamation with other complications. The cause is a filterable virus or micro-organism too small to be visible with the high-power microscope. The virus is present in the blood and in the secretions of nose, mouth and throat of patients. Children are more commonly affected than adults. The mortality from this disease is not high, but it frequently causes complications and opens the way for other diseases.

Gonorrhœa.

Gonorrhœa is a contagious venereal disease widely disseminated, caused by *Microroccus gonorrhœa.* A purulent inflammation is established at point of infection which becomes chronic. The disease slowly spreads to other parts of the body, particularly to the joints where it affects the synovial membranes, causing gonorrheal rheumatism, and to the valves of the heart where it causes endocarditis. It is estimated that 10 per cent. of all cases of blindness are due to this disease, and that in the United States there are at least 12,000 children blind from this cause, through gonorrhœal ophthalmia following infection of the eyes at birth. The disease is spread mostly by sexual intercourse, but also through careless use of towels, wash-cloths and bath tubs, particularly in institutions and public baths.

Syphilis.

Syphilis is a dread contagious and hereditary venereal disease, caused by a spiral-shaped micro-organism known as *Treponema-pallidum.* On gaining entrance to the body tissue this micro-organism begins to multiply and to produce a toxin, which, acting locally, produces a chancre. This is the first stage of the disease. In a few weeks after the production of the chancre at the point of infection, the whole system becomes invaded with the virus, leading to grave and general constitutional disturbances very complex in character. Every tissue in the body is liable to be affected with tumor formation, ulcers, granulation, wasting away and death.

Syphilis is one of the very few diseases that are congenital. It is handed down from parent, either father or mother, to the child with dire results, and as a consequence there is more human misery from this disease than from any other.

Asiatic Cholera.

The home of Asiatic cholera, as the name implies, is in Asiatic countries, particularly India. Here in certain districts it is more or less always present, and from thence it is liable to spread by the trade routes, both land and sea, to other countries, thus causing epidemics of cholera wherever it gets established. During the nineteenth century several widespread epidemics occurred in Europe and America, causing many fatalities. During an outbreak in Germany in 1892, there were 17,000 cases with 8,600 deaths all in a few weeks.

The disease is caused by the cholera spirillum or *Cholera Vibrio,* a small spiral bacterium which enters the system through the mouth with contaminated food or water and becomes established in the intestines, where it multiplies and thus induces the disease. It causes acute diarrhœa, vomiting, great exhaustion, acute thirst, weakness of the heart, cramps and other symptoms, leading to death. The causal organism is passed out in great numbers in the dejecta of the patients, this being the main cause of the disease spreading through a community. The spirilla live in water or contaminated food for a long time, and thus may be transferred long distances.

Owing to the strict quarantine regulations that have been established at the ports of landing in most civilized countries, the disease is now prevented from spreading, as was formerly common.

Bubonic Plague.

Bubonic plague is another acute infectious disease common in Eastern countries, which runs a rapid, severe course, often ending fatally. It is characterized by high fever, hemorrhages, pustules or Buboes, extreme weakness and exhaustion.

It is caused by a small bacillus known as *Bacillus pestis* or the *Plague bacillus.* This bacillus gains entrance to the body mostly through the skin by wounds, scratches, insect bites, etc. On gaining entrance to the body it multiplies and spreads to other parts by means of the lymph and circulatory systems. Rats, fleas, flies, bugs and lice are all active agents of dissemination in connection with this disease.

Strict quarantine regulations at ports of entry are largely responsible for preventing this disease from entering other countries than those where it is common.

Leprosy.

Leprosy is a dread contagious disease endemic in India, Japan and other Asiatic countries. A limited number of cases occur on the North American continent and in northern European countries. Its cause is *Bacillus leprae,* an organism very like *Bacillus tuberculosis* in many ways. The bacillus is not known to develop naturally outside the human body. The disease is most commonly spread from individual to individual by direct contact of person or clothes. An interesting case was recently reported from New York, where a young lady developed the disease on head and face through wearing a coil of false hair. This hair was traced to a shipment that arrived from the East, some specimens of which had been obtained from a district in which leprosy was common.

The bacillus, when growing in the body tissue, produces a poison which causes a rot to develop, giving terrible distortion and mutilation, finally ending in death.

Persons suffering from the disease are segregated. No cure for the disease is known at present.

Anthrax.

Anthrax is a highly contagious, usually fatal disease, affecting primarily herbivorous animals as cattle, sheep, horses and goats, but also affecting man, swine, cats and dogs. The two latter, however, are only slightly susceptible.

The disease is one of the oldest known. Many references to it are found in ancient writings. It exists in all countries and latitudes, being most prevalent in Europe, China, Siberia, South Africa and South America, where it causes heavy losses to live stock owners.

The cause of the disease is *Bacillus anthracis,* a comparatively large, rod-shaped micro-organism, which gains entrance to the body either through wounds or by ingestion with contaminated food or water, or by inhalation from the air. With cattle, sheep and horses, ingestion with food and water is the more common means whereby the disease becomes established.

On gaining entrance to the body the bacillus rapidly multiplies and spreads throughout the system by means of the blood. In one or two days every blood vessel in the body will be crowded with the bacilli. As a result of this the animal appears to be suddenly seized with trembling and swaying motions, has a haggard expression, colicy pains, difficult breathing, dark bloody discharges from nose and rectum, followed by convulsions and death. Death occurs in from one to five days after symptoms are first noticed; sheep, one day; cattle, two to five days; horses, one to five days. The blood will not coagulate like ordinary blood, but is thick, dark and tarlike, and every drop of it in the animal's body will contain many of the bacilli; consequently the bloody discharges are highly infectious and should be carefully disinfected or burned. After death the bacilli will still be present in the blood in immense numbers; consequently the carcase should *not be skinned or cut open,* or the bacilli will be scattered around.

When anthrax is suspected, a veterinary surgeon should be called in and he should send a bit of the ear or a smear of blood on a piece of paper, carefully wrapped up and enclosed in a bottle or box, to the Veterinary Director-General at Ottawa, who will have an analysis of the blood made to determine whether or not anthrax is present. The carcase should be either burned or buried deeply in quicklime and a thorough disinfection of the premises carried out.

The *anthrax bacilli* are very resistant spore formers, but the spores are produced only in the presence of air. This is another reason why the carcase should not be skinned or cut up, as the millions of the bacilli in the blood of the body will be destroyed by the ordinary process of putrefaction after the carcase is buried, if they are not allowed to get to the air. If they get exposed to the air they will produce spores and it is mainly by these spores that the disease is spread. The spores will remain dormant for years in the soil on pastures or on fodder, or on the surface of anything, where they are deposited, but will immediately become active on gaining entrance to the body of an animal. Pasture fields once contaminated are liable to cause the disease whenever cattle are turned into them.

Anthrax in man is known as wool sorters' disease and malignant pustule. It is contracted by people handling wool and hides that have been removed from infected animals. Such wool and hides are liable to have large numbers of the anthrax bacterial spores on them, which set up the disease on gaining entrance to the body either through wounds, breathing or ingestion.

Contaminated drainage water from tanneries, after entering streams and flowing through pasture fields is a frequent cause of outbreaks of anthrax.

Prevention—Vaccination.—There is no cure for anthrax when once it gets established in an animal, but other members of the herd or flock may be vaccinated with anthrax vaccine to prevent their taking the disease. This vaccine is active in the body for about one year.

Anthrax vaccine may be obtained from the Veterinary Director-General at Ottawa at a cost of five cents per dose, and the outfit for administering the vaccine at a cost of fifty cents. Full directions are sent with the material.

The vaccine is administered in two treatments, the second treatment being given ten to twelve days after the first, and the animal will be immune to the disease twelve days after the second treatment.

Any case of anthrax should be reported to the Veterinary Director-General or to a Government inspector.

Symptomatic Anthrax, Also Known as "Black Leg" and "Quarter Evil."

This is a disease of cattle widely spread in Europe, America and Africa. It is caused by an anaerobic bacillus known as *Bacillus anthracis symptomatici* or *Bacillus chauvei,* fairly common in the soil. The bacillus enters the body through a wound, usually in one of the quarters, and the disease runs a rapid course, usually ending fatally in one or two days.

Symptoms.—Local swellings are produced around the point of entrance, usually the thigh, shoulder or neck, and may attain a large size in a few hours. The swelling is due to the production of gas in the tissues beneath the skin, and if the swelling is pressed or firmly rubbed a crackling sensation will be felt. Lancing the swelling causes a red, frothy, strong-smelling fluid to issue, which is infectious. The muscle tissue of the affected part is very dark; hence the name "Black Leg."

As the swelling increases in size, the general symptoms appear:

The temperature rises to 107° F.; respiration is rapid, 140 per minute. The animal falls down and is unable to rise; the extremities turn cold; violent convulsions ensue, followed by death.

The carcase should be burned or buried deeply in quick-lime, and the premises thoroughly disinfected.

There is no cure for the disease. Other animals in the herd should be vaccinated with black leg vaccine at once to prevent their taking the disease. The vaccine may be obtained from the Veterinary Director-General at Ottawa. It is put up in the shape of pills, which are injected under the skin of the shoulder with a hypodermic syringe. The complete outfit for injecting costs 50 cents.

Contagious Abortion of Cattle.

Contagious abortion of cattle is a disease which is considered to cause heavier financial losses among cattle than any other disease, except, possibly, tuberculosis. It is very common in Europe and on the American Continent. Much investigational work has been done and is still being carried on in connection with this disease. The cause of the disease is known, but satisfactory measures for its complete control or eradication have not yet ben devised.

The trouble is due to the action of *Bacillus abortus* in the foetus and uterus of pregnant cows, setting up a local inflammation, which leads to any one or all of the following conditions—abortion, premature birth, retention of the foetal membranes, metritis and sterility.

Abortion may take place at any time during pregnancy. If it occurs in the early stages of gestation, the small embryo comes away enveloped in the inconspicuous foetal membranes and easily escapes detection. If it occurs after the foetus has attained considerable size, the foetal membranes are usually retained by the cow and the assistance of the veterinary surgeon is required to remove them. They should be removed within twelve hours after abortion, or fatal consequences may result from blood poisoning or bacterial infection. A catarrhal condition of the uterus may cause gradual death of the foetus which is not immediately expelled but becomes mummified.

Heifers, as a rule, abort earlier than cows. In herds recently infected the animals usually abort in from three to five months after pregnancy; in herds where the disease is of long standing abortion frequently takes place from the fifth to the seventh month of pregnancy.

Unfortunately, there are no well-marked symptoms of the disease until abortion is about to take place. The animal generally will appear to be normal and in good health until just before aborting. Then may be noticed a springing of the udder, enlargement of the vulva, an odorless discharge from the vagina, dullness and desire to be alone. Any, or all, or none, of these symptoms may be noticed shortly before abortion takes place.

Much of the difficulty experienced in the control of the disease is due to lack of knowledge as to how the bacillus gets into the uterus.

Some investigators contend that it gains entrance indirectly through the alimentary canal by the ingestion of contaminated food and water; others contend that it gains entrance mainly, if not solely, through the genital organs previous to the sealing of the uterus, which occurs within thirty days of conception.

It has recently been shown (Schroeder and Cotton, 1917) that the abortion bacillus is frequently present in the udder and adjacent lymph glands of non-pregnant cows, but not in any other part of the body, and that it is given off in the milk from such cows, the cows appearing normal and healthy in every particular. In the case of affected pregnant cows, the bacillus is found in the uterus, where it sets up the inflammation leading to abortion. It has been experimentally demonstrated that the bacillus will pass from the udder to the uterus of pregnant animals, the bacillus having an affinity for foetal tissues. Consequently, the disease may be spread by milking operations, the milker passing from a non-pregnant animal that has the bacillus in the udder and is giving it off in the milk, to a pregnant animal, thus conveying the bacillus on the hands to the teats of the pregnant animal, whence it would gain entrance to the udder and pass to the uterus, leading to abortion.

Attempts are being made to prepare a serum or vaccine the injection of which into breeding cows will prevent abortion. Some success has been reported, but further investigational experiments are necessary before any general application of such measures can be made.

In the meantime it is well to practise the strictest hygiene in the handling of herds where abortion is present.

The foetus, foetal membranes and exudate, which will contain the bacilli in large numbers, should be buried deeply in quicklime. Everything with which they come in contact should be thoroughly disinfected. The aborting animal should be isolated, and, so long as there is a discharge from the vulva, the external genitals, thighs and udder should be washed daily with a suitable disinfectant, as two per cent. lysol or cresol. The cow should not be bred again until all discharge has ceased. The bedding contaminated with the discharge should be burned, and the stall well disinfected after the animal is removed. The attendant in charge of animals that have aborted should not have anything to do with other cattle without first changing his clothes and disinfecting his hands.

Contagious Abortion of Mares.

So-called sporadic abortion of mares may take place following an injury such as a kick or a bad fall, or as a result of ergotism. Such cases, however, have nothing to do with contagious abortion and do not spread from animal to animal.

Contagious abortion of mares is due to a specific bacillus, *Bacillus abortivus equinus,* which like *Bacillus abortus* of cattle, gets established in the uterus, foetal membranes and foetus, setting up local inflammation, leading to expulsion of the foetus, dead or alive, at any time during pregnancy.

The symptoms of approaching abortion are not usually in evidence until just before abortion takes place. Then the animal is seized with colicy pains, restlessness, straining and a swollen vulva, with a mucous discharge, is noticeable. After abortion, the symptoms are more specific. There is a chocolate brown fluid discharge from vulva, which has a typical offensive odor, and the foetal membranes are inclined to remain intact, thus necessitating artificial removal to prevent blood poisoning.

The mortality of aborting mares is not high, but the animal after abortion is liable to become unthrifty and the foetus or colt, if born alive, has a strong tendency to septic arthritis or joint ill. Hence the disease is the cause of considerable financial loss to the farmer who has to contend with it.

The disease has been known in Europe for many years, but it was not found on the American Continent until 1886, when it appeared in the Mississippi Valley.

Since then it has spread far and wide in the United States and Canada. Although many investigations were made both in Europe and America, it was not until 1912 that the cause of the disease was discovered. In that year, E. S. Good, of Kentucky, discovered the bacillus which causes the disease. The same year Dr. Schofield, of Toronto, discovered the same bacillus in some cases of joint ill in colts, which had developed in districts in Ontario where contagious abortion of mares was prevalent, and the following year found the same bacillus in cases of contagious abortion of mares in Ontario.

Method of Spreading.—The disease is spread mainly by the discharges from the vulva of aborting animals. If a mare that has aborted is served before all discharges from the vulva have ceased and the gentalia have been efficiently disinfected, then the stallion is liable to get contaminated with the bacillus and spread the disease to other mares which he subsequently serves. If the discharges from an aborting mare are allowed to contaminate the bedding or other materials that other mares come in contact with, then these mares are liable to contract the disease. If the discharges are allowed to contaminate water or food materials that are given to other mares, the latter are liable to contract the disease.

Measures for Control.—(As suggested by Dr. Schofield, recently of Toronto.)

1. Three months must elapse between abortion and subsequent breeding.
2. Mares that have aborted must not be bred if there is evidence of uterine catarrh, even after three months.
3. Mares that have aborted must only be bred at the end of the stallion season.
4. Application of an efficient disinfectant to the external genitalia of the stallion after each service in affected districts.

These regulations should also extend to mares in affected districts whose colts have developed septic arthritis.

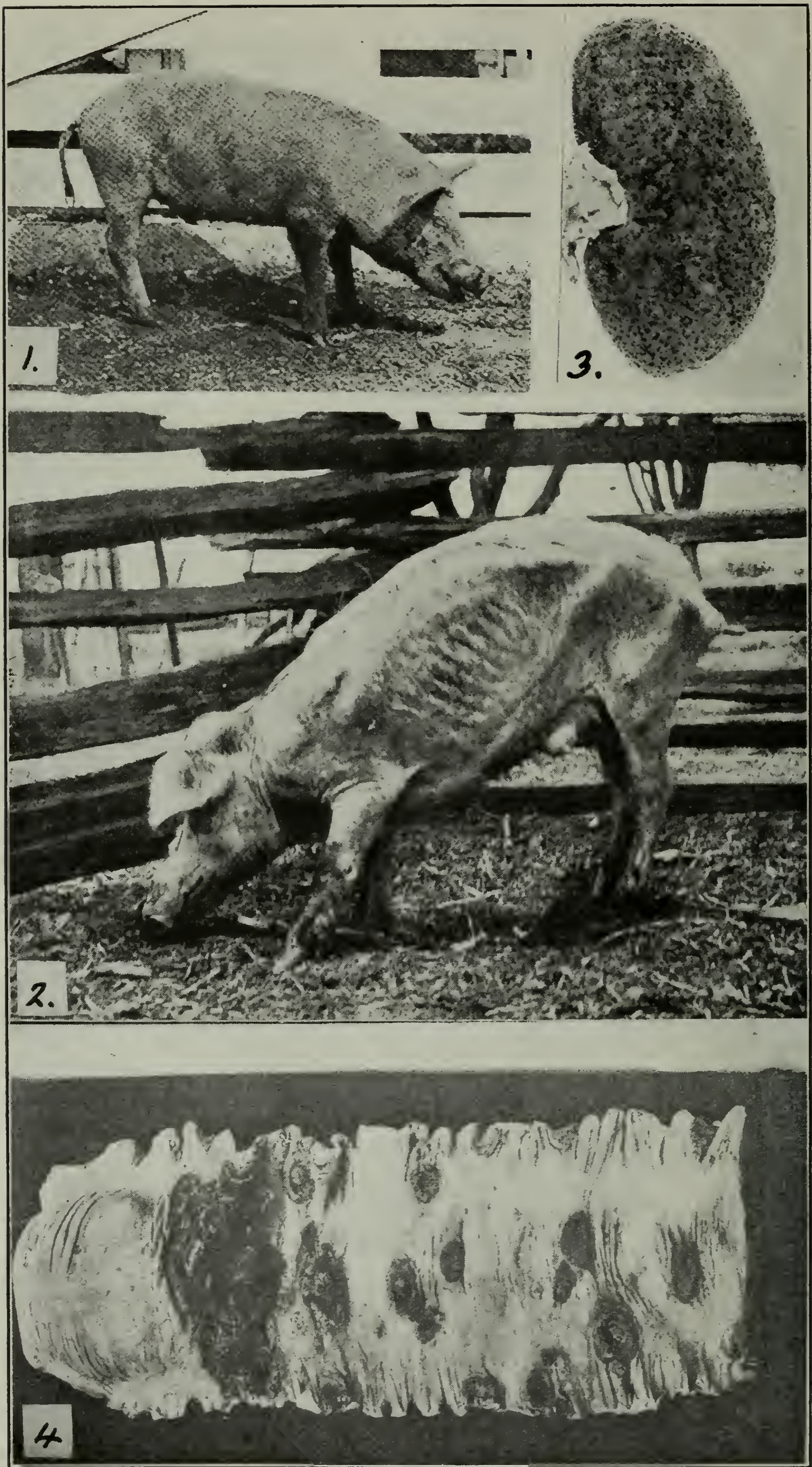
Measures to be Employed at Time of, or Subsequent To, Abortion.

1. Isolation of mare at first sign of approaching abortion.
2. After abortion the foetus and membranes should be burned, if possible, or buried deeply in quicklime.
3. Those handling the foetus and mare should disinfect hands and clothing.
4. Bedding should be burned and the stall washed with a strong disinfectant.
5. External genitals, thighs and tail of mare should be washed daily with a good disinfectant. Two per cent. bacterol, lysol, or creosol, is satisfactory for this purpose.
6. Isolation of mare should be maintained for at least a month or until all evidence of uterine discharge has ceased.

Treating the animal with drugs, as carbolic acid, black haw and methylene blue, though popular in some districts, cannot be recommended as being of any value.

Hog Cholera.

Hog cholera is a highly contagious disease of swine. So far as known, it does not affect other animals or man. It is caused by a filterable virus or ultra-microscopic organism, i.e., an organism so small as to pass through the finest porcelain filters and too small to be visible even with the highest-power microscope. A bacillus known as *Bacillus cholera suis,* which is frequently found in connection with hog cholera and is about the size of typhoid bacillus, was formerly thought to be the cause of the disease. It is now known to be merely an occasional accompaniment of the disease and not its cause.



Hog Cholera.

1. Hog suffering from the acute type of hog cholera. (After Lynch.)
2. Hog suffering from the chronic type of hog cholera—advanced stage. (After Torrance.)
3. Kidney from a hog dead of chronic hog cholera. Note the typical spotted condition.
4. Ulcerated intestine from hog dead of chronic hog cholera.

Hog cholera is considered the most serious disease of hogs and is found at present in most countries where hog raising is practised. It is very prevalent in the United States, where the average annual loss from the disease for the last forty years is estimated to be $30,000,000. The losses, however, are gradually being reduced by the use of hog cholera serum. In Canada the disease cannot be considered prevalent, although isolated outbreaks occur from time to time, following the introduction of the virus in various ways, as by contaminated foods, garbage, cattle cars, exhibition grounds, and the handling of diseased stock.

SYMPTOMS OF HOG CHOLERA.—The symptoms of hog cholera differ somewhat according to the virulence of the virus and the resisting power of the hogs in any particular outbreak. Owing to this variation, two forms of the disease are recognized—the so-called acute form and the chronic form.

In the acute or severe form, the hogs sicken and die quickly, appearing to be well one day and frequently dead the next. In the chronic or less severe form, the hogs may be sick for weeks or months before they die or get better.

When cholera enters a herd, the hogs do not all become sick at once. One or two will fail to come for their feed and will be found lying down in some dark corner. On being raised up their backs will be arched, and they will shiver as with cold. They soon become thin and tucked up in the flank and stagger around when trying to walk, the hind legs being particularly weak. The eyes become inflamed and show a whitish discharge, sometimes causing the lids to stick together. When the lungs get affected there is a cough. Constipation is noticed at first, followed by diarrhoea; red and purple blotches appear on the skin of ears, belly, and inner surfaces of the legs. The temperature of the sick hogs will rise to as high as 107° F. or even higher, the normal temperature of healthy animals being 101°-104° F.

The discharges from the sick animals, both urine and faeces, contain the virus in large quantities, and so other members of the herd associating with the sick ones soon contract the disease.

POST MORTEM SYMPTOMS.—An examination of the body of a hog dead from hog cholera will usually reveal any or all of the following symptoms:

1. Purple patches on the skin.
2. Blood-colored spots, varying in size from a pin point to a pin head, on surface of lungs, heart, kidneys, and on the outer surface and inner lining of intestines and stomach. These are most common in acute cases of the disease.
3. Uulceration of the inner lining of the large intestine and particularly at the junction of the large intestine with the small intestine, where the ileo-caecal valve is situated. These are most common in the chronic form of the disease.
4. Reddening of the lymphatic glands.
5. Enlargement of the spleen in acute cases.

METHODS OF SPREADING.—So far as known, the virus of hog cholera will not propagate outside the body of the hog. As already stated, the virus is given off in large quantities in the urine and faecal discharges of sick hogs. Anything that gets contaminated with these discharges is liable to spread the disease to healthy hogs that come in contact with it. Consequently, boxes, wagons, and cars in which sick animals are shipped, are potent sources for spreading the disease. The pens and yards in which sick anmals have run get heavily contaminated, so that anyone walking over the same get their shoes or clothes contaminated, and so may carry the disease to other herds subsequently visited. Offal from slaughter yards fed to hogs has been known to be the source of the disease in a number of outbreaks. Streams running past premises where hog cholera is present have been known to spread the disease to other places. The purchase of new stock and the borrowing or lending of stock for breeding purposes has been shown to be the cause of a number of outbreaks.

Consequently, the greatest care should be taken to strictly quarantine any place where the disease gets established. After the outbreak has been stamped out the most thorough disinfection of the premises is necessary.

Prevention and Treatment.—From what has been said above regarding the way the disease is spread, it will at once be seen that one way to keep the disease from a healthy herd is to take all steps necessary to prevent materials contaminated by sick hogs from coming in contact with the healthy herd.

In Canada (By order of the Veterinary Director-General).—If by any chance the disease gains entrance to a herd anywhere in Canada, the laws of the Dominion require that a veterinary inspector be notified without delay. Failure to make this notification means loss of compensation for animals slaughtered under the Act. and liability to a heavy fine.

"The veterinary inspector, upon making sure of the existence of hog cholera, will have all the hogs on the premises slaughtered immediately. Those actually diseased are then destroyed by burning them up completely, or else deeply burying them in the ground. Hogs which are not sick, but have been in contact with the diseased ones, and are in fit condition for food, may be dressed under the supervision of the inspector. If a careful examination shows them to be healthy, they are allowed to be sold as dressed pork. The inspector assesses the value of the hogs slaughtered, and, if the owner has not been guilty of any neglect or infraction of the law, and carries out the instruction of the inspector regarding the disinfection of the place, he will receive compensation for his losses up to *two-thirds of the assessed value.*

"The premises occupied by the diseased hogs are placed in quarantine until thoroughly cleaned and disinfected to the satisfaction of the inspector, and no fresh hogs are allowed on the premises for a period of at least three months afterward. The inspector then revisits the premises to make sure that the regulations have been complied with, and, if satisfied that such is the case, will recommend to the Minister of Agriculture the release of the premises from quarantine. The Minister is the only person authorized to grant this release, and he grants it on the recommendation of the inspector.

The following are the Official Rules for the cleansing and disinfecting of premises after outbreaks of hog cholera:

"After infected hogs have been slaughtered, the carcasses should either be completely burned or buried at a depth of at least eight feet; if buried, they should be covered to a depth of several inches with quicklime.

"In most cases it will be found safest and most profitable to remove and burn the floors, partitions and lining of pens previously occupied by infected hogs, as also any rails, loose boards or other lumber to which such hogs have had access.

"Pens, other buildings and fences with which affected hogs have been in contact are, when possible, to be thoroughly gone over with hot steam or boiling water before being coated with fresh lime wash, each gallon of which should contain a pound of carbolic acid, creolin or other germicide of equal strength.

"The surface soil of pens and yards should be removed to a depth of at least six inches and well mixed with fresh lime, which should also be freely applied to the surface of the newly exposed soil. Ground so treated should receive over the lime a fresh coating of earth or gravel. Fields, orchards and gardens to which the diseased hogs have had access are to be ploughed as soon as possible.

"Every precaution should be taken to prevent the conveyance of infection from one place to another by means of the clothing or shoes of persons who have been attending to or otherwise dealing with diseased hogs.

Visitors should be discouraged during outbreaks of disease or until cleansing and disinfecting operations as above indicated have been completed.

"Animals, especially dogs, are frequently the means of conveying the disease, and should, wherever possible, be prevented from entering infected premises. When, owing to severe weather or other unavoidable cause, it is found impossible to cleanse and disinfect immediately pens or yards formerly occupied by diseased hogs, such pens or yards should be closed up in such a manner as to prevent persons or animals obtaining access thereto until such cleansing and disinfection can be properly carried out.

"Owners of diseased hogs should bear in mind that inspectors cannot recommend the release from quarantine of any premises the disinfection of which has not been carried out in a satisfactory manner."

Anti-Hog-Cholera Serum.—In the United States the use of anti-hog-cholera serum is generally practised as a preventive, more particularly where hogs are exposed to the disease. In some districts it is almost impossible to raise hogs without the use of the serum, the disease being so prevalent that all hogs are exposed to it.

The use of this serum in Canada is forbidden by law except under Government supervision. The reason for this is that in order to render a hog permanently immune to hog cholera by the serum treatment, it is necessary to make use of the virus that causes the disease as well as the serum itself. Such a practice is desirable in districts where the disease is endemic, as is the case in many of the States. But in Canada, where the disease is not generally prevalent, the indiscriminate use of the serum and virus would mean the introduction of the disease in many districts that are free from it. The practice implies use of the disease to combat the disease.

The serum is prepared as follows:

A hog that has been rendered immune as a result of recovery from an attack of the disease, following either a natural or artificial inoculation, is rendered hyper-immune by the injection into his muscular tissues of large quantities of virulent blood, taken direct from another hog very sick of the disease. This virulent blood is injected in increasing doses, at intervals of a few days, until the blood of the animal has become hyper-immune, that is, excessively resistant to the disease.

Blood is then withdrawn from the animal by cutting off the end of the tail and catching the flow in a sterile vessel. When sufficient blood has been withdrawn, the wound is ligatured and the animal is fed up and again treated in the same way. The blood so obtained is allowed to coagulate and the serum is removed, its strength established, a preservative added, and then it is ready for use.

This serum when injected into hogs, 20 c.c. per 100 lbs. hog, will render them immune for a few weeks. It is useful when sending hogs to exhibitions where they are liable to be exposed, or when shipping them through an infected district. This method is known as the "Serum Alone Method."

To make a hog permanently immune, it is necessary to use the virus in conjunction with the serum. This may be done in one of two ways. One is known as the "Simultaneous or Quick Method," in which a dose of serum, 20 c.c. per 100 lbs. hog is injected in one place, and 1-10 that quantity of virulent blood taken from an animal sick of the disease is injected in another place. This treatment results in a mild attack of the disease. If the serum were not given, the virulent blood would cause fatal results, but the serum helps the animal to get the better of the virus, with active permanent immunity as the final result. Sometimes fatal results occur with this treatment when the serum is not sufficiently strong to offset the virus.

A better method than the above is the so-called "Combination Method." This is a combination of the serum alone and the simultaneous methods. First, treat with the serum alone method and ten days later with the simultaneous method. This, of course, takes longer time, and is more expensive, but is safer and more sure.

Foot and Mouth Disease.

Foot and mouth disease is a highly infectious disease affecting domestic animals. Cattle are most susceptible; hogs, sheep and goats less so; while horses.

dogs, cats and man are still less susceptible, and rabbits, guinea-pigs and birds are practically immune.

The disease is caused by a filterable or ultra-microscopic virus, and is spread by contact with a diseased animal or by contaminated water, bedding, food, pasture and attendants. Contaminated milk affects young stock.

The disease has been known in Europe for three centuries, where it has affected millions of cattle, thus causing heavy losses. Outbreaks occurred on the North American continent in 1870, 1880, 1884, 1902, 1908 and 1915. In the last outbreak, over two thousand herds of affected cattle, sheep and swine were slaughtered in order to stamp out the disease and prevent its further spread.

Symptoms.—In cattle symptoms develop in from two to seven days after exposure to infection. At first there is a slight fever, frequent pulse and loss of appetite. Then comes inflammation of mouth, lips and throat, accompanied by pain in swallowing, drooling of saliva, listlessness and emaciation. Vesicles, filled with fluid, appear on lips, gums, cheeks, udder, and on the feet, principally just above the hoof. These vesicles rupture, and the fluid which they contain is discharged and is very infectious. Abscesses develop around the feet, causing loss of hoof and injury to the joints.

The mortality directly resulting from the disease is usually not very high, but the losses in milk and beef resulting from an outbreak and the rapidity with which the disease spreads when once it gets started, are sufficient to warrant the government of most countries, including Canada and the United States, to institute radical measures for its control. Quarantine and slaughter of all affected animals, followed by thorough disinfection of premises, is carried out under government supervision.

In man the symptoms are similar to those in cattle, though often mild in form. The hands are most often affected, particularly at the finger tips; but the feet, toes and heels, and also other parts of the body, may become affected. In children there are more serious general symptoms than with adults.

Glanders and Farcy.

Glanders is a serious infectious disease naturally affecting horses, mules and donkeys. It is also communicable to man, sheep, goats and guinea pigs. Cattle are immune. *Bacillus malei* gaining entrance to the system is the cause of the disease, and it is spread mainly by contamination of food, mangers, drinking-troughs, etc.—rarely through wounds.

The disease may be *acute* or *chronic,* according to the virulence of the bacillus and the resistance of the animal.

Symptoms.—*The Acute Type* begins with a chill followed by fever, inflammatory changes of lymph glands, ulceration of membrane in nose and mouth, with muco-purulent discharge; then death in from one to four weeks.

The Chronic Type shows no marked characteristics in its early stages. The lymph glands in various parts of the body become infected and enlarge. Nodules develop in the mouth, nose and lungs, which are small at first, gradually enlarging to size of pea, when they break down and suppurate, thus forming chronic ulcers. The chronic form may change to the acute form at any time.

In man the disease is practically always fatal, following infection mainly through wounds.

Farcy or Cutaneous Glanders is the name given to the disease when present in the skin. Nodules form in the skin, usually break through to the surface and ulcerate. Lymph vessels swell and feel like a string of beads or knotted cord.

Owing to the heavy losses from the disease in horses and mules when an outbreak occurs, and to the ease and rapidity with which the disease spreads, the Government insists on the immediate slaughter of all affected animals and the testing with mallein all horses and mules that have been exposed to infection, all animals re-acting being slaughtered.

The Mallein Test for glanders is somewhat similar to the tuberculin test for tuberculosis. Mallein is a suspension of *Bacillus mallei* killed by the application of heat. When a dose of mallein is injected under the skin of an animal suffering from glanders, there is a rise in temperature after six to eight hours. This is accompanied by a swelling of considerable size at the point of injection which is hot and painful and persists for several days. In an animal not suffering from glanders there will be a slight rise in temperature following injection, but no hot painful swelling.

Other tests for the determination of glanders have been devised and used with more or less satisfaction. These are the guinea pig inoculation test, the complement fixation test, and the conglutination test.

White Diarrhœa of Chicks.

"White diarrhœa" of chicks is usually an infectious disease, and results in heavy losses among little chicks, particularly those which are incubator hatched. The heaviest losses usually occur between the ages of one and three weeks. In cases where the trouble is not due to an infection, the cause may be sought in improper incubation, improper brooding, overheating, chilling, poor ventilation and overcrowding.

The cause of infectious white diarrhœa of chicks has been shown in a number of outbreaks to be due to a bacillus named *Bacillus pullorum,* by Dr. Rettger, who first discovered it.

Symptoms.—Affected chicks appear small for their age, dull, hunched-up in the back, big-bellied, feathers roughened, pasted up behind with sticky, whitish, creamy discharge from vent, wings drooping and head drawn in. They isolate themselves from rest of flock, remain under the hover, eat with difficulty and utter shrill little chirps as if in pain, particularly when attempting to void excreta. In some cases the chicks will die suddenly after showing but few of the above symptoms; others will drag out a miserable existence for a time and show all the symptoms. A few get better, but most of them die.

On post-mortem examination, the following conditions are common: Chick usually emaciated and dirty; crop empty or partially filled with a slimy liquid or with food; lungs, apparently, normal; liver, pale with patches of red; kidney and spleen apparently normal; intestines, pale and for the greater part empty, except for a little greyish or brownish matter; cæca, partially filled with soft, greyish substance, occasionally cheesy or firm contents found.

Methods of Spreading.—It has been found that female chickens which recover from white diarrhœa frequently have *Bacillus pullorum* retained in their system, particularly in the ovarian tissue. The presence of the bacillus there induces a diseased condition of the ovaries. The egg yolks of the ovaries of a healthy hen in the laying condition are mostly spherical, bright golden yellow, covered with interlacing blood vessels; the egg yolks of the ovary of a hen affected with *Bacillus pullorum* will be more or less angular, dull brown and dirty greenish or otherwise discolored, frequently soft and flabby. The eggs from such a hen are very liable to contain *Bacillus pullorum* and the chicks from such eggs will have white diarrhœa. The chicks which have the disease on being hatched soon give off large numbers of bacilli in their droppings, and thus the chicks with which they associate contract the disease. One or two such chicks in a hatch will frequently cause an infection of a considerable percentage of their companions in the incubator or brooder. The greatest danger of infection is usually during the first 48 hours, but it may occur any time during the first week, after which there is not much danger.

Treatment.—Not much can be done for a chick that has contracted the disease. Steps should be taken at once to prevent the disease from spreading to the healthy ones. It is better to remove the healthy chicks to fresh quarters than to move those which are sick. Every incubator and brooder should be thoroughly disinfected before using, and between each batch, with some good disinfectant as cresol soap.

A means for testing whether or not a laying pullet or hen is affected with *Bacillus pullorum* has been devised by Dr. Rettger. It is known as the *Agglutination Test.* A trained bacteriologist is necessary for preparing the material and conducting the test.

For the test it is necessary to have pure cultures of *Bacillus pullorum,* several strains being preferred to any one single strain. The bacterial growth from 24-hour old nutrient agar cultures is mixed with physiological salt solution and filtered through paper. The filtrate should be faintly cloudy with the suspended bacilli, and this constitutes the test solution.

A sample of blood, 3-5 c.c., is drawn into a small test-tube from the large vein under the wing of each bird to be tested. This is allowed to clot and placed in the refrigerator over night. The clear serum is then pipetted off and diluted with physiological salt solution (0.2 c.c. serum to 4.0 c.c. of salt sol.), thus giving a dilution of 1-20.

The diluted serum is then mixed with the test solution in varying quantities: 0.8, 0.4, 0.2 c.c of the diluted serum to 2.0 c.c. of the test solution, thus giving dilutions of the original serum of 1-50, 1-100 and 1-200.

The mixtures are shaken and placed in the incubator at 37° C. and examined later at intervals for agglutination. Two days incubation is sufficient for obtaining final results.

If the bird from which the blood is drawn is affected with *Bacillus pullorum,* the blood serum will cause the bacilli in the test solution to agglutinate, that is, clump together in little masses, leaving the solution around them clear. If the bird is not affected with *Bacillus pullorum* then no change will be noticed in the mixture after incubation.

Fowl Cholera.

Fowl cholera is a highly infectious disease of poultry. It is usually fatal. It spreads rapidly through a flock when once it gains entrance.

The cause of the disease is a bacillus named *Bacillus avisepticus,* first discovered in cases of the disease by Pasteur in France.

Symptoms.—The first symptom usually noticed is diarrhoea. The droppings occur frequently and consist largely of yellow-colored urates (which in health are white) suspended in a thin transparent liquid. In later stages of the disease the urates may become greenish. The affected bird separates itself from the flock, its feathers become roughened, wings droop, head is drawn in. Drowsiness and extreme weakness follow and death after a day or two is usually the result.

Post-mortem examination shows mouth, nose and throat filled with mucus, crop usually well filled with food, inflammation of the digestive system, kidneys and mesentery. Pin point hæmorrhages are found on surface of heart and tiny white spots on and in the liver. The blood vessels of the liver are congested. The duodenum or first fold of the intestines is highly inflamed and reddened on the inner surface. The intestinal contents may be creamy, brownish or green in color. The ureters are usually very noticeable on account of their being filled with the yellow urates. The bacilli are found in considerable numbers in the blood and organic tissues.

METHODS OF SPREADING.—It is sometimes difficult to determine how the disease gains entrance to a flock. The introduction of new stock or the return of birds from poultry shows, or the contamination of food and water may be responsible in some cases. In others it appears almost to develop spontaneously. In such cases it is considered that healthy birds, resistant to the disease may have the bacillus in a low state of virulence in their system and that birds in their company that are not resistant to the disease get the bacilli from them. In these birds the disease develops and the bacilli become more virulent, and as these virulent bacilli are scattered around in the pens, runs, food and water an epidemic gets started.

TREATMENT.—There is no known satisfactory curative treatment. Birds that show marked symptoms of the disease should be killed at once, care being taken not to scatter the blood around, as the bacilli will be present in every drop of the blood. The bodies of the birds should be burned or buried deeply in quicklime and a thorough cleaning and disinfection of the premises carried out.

CHICKEN POX, CANKER, AND ROUP OR FOWL DIPHTHERIA.

Chicken pox, canker, roup or fowl diphtheria have given trouble to poultry raisers in Europe, United States and Canada for many years. Much work has been done on the disease, or diseases, by various pathologists on both continents. Some authorities contend that one disease only is responsible for the various conditions represented in chicken pox, canker, roup or fowl diphtheria, others again contend that the conditions referred to are separate and distinct diseases.

A local inflammation which has a tendency to spread is responsible for each condition. In chicken pox the inflammation occurs within the epithelium or skin of the comb, wattles and other parts of the head, and an exudate forming scabs is given off. With canker and roup or fowl diphtheria the inflammation occurs in the mucous membrane, or lining of the throat, nose and eye sockets and a tough, cream-colored fibrinous exudate containing pus cells and various bacteria is produced in the inflamed area.

When this exudate is produced in the larynx it frequently causes death from suffocation. When it occurs in the mouth, cankers are produced both large and small, and when it occurs in the nose and eyes, swellings develop due to the presence of large quantities of the exudate within the cavities.

Some investigators have contended that fowl diphtheria and human diphtheria are one disease due to the same species of bacteria. This theory, however, has been disproven, as the human diphtheria bacillus has not been found present in the fowl disease.

Various species of bacteria are found associated with the disease, but so far no one species of those which have been isolated has been shown to be the cause.

Some contend that the cause is an ultra-microscopic organism, and that the bacteria found present are simply associated with it. Others again contend that the disease is due to the presence of various species of bacteria, the combined associative action of which sets up the inflammation. All agree, however, that the disease is infectious and contagious and hence is due to some living virus, the exact nature of which has not so far been ascertained.

During the investigation of an extensive outbreak of pox and roup in a large flock of poultry in 1916, the writer isolated five different species of bacteria from the lesions of the birds but none of these species of bacteria produced the disease, either singly or collectively, when inoculated in various ways or fed to healthy birds. The results of the investigation thus favoring the theory that the cause of the disease is an ultra-microscopic organism.

Various methods of treating the disease have been recommended with more or less success. If the disease is present in only a small number of birds they should at once be isolated and the pens from which they are moved should be thoroughly disinfected. The affected birds may then be treated individually, the scabs and exudate removed with forceps or by squeezing, and the exposed surface swabbed with a disinfectant such as tincture of iodine, or potas. permanganate, or touched with silver nitrate. Thorough disinfection of the premises and strict hygiene should be practised.

If, however, the flock is a large one in which the disease is spreading rapidly, such individual treatment is practically impossible. In such cases a preventive as well as curative is desirable, and vaccination has been resorted to for this purpose.

Various vaccines have been prepared and tried, but the one which seems to have given the best results is one that was first prepared in Europe in 1905. This vaccine has since been prepared and used with varied success in bad outbreaks in California, Wisconsin, Michigan, British Columbia and Ontario.

The vaccine is made from a mixture of the scabs and exudate taken from sick birds. This material is pulverized with pestle and mortar, a little sharp sand being thrown in to help the grinding process. This is then added to physiological salt solution (1 gram of salt to 100 c.c. of boiled water) at the rate of 1 gram of exudate to 200 c.c. of the physiological salt solution. After well mixing it is filtered through filter paper and the filtrate is then attenuated at a temperature of 55° C. for 1 hour. This attenuated filtrate is the vaccine and contains millions of bacteria of various species per c.c. One c.c. constitutes a dose for a bird and the treatment consists in injecting subcutaneously with a hypodermic syringe 1 c.c. of the vaccine. The place recommended for the injection is the skin of the breast just under the wing. A few feathers should be removed from the point of injection, and the surface wiped with a disinfectant before and after injection. A second injection is recommended 5-7 days after the first.

The writer tested this method of preventive and curative vaccination on more than three hundred birds housed in fourteen adjoining pens. A considerable number of these birds were suffering from the disease in all its stages. A vaccine was first prepared and used on thirty sick birds that had been isolated. Some of these birds appeared to be almost in a dying condition at the time of vaccination. On the third day after vaccination there was a very marked diarrhœa, and on the fourth day a general improvement in condition of the birds was noticed. This improvement continued until the time for a second vaccination.

A second vaccine was prepared in the same way as the first, but the material for this vaccine was taken from different birds from that used in the first vaccine.

A sufficient quantity of vaccine was prepared to treat the whole flock of over three hundred, in addition to those already vaccinated. For some reason or other not determined, this second vaccine did not have the same favorable results, neither on those birds which were receiving the second treatment, nor on those, whether they were sick or healthy, that were receiving treatment for the first time. A number of deaths occurred after a few days following the vaccination both of sick birds and birds that were healthy before vaccination. Post-mortem examination of these birds indicated death to be due to toxic action. It would appear that the material used for the second vaccine, although obtained in the same way as the material used for the first vaccine, but taken from different birds, had contained some toxic substance sufficiently strong to cause death of some of the birds on which it was used.

Thus, though the first vaccine prepared had a curative effect on the sick birds on which it was tried, the second vaccine appeared to have no curative effect on sick birds, and we could not consider that it had much preventive power, as a number of healthy birds that were treated with it contracted the disease later.

Therefore, while some report successful results being obtained for this method of vaccination both curatively and preventatively, we cannot give the method an unqualified approval.

There is more danger of the disease establishing itself and making headway in damp, muggy weather and when the floors of the pens and runs are wet or constantly damp, as is common in the springtime. These conditions, however, while they favor the disease cannot be considered as its cause.

"Blackhead" of Turkeys, Spotted Liver.
(*Infectious Enterohepatitis.*)

We occasionally get sick or dead turkey poults, half-grown turkeys and the diseased livers of adult turkeys that have been killed, sent us for examination. Almost invariably the disease from which these have been suffering is the one known commonly as "Blackhead" or Infectious Enterohepatitis. This is an infectious disease that is most fatal to turkey raising and is largely responsible for the dearth of turkeys at the present time, as compared with the numbers of years ago.

The disease is not due to bacteria but to a species of protozoa, an amoeba known as *Amoeba maleagridis.* This is a microscopic animal organism slightly larger than bacteria. It is considered that ordinary fowls harbor the parasite, but that they are not subject to the disease to the same extent as turkeys.

Symptoms.—The disease is most common among turkey poults from two weeks to four months old. The affected birds lose their appetite and get dull and listless; diarrhoea develops, the wings and tail droop and the head gets darkly discolored, hence the common name of the disease "Blackhead."

The greater number of affected poults die before they reach four months of age. In other cases the disease assumes a chronic form, but the affected birds are never thrifty and never do well.

Post-mortem examination shows the caeca or blind pouches of the intestines to be swollen and inflamed, sometimes almost gangrenous, and filled with a rather hard cheesy exudate which adheres rather tenaciously to the inner lining of the caeca. Sometimes other parts of the intestine are inflamed. The liver will be more or less spotted with somewhate circular, flat or slightly sunken, straw-colored areas from a quarter of an inch to an inch in diameter, sharply defined from the rest of the liver tissue. These pale yellow spots may sometimes be mistaken for the tubercles of tuberculosis. The surface of the latter, however, is usually slightly raised above, instead of sunken below the surface of the surrounding liver tissue.

The amoeba which causes the disease is given off in large numbers in the droppings of affected birds, and so the disease is spread through a flock by the food and water contaminated by such droppings. On gaining entrance to the bird's digestive tract the amoeba establish themselves in the walls of the caeca, where they multiply and set up inflammation and migrate thence to the liver, where they multiply and produce the pale yellow-colored spots.

The disease has proved to be one of the most difficult ones to deal with satisfactorily. No treatment so far practised has shown very good curative results. Hence turkey raisers should prevent, as far as possible, the disease from getting established in their flocks by practising the strictest hygiene.

Foul Brood of Bees.

There are two varieties of foul brood of bees, one known as American Foul Brood, caused by *Bacillus larvae,* a resistant spore producer and the other known as European Foul Brood, caused by *Bacillus pluton,* which is not a spore producer.

American Foul Brood is common in United States, Canada, France, Germany, Switzerland, England, New Zealand and probably also in other countries.

It affects the larva and pupa of bees and is usually first visible about the time the larva fills the cell, after it has ceased feeding and is sealed over in the comb. The larva gradually sinks down in the cell and turns brown in color. If a match or bit of stick is inserted and withdrawn the larval remains adhere to it and string out in a slimy thread. The larval remains continue to dry down and gradually lose the sliminess until finally they become a mere scale at the bottom of the cell.

A characteristic odor something like heated glue is given off by the diseased larvæ.

Usually the disease attacks only worker broods, but occasional cases are found in which queen and drone broods are diseased.

Control.—Brood from badly diseased colonies should be burned. The swarm should be transferred from the infected hive to one that has been cleaned and disinfected. The combs from the infected hive should either be burned. melted or boiled thoroughly before the wax is used again. Infected hives should be burned over inside with a gasoline or oil torch.

European Foul Brood, also known as "black brood" or "New York" bee disease is not so widespread on the American continent as is the American Foul Brood. It is found pretty general in England, Germany and Switzerland. Wherever it develops it causes heavy losses to the honey industry.

Symptoms.—Diseased larva appears yellowish tinted or transparent instead of the bluish white or glistening white of healthy larva. The peristalsis-like motion of the bodies of sick larva is much more pronounced than that of healthy larva. Larva dying from this disease frequently show the segments of the body marked off less distinctly than living healthy larva.

Methods of Control.—Similar to those for American Foul Brood.

GROUP VII. BACTERIAL DISEASES OF PLANTS.

The bacterial diseases of plants fall naturally, according to the changes which they induce in the host plant, into four types, as follows: 1. Bacterial Soft Rots; 2. Bacterial Wilts; 3, Bacterial Canker or Blights; 4, Bacterial Galls.

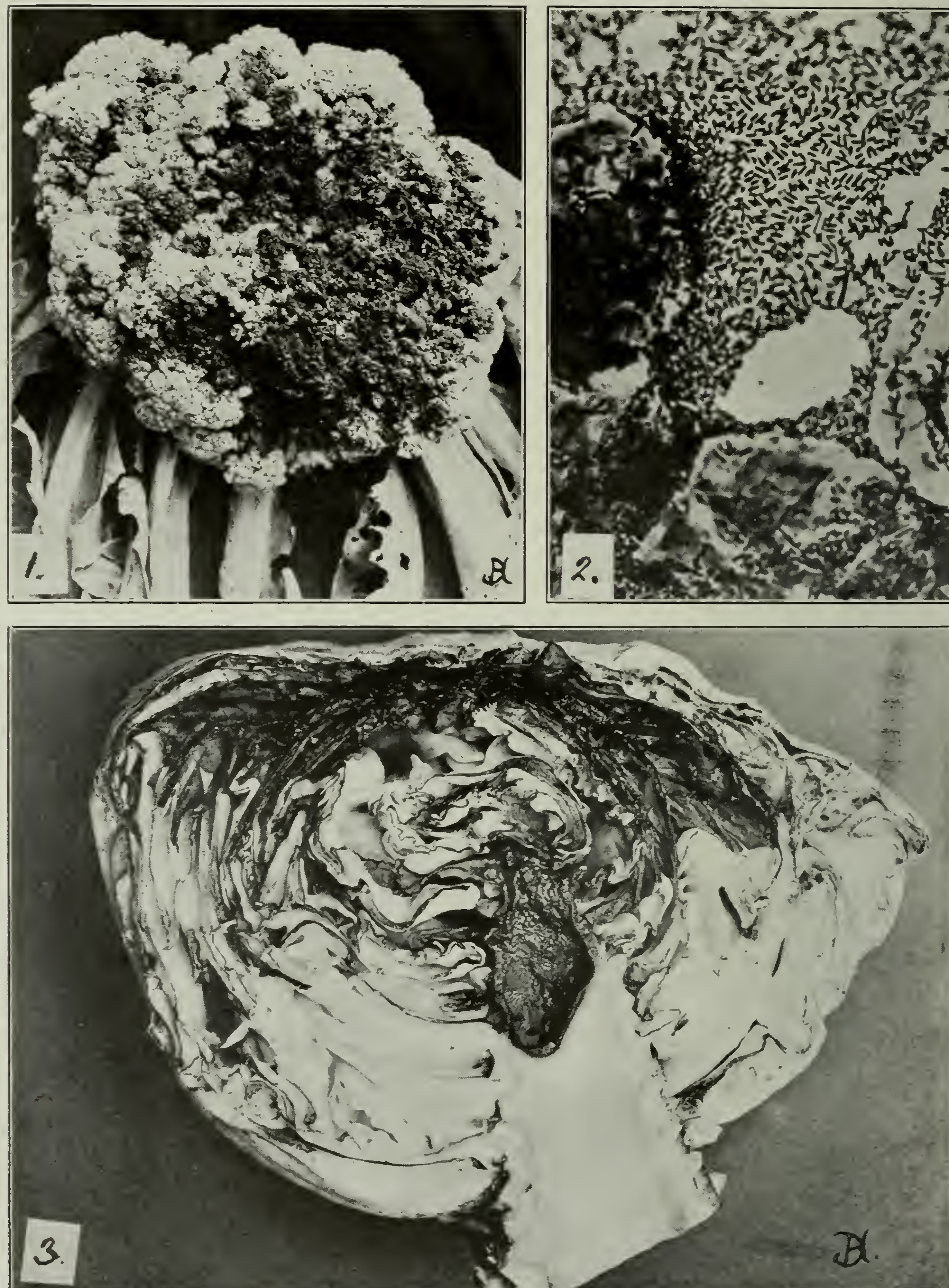
Bacterial Soft Rot of Vegetables.

Bacterial soft rot is a disease liable to attack fleshy vegetables and flowers, particularly carrots, cauliflower, turnips, celery, tomatoes, potatoes, German iris and calla lily, and in a lesser degree onions, asparagus, salsify, sugar beet, mangel, muskmelons, rutabaga, and some others. Occasionally the disease results in heavy losses to the grower of these crops.

General Appearance of the Disease.—As the name signifies, the disease results in a soft, wet rot of the plant attacked. The rotted portion of the plant is darker in color than the rest of the plant. The color of the diseased part varies from a light, reddish brown to a very dark brown.

The Cause of the Disease.—The cause of the disease is a bacillus which has been given a variety of names by different men, who at different times in various countries have studied the disease in different species of plants. Prof. L. R. Jones, of Vermont, studying the disease in a crop of carrots, named the causal organism *Bacillus carotovorus*. Prof. Harrison, of Ontario, studying the disease in an outbreak in a crop of cauliflower, named it *Bacillus oleraceae;* Prof. Potter, in England, studying the disease, found it to be destructive to quite a number of varieties of plants, and named it *Pseudomonas destructans;* N. J. Giddings, of Vermont, studying the disease in a crop of melons, named it *Bacillus melonis;* C. O. Townsend, of Washington, studying the disease in a greenhouse of calla lilies, named it *Bacillus aroideae*. More recent investigations have shown that the disease is practically one and the same in all the plants mentioned. While to the bacteriologist there may be a few slight differences in the nature of the bacillus causing the disease in the melon from that causing the disease in the lily, or that causing the disease in carrots, turnips and cauliflower and other vegetables, yet the disease is for all practical purposes to the horticulturist one and the same—a soft, wet rot of the plant attacked.

Histology of the Disease.—When the *soft rot bacillus* gets on to a freshly made wound, either small or large, in plants liable to the disease, it feeds on the plant juice which emerges on to the wounded surface, and on this it grows and rapidly multiplies. As it multiplies it produces digestive enzymes, e.g., cytase, which digests cellulose; diastase, which digests starch; and proteolytic enzymes, which digest proteids. These are diffused through the living bacterial cells and act upon the healthy vegetable tissue around them, making it soluble, to be used as food material by the bacilli. The action of these enzymes is greatest on the middle lamellae, i.e., the thin strip of tissue which lies between the walls of adjacent plant cells. The lamellae are quickly dissolved and form good food for the multiplying bacilli, which, as they multiply, pass along between the cells, filling the intercellular spaces and separating the cells from one another. The protoplasm within the plant cell is plasmolised, that is, it is made to shrink from contact with the cell walls and to contract into an irregular mass within the cell by the action of the enzymes produced by the bacilli in the intercellular spaces. In this way the collapse of the tissue is brought about, and such tissue constitutes the rotted part of the plant.



Bacterial Soft Rot of Cauliflower and Cabbage. (Original.)

1. Bacterial soft rot of cauliflower, natural infection; specimen taken direct from garden.
2. *B. carotovorus*, the vegetable soft rot bacillus seen between cells of broken-down, rotting cauliflower. (X 1,000 di.).
3. Bacterial soft rot of cabbage. Artificial stab inoculation of a pure culture of *B. carotovorus* in healthy cabbage. Photo taken twenty days after inoculation.

In *cauliflower* the disease is found more often in the flower than in the leaves or stem; the latter parts, however, are also subject to attack.

The disease in the flower is very easily noticed, the normal color of the flower being white or creamy and that of the diseased portion light to dark brown and very soft, and having an offensive odor. The writer has noticed a number of times dark brown areas, varying in size, which looked at first sight like soft, rotted areas, but which on investigation proved to be discolorations due to excreta of cabbage caterpillars which had been feeding on the leaves overhanging the flower. In such cases the tissue immediately below the surface of the discolored area is not softened as it is in the case of the rot, and the discoloration is only on the surface. Observations have shown, however, in a number of such cases that the rot has later developed, within such discolored area, thus indicating that in all probability the caterpillar had previously been feeding on a rotted plant, and all the bacilli in the portion consumed had not been killed in the process of digestion, but had passed through the alimentary tract of the caterpillar with the excreta, or that the mouth parts and feet of the caterpillar had been contaminated from a diseased plant, and on crawling over the surface of the healthy plant had inoculated it.

In the stem the disease results in a complete softening of the interior, the softened tissue becoming a dirty grey in color, with strong odor. The disease may enter the stem from injury to the exterior caused by the breaking of leaves, or the biting of insects, slugs and caterpillars during cultivation, etc., and from the stem pass up into the flower, or the stem may become so far rotted that the head will fall off. The stem may also become infected through the flower.

In the leaves the disease is more often found in the petiole, or midrib, rather than the blade. It appears as a dirty grey softened area, which, when in the petiole, soon results in collapse of the leaf.

In *turnip,* the disease most frequently enters at or near the crown, through caterpillar or slug attack, or through injuries received during hoeing or cultivation. It softens or rots the leaf petioles at their base, causing them to fall over, and spreads slowly in dry weather, rapidly in wet weather, through the tissue of the root, inducing a brown-colored soft rot, with strong odor.

In *carrot* the disease enters and develops in much the same way as described for the turnip. It is more apt to spread rapidly through a crop that is thickly sown and not well thinned out, the shade produced by the heavy tops making ideal conditions by keeping the ground moist for the development of the disease when once it gains entrance, and harboring slugs and caterpillars that spread the disease. Carrots which crack beneath the ground are liable to be attacked by the disease, the soft rot bacillus gaining entrance to the tissues through the cracked surface.

In *celery* the disease is not very common, but when present is most often found starting at or near the tops of the young growth. The affected parts become dark brown and very soft and mushy. The parts so affected cease growing, the growing tips being destroyed, and the disease slowly passes down the stem, completely rotting the tissue as it progresses. If the disease starts below the end of the stem, the upper part soon topples over as a result of the softening of the part attacked. The disease spreads from plant to plant through the agency of slugs, caterpillars, etc., and during the process of handling when cultivating and banking up. When the plants are stored away for winter use, if a plant having the disease is stored with the healthy plants, the rot is liable to spread to the healthy specimens.

In *tomatoes* the bacterial soft rot is very common during wet seasons. It is found most frequently in the fruits that are in contact with the soil after they have commenced to ripen. The bacillus will not readily penetrate through the unbroken

Bacterial Soft Rot in Turnip. (Original.)

1. Turnips direct from field badly affected with bacterial soft rot. Shaded areas were soft, pulpy and strong smelling. Evidently inoculated near the crown, probably through wounds made by slugs or caterpillars or during cultivation.
2. Soft-rotting turnips direct from field, in which the disease had been prevalent the previous year. These had evidently been inoculated from the soil through wounds made while hoeing or cultivating.

skin of the tomato. But when a tomato is resting on the damp earth, that part of the skin in contact with the soil is frequently weakened, thus providing a means of access to the bacillus. This, however, is not the only means whereby the disease enters the fruit. Slugs are very partial to tomatoes just ripening. In their attack on the fruit they eat through the skin, leaving the interior flesh exposed. This exposed surface is an ideal medium for the bacillus of soft rot to develop in. The writer has found many tomatoes, particularly in wet seasons, when slugs are plentiful, that have contracted the disease in this way.

Eradication and Control of the Disease.—Spraying with fungicides, which is so effective in controlling the fungous diseases of plants, is of no avail with bacterial diseases, as the bacteria which cause the disease act in the interior tissue rather than on the surface; hence the spray will not reach them.

Spraying with insecticides is helpful indirectly, as it tends to keep in check the insects, slugs, caterpillars, etc., which are one of the most common means of spreading bacterial diseases from one plant to another.

As a rule, the best method to adopt in dealing with a plant infected with bacterial disease is to carefully remove and burn it. Insects, garden tools, etc., coming in contact with it will spread the disease to the plants with which they come in contact later. This is particularly the case with the bacterial soft rot of plants, as the affected tissue is so very soft and pulpy that it cannot be touched without heavily contaminating whatever touches it.

Again, if affected plants are allowed to remain on the ground they infect the soil with the organisms of the disease to such an extent as frequently to cause the disease to establish itself in the succeeding crop of any plants which are susceptible to the disease, but particularly plants of the same species.

Some time ago we received for examination a box of rotting, half-developed turnips from a farmer, who said that five per cent. of his crop were similarly affected. Upon inquiry, we found that the affected ones were growing on soil on which turnips had been grown the year previous, and 25 to 30 per cent. of these, having been affected with the same rot, had been allowed to remain on the ground at harvest time, and later were plowed in. It was evident that the soft rot bacilli from the diseased turnips had remained alive in large numbers in the soil, and that many of the turnips of the subsequent crop had been inoculated with these bacteria during cultivation, and possibly by insect attack also. The hoe or the teeth of the cultivator would get contaminated from the soil, and the accidental wounding of a turnip with such an implement would result in the inoculation of the turnip with the germs of the disease.

Another man sent a head of celery for examination, which we found to be suffering from the bacterial soft rot in the young growing tips. In reply to our enquiries, he sent word as follows: "I had celery on this ground two years ago, and the row that was where the rot is worst now was so bad that I lost all, but only that row was affected. This year two rows have it, but one a great deal worse than the other. There were five rows in this patch, all planted about the same time. The healthy rows matured away ahead of the two which were diseased." Here it is evident that the soft rot bacteria had remained in the soil for two years, and that cultivation had spread the bacilli to some extent through the soil, as on the second occasion that celery was grown on that patch the plants in two rows developed the disease.

The writer had under observation a garden where turnips and carrots were both affected with the bacterial soft rot. The affected plants were not removed, but were dug in. The next year tomatoes were planted on the same ground. The disease did not develop in the growing plants, as care was taken not to wound them. However, about 60 per cent. of the fruit became affected before it was fully ripe. The affected specimens were either those that were in contact with the soil or had been bitten by slugs. The soft rot bacteria, which cannot penetrate through the sound skin of a tomato, found entrance through the slug bites, or through the weakened skin that had been in contact with the soil.

Therefore, in order to prevent losses from bacterial soft rot of plants, remove and burn affected plants, or parts of plants, as soon as observed; be careful during cultivation not to wound plants, and keep caterpillars, slugs and biting insects in check. Affected plants should never be put on the compost heap or manure pile.

Harvesting and Storing.—When harvesting and storing turnips, cauliflower, cabbage, celery, tomatoes, or other vegetables from crops in which the disease has been present, great care should be taken not to include any specimen that shows the slightest appearance of the disease, or to smear the healthy specimen with the soft, rotted parts of diseased specimens. If these precautions are neglected, the disease is liable to establish itself and spread more or less rapidly through the entire crop stored.

Black Leg and Soft Rot of Potatoes.

Causal organism—*Bacillus solanisaprus* (Harrison); *B. phytophthorus* (Appel).

As the name of this disease implies, there is a darkening of the lower stems and soft rot of affected plant. The discoloration may range from brown to black; usually it is dark brown. It is most often found below the soil surface from the seed tuber up, but may extend upwards an inch or two above the soil. The discolored part shrinks and is liable to rot.

The disease affects young plants more particularly and kills them off early in the season. A disease of this character is common in Europe, particularly in Germany, where it has been known for years. It is considered that it was introduced to the American continent from Europe on imported seed. It is spreading rapidly in Canada and the United States.

Symptoms.—The tops of plants affected with the disease lose their bright green color, which fades away to a brownish or dirty yellowish green, presenting a withered and drooping appearance. On examining the lower stems of such plants, the brown or black discoloration will be noticed. In many cases such discolored tissue will be soft rotting, and an examination of the seed tuber usually shows it to have rotted away, with a soft, slimy, wet rot, often nothing but the skin being left. The soil underneath such a rotted seed tuber appears as though it had been wet puddled, due to the rapid extraction of water from the seed tuber during the rotting process. A microscopic examination of the soft rotting tissue, both in the seed tubers and the stems, shows large numbers of bacteria, usually several species being found in the older rotted parts.

If a number of shoots arise from an affected seed tuber, it is likely that one or more of them will develop the disease at an early date, while the others will flourish for a time and be apparently healthy. As they grow they will produce tubers, and, should the season be dry, these may reach maturity without being seriously affected. If the season is wet, however, the disease is most liable to spread to the healthy stems and tubers, thus establishing a soft, wet, slimy rot of the entire plant, tubers included.

In other cases of so-called black leg, where the stem of the plant is badly discolored, the soft rot may not be in evidence. A microscopic examination of the

Black Leg of Potato. (Original.)

discolored epidermis shows no bacteria, but strands of fungus mycelium, most of which presents the typical appearance of the fungus, *Rhizoctonia,* a species of fungus which is responsible for the root rot or canker of many vegetables. In some cases potato plants so affected appear later to get the better of the disease. That is, they do not die down or rot off; or, if some stems on the hill which are the worst affected die down, other stems not so badly affected, or not affected at all, develop apparently all right. However, later in the season, when the crops are harvested, hills which have very vigorous tops, heavy foliage and thick stems, may have also aerial tubers, that is, tubers as very irregular swellings on the stems above ground, and usually a large cluster of very small malformed tubers crowded together at the surface of the soil. Examination of the underground stems of such plants usually shows discolored, brown shrunken areas, which evidently have been affected by the *Rhizoctonia.* The theory which has been advanced regarding the formation of such heavy top growth and the production of aerial tubers on the stems of the plant, with large clusters of small malformed tubers at the crown, is that the growth of the fungus on the stems of the plant interferes with the transmission of the reserve food substance manufactured in the foliage which, under normal conditions, is returned to the roots, where it forms the tubers. The injury to the underground stems caused by the *Rhizoctonia* prevents the passage of this reserve food material to the usual parts of the root system and forces its deposition in abnormal places, either at the surface or above the surface of the soil in the shape of malformed tubers, which are usually small and numerous.

In many cases of the bacterial soft rotting type of black leg, the writer has found on the epidermis of the discolored stem, interlacing strands of *Rhizoctonia* mycelium. It is possible that this fungus is the primary cause of most cases of this disease, and that the bacterial soft rotting of the affected tissue in such cases is secondary, owing to an invasion of the weakened epidermis by the decay bacteria common in the soil.

The disease is most common in wet, backward seasons, when the resistance power of the young growing plant is low.

Control of the Disease.

1. Do not plant potatoes that show any brown discoloration. brown or black scab, or other indications of either wet or dry rot.
2. Plant in well-drained land.
3. Destroy by burning all diseased plants and tubers.

Bacterial Wilt of Cruciferae.

(Black Rot of Cabbage, Turnip, etc.)

Causal organism—*Ps. campestris.*

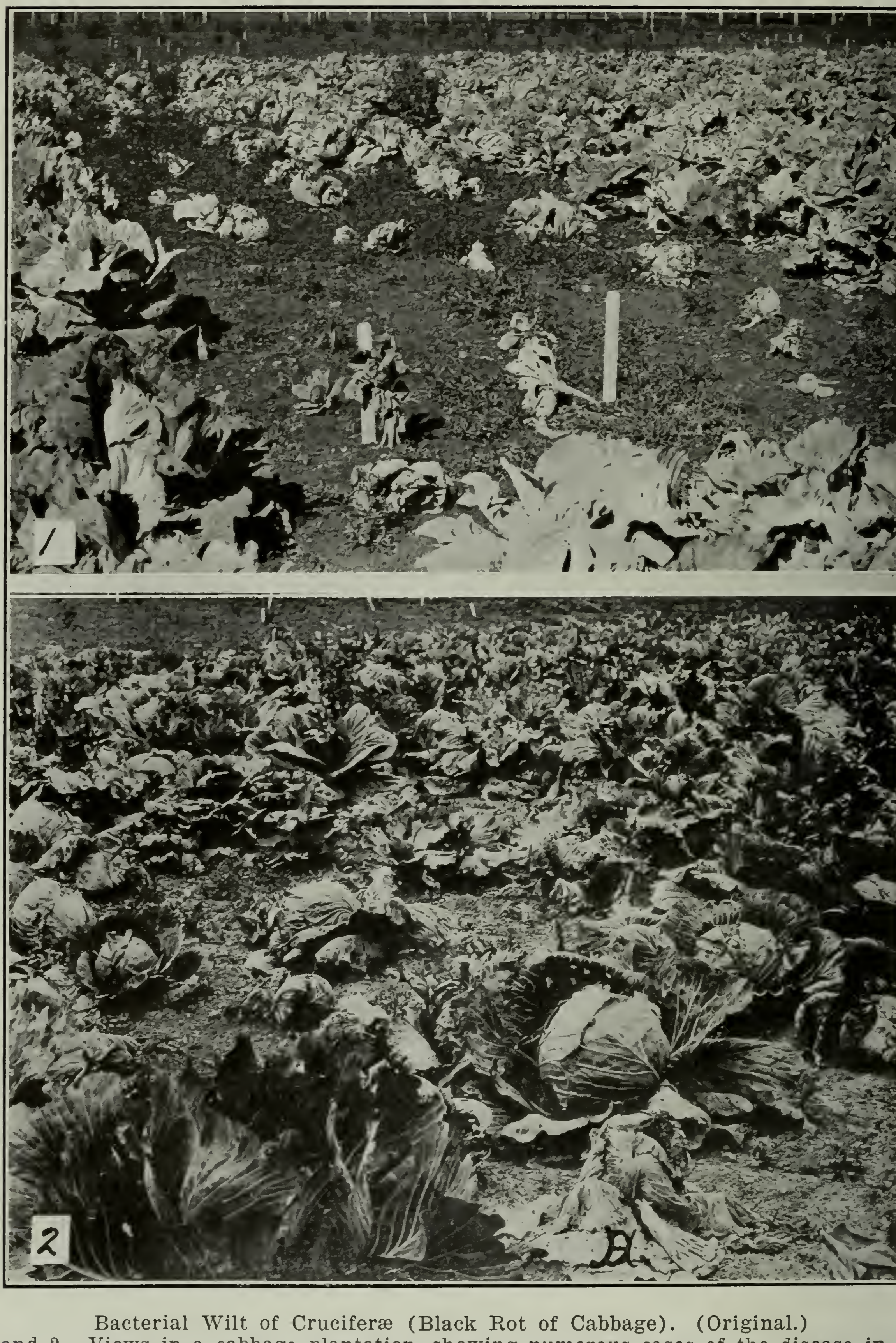
This wilt, commonly known as Black Rot of Cabbage and sometimes as Brown Rot, is a very bad disease and causes much loss to the kitchen gardener. It is found attacking many cruciferous plants, including cabbage, cauliflower, collards, kohl rabi, brussels sprouts, broccoli, turnips, wild radish. and mustard. the latter. unfortunately, only to a very slight extent.

It is widely distributed, occurring throughout Canada, United States. Great Britain, Holland, Germany, Denmark, Austria, France, Switzerland, and other countries.

Appearance of the Disease.—In the growing cabbage plant the disease manifests itself as a yellowing or browning of the leaves. This yellowing occurs in

Bacterial Wilt of Cruciferæ (Black Rot of Cabbage). (Original.)

1. Cabbage leaves affected with the bacterial wilt or black rot. The lighter-shaded areas around the outer edge of the leaves are the diseased parts showing natural inoculation through the water pores on the edge of the leaves; the light-shaded areas were yellow.
2. The lighter shaded part of the leaf near the base indicates the disease, and the blackened vascular bundles of the stem, where it is cut, indicates that the disease entered this leaf from the main stalk of the cabbage.
3. Cabbage stalk and stunted head; the blackened vascular bundles indicate that the disease was general throughout the plant. The leaf of Fig. 2 was taken from this plant.



Bacterial Wilt of Cruciferæ (Black Rot of Cabbage). (Original.)
1 and 2. Views in a cabbage plantation, showing numerous cases of the disease in all stages of development.

irregular areas sharply defined, which gradually enlarge until the whole leaf becomes browned, wilted and shrivelled.

If the plant be attacked by the disease when young it will not develop normally, but will be dwarfed, and will present a pale, sickly appearance, and often no head will be produced in the case of a cabbage, and no bottom produced in the case of a turnip.

The browning and wilting of the leaves is due to the supply of sap being cut off in the veins and midribs that are situated near or within the brown areas.

If the midrib of a diseased leaf or the veins leading from a diseased part of a leaf be cut, it will be noticed that the vascular bundles or fibres are black or dark brown, instead of yellow or white. This discoloration is due to the presence and action of immense numbers of the disease-producing bacteria within the veins or fibro-vascular bundles. Here they feed on the sap, multiply rapidly and choke up the passages, so that the supply of sap is cut off from the surrounding tissue, thus causing it to yellow, wilt and die.

If the whole head of cabbage be yellowish, sickly, and wilted, or if several leaves of a cabbage present such an appearance, a section of the stalk, either cross or longitudinal, will almost invariably reveal the disease in the blackened vascular bundles forming the vascular ring, the woody portion of the stem. In such a case the germs will have spread almost throughout the entire vascular system of the plant, passing down the veins of one leaf into the stem, where they would pass both up and down the veins of the stem, to veins of other leaves, until the whole plant became affected and worthless.

Means of Infection.—Infection is most common at the water pores around the margin of the leaf. In the early morning, especially in moist weather, dew-drop-like beads of water may be noticed around the leaf margins of growing cabbages. This is usually water of transpiration, given off by the plant through the water pores. If the atmosphere were dry, this water would not be found there, as it would evaporate as soon as it came to the surface of the plant. But when the atmosphere is moist this evaporation does not take place, and so the water extruded from the pores forms little beads.

Should the disease germs by any chance get into these drops of water, it is very easy for them to enter the vascular system of the plant through the open pores. Thousands of cases where such has been the means of entrance of the germs into a plant have been observed.

The question remains: How do the germs get into the drop of water? This may occur in several ways. Slugs and caterpillars crawling around after feeding on or crawling over a diseased plant may carry and deposit the germs wherever they crawl on the healthy plants. The cultivator, in passing along the rows, may brush against and wound a diseased plant and some of the germs thus get onto the cultivator, and so be carried along and brushed off on healthy plants. In transplanting, the hands of the workman may become contaminated from handling a diseased plant, and plants subsequently handled have the germs deposited on them from the hands of the workman. Even should the plant be dry at the time it is so contaminated, the germs may remain alive on the plant for days, until the right conditions occur, that is, sufficient moisture be present in the atmosphere and in the soil to allow of the formation of water drops at the water pores when infection would take place.

Again, biting insects, caterpillars, slugs, and other forms of animal life which feed on growing cabbages, may, after feeding on a diseased plant, inoculate directly a healthy plant by biting through one of the small leaf veins and depositing there some of the germs adhering to their mouth parts after their visit to the diseased plant. Such means of inoculation have been observed again and again. Caterpillars and slugs, feeding on diseased leaves, have been transferred by hand to healthy plants and in a large percentage of cases the disease has subsequently developed in the healthy plants at the point where the caterpillar was placed.

Infection through contaminated seed may occur. By a series of experiments, conducted at the New York Experiment Station, Geneva, it has been proven that the germ can live on dry seed for longer than nine months. Such contaminated seed when germinating is liable to infect the young plant, and cases of such infection may occur in seed beds.

Again, seed beds are often badly contaminated with the germ by spreading on them material from the manure pile or compost heap, where diseased plants have been deposited to rot. And while it is very doubtful that the germ enters the plant through the root hairs, any injury to the root, or leaves that are near the ground, may result in the inoculation of the plant with the disease. Caterpillars and slugs crawling over such soil would be very liable to inoculate the plants growing there by crawling over and feeding on them.

Control of the Disease.—The best way to keep the disease under control is to prevent its development.

Disinfecting the Seed.—It was proven at the Geneva station that germs on the seed may be killed without any injury to the seed by soaking it for fifteen minutes either in a corrosive sublimate solution or in formalin.

If corrosive sublimate is used, the strength of the solution should be one part corrosive sublimate to one thousand parts of water. The most convenient method of preparing this solution is to use the corrosive sublimate tablets sold by druggists for making disinfecting solutions. One tablet, costing one cent, is sufficient to make a pint of solution, which is about the quantity required to treat one pound of seed. The seed should be soaked in this solution fifteen minutes, and then spread out to dry.

If formalin is used the strength of the solution should be one part formalin (40 per cent. formaldehyde), to 240 parts of water, and the seed soaked for fifteen minutes.

A convenient method of treating the seed is to place it in a small bag, made of any loose cloth readily penetrated by water, and suspend the bag in the disinfecting solution for the required length of time. The seed should be dried without delay in the shade.

Handling Diseased Plants.—Should the disease be noticed among seedlings in the seed bed, the diseased plants should be removed and burned. If they are not burned the germs within them are liable in many ways to get transferred to the healthy stock, and so the disease be spread instead of being checked.

Seedlings that show signs of the disease should not be planted out. It is not usually of much service simply to break a diseased leaf from what appears to be an otherwise healthy plant. If the disease is confined to the marginal areas of the leaf entirely, then breaking off the leaf would prevent the rest of the plant from developing the disease. But, should the vascular bundles in the midrib of the leaf at the point of its contact with the plant stalk be discolored brown or black, we may take it for granted that the germs are already established in the vascular bundles of the stalk. So, after breaking off a diseased leaf, one should look to see if any discoloration of the vascular bundles exists, and should there be any, the whole plant should be destroyed.

If an entire bed, or a considerable portion of a bed be badly attacked, all the plants should be pulled and burnt and the broken leaves, etc., raked up and burnt also. Cabbage or turnips should not be planted again on such ground for one or two years.

Insects and caterpillars, slugs, etc., should be kept in check, as they are noted carriers of the disease germ by feeding on diseased plants and then going to healthy plants.

Bacterial Wilt of Cucurbits.

Causal organism—*Bacillus tracheiphilus.*

This will often cause serious losses to the growers of cucumbers, squashes, melons, and other cucurbits. Whole plantations of these plants are sometimes completely destroyed, and the disease will pass rapidly through a house of cucumbers.

A diseased plant loses its bright green color and turns to a dull, dirty yellowish green. The leaves and stems become flaccid and droop, hang down limp and lifeless, having lost all turgidity. The fruit, when affected, becomes soft and appears somewhat water-soaked, and if squeezed will readily yield to pressure, and often under such treatment the skin will rupture and a slimy, clear liquid will ooze out. If this liquid is touched with the finger or any instrument, it will be found to be viscid, slimy or gummy, and will string out in long strands. If a diseased stem is broken or cut, similar conditions will be found to exist, i.e., the plant juice will be viscid, slimy and will string out in long strands when the cut surface is scraped with a knife or rubbed with the finger.

This sliminess or viscidity is the most characteristic feature of the disease, for a plant may wilt for lack of moisture and present an appearance something like a diseased plant. But if such a plant be cut and its juice expressed, this juice will prove to be quite watery and will not draw out in threads.

A microscopic analysis of the slimy juice from a diseased plant will show millions of bacteria within the smallest drop that can be obtained; while a similar preparation made from the juice of a healthy plant or a plant that has wilted merely from the lack of moisture will not show a single germ.

If a little of this slimy juice from a diseased plant be transferred on the point of a needle to the inner tissue of a healthy plant, by puncturing the healthy plant with the contaminated needle, in a day or two the plant will wilt, the bacteria inserted on the point of the needle having multiplied so rapidly and spread through the vascular system of the plant.

Pure cultures of the germ on artificial media are rather difficult to obtain as the germ will not grow readily on the ordinary media. However, pure cultures have been obtained on special media, and these inoculated into healthy plants have rapidly produced the disease.

In the stem and leaf the disease germ is found mostly in the vascular bundles, in the plant juice of which it lives and multiplies rapidly, spreading up and down and plugging the sap channels. Eventually the walls of the vascular bundles are broken down and the organism gets into the surrounding tissue to a limited extent.

The flesh of diseased fruit is transparent and water-soaked in appearance.

The plant juice in all affected parts becomes slimy or viscid and strings out in long strands.

Methods of Spreading.—1. The disease is spread from plant to plant mostly by biting and sucking insects, particularly the striped cucumber beetle and squash

Bacterial Wilt of Cucurbits. (Original.)

1. Bacterial wilt of cucumber.
2. Bacterial wilt of cucumber.
3. Bacterial wilt of squash.
4. Stained microscope preparation from the viscous slimy exudate of a vascular bundle of a wilting cucumber plant, showing the bacteria (*B. tracheiphilus*). **(X 1,000 di.).**

bug. These insects, after feeding on a diseased plant, have their mouth parts covered with the germs of the disease and on subsequently feeding on healthy plants, they inoculate the healthy tissue with the disease.

2. The gardener, in removing and destroying the diseased plants, cannot help but get his hands and the tools used badly contaminated with the disease germs, even when exercising the greatest care, and so, if he does not take the precaution to disinfect his hands and the tools used before handling any healthy plants, he is very likely to inoculate them with the germs of the disease.

Methods of Control.—All diseased plants should be carefully removed and burned immediately. If they are allowed to lie around, insects will swarm about them, get themselves contaminated with the germs and thus spread the disease wherever they go.

Hands and tools used in removing and destroying diseased plants should be thoroughly disinfected by washing them in five per cent. carbolic acid, or in corrosive sublimate of a strength one to one thousand, or some other good disinfectant.

Biting and sucking insects, especially the striped cucumber beetle and squash bug, should be kept under control by spraying and hand picking.

Bean Blight.

(Bacteriosis of Beans.)

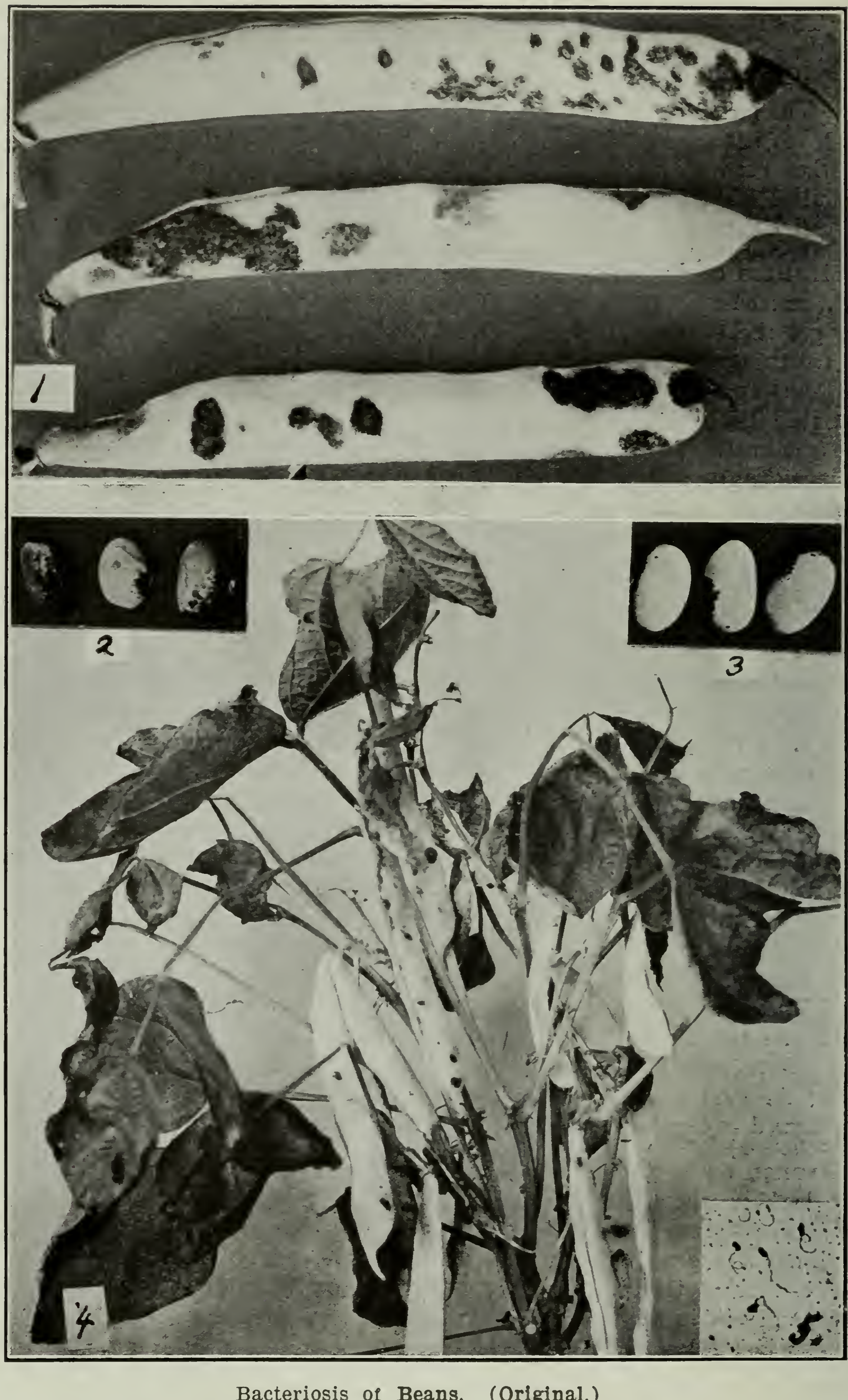
Causal organism—*Ps. phaseoli* (Smith).

Whilst there has been no record of heavy losses from this disease in Ontario, we get every year bean plants suffering from the disease forwarded to us. Letters accompanying these plants often state that considerable damage was done to fields from which the plants were taken, many plants being attacked in the same way. Scarcely a season passes but what more or less of this disease is present in the beans of the College garden and in the bean plots in the experimental grounds. In the United States, where wax beans and lima beans are grown extensively, heavy losses are caused by the disease, and it is getting more general in Ontario.

The disease may be found on the foliage, the stems, the pods, and the beans within the pods. At first the disease on the pods appears as small, water-soaked areas. These areas gradually enlarge and usually are outlined by a reddish-brown border. As the disease progresses and the areas continue to enlarge, the whole of the affected area becomes a light brown, and does not develop the black or pink color or the sunken spots produced by anthracnose. The foliage becomes spotted and yellowed in large areas of the leaf surface, soon withers and falls away.

Method of Infection.—*Leaves.* The disease usually begins at the margin of the leaf, or where the leaf has been torn by insects, wind or hail. Here the germs find entrance into the plant tissues through the wound. A yellow spot is formed and the green color destroyed. The spot increases in size rather slowly, and the diseased tissue becomes brown and papery, turning dry and brittle in the sun and soft in the rain, and then is often torn away, leaving ragged margins and holes in the leaf. The whole leaf may die and fall to the ground or remain withered on the stem.

Stems and Pods. The disease usually enters the stem by way of the leaf stalk, and advances in the stem to other leaves and to young pods. In severe cases the pod may wilt and die. and on opening it the half-grown seeds will be found shrivelled and discolored by irregular brownish areas. outlined by the characteristic red-



Bacteriosis of Beans. (Original.)

1. Diseased pods.
2. Diseased beans from diseased pods.
3. Healthy beans.
4. Bean plant badly affected with bacteriosis in foliage and pods.
5. *Ps. phaseoli.* the cause of the disease.

dish-brown margin. The beans may be apparently sound or only slightly discolored, or they may be much discolored. The whole plant does not usually die outright, but lingers through the season. Separate infections may occur at any place on pod or stem.

Seed Beans. In germination tests of diseased beans, less than half the number sown germinated. The remainder rotted. Those that germinated never produced healthy plants, but plants that were weak and soon wilted. Healthy seed sown under the same conditions germinated ninety-eight per cent., and produced vigorous, healthy plants.

The germs live over winter in the bean tissue and infect the plant on germination.

In appearance the diesase is somewhat similar to bean anthracnose or "pod spot" caused by the fungus *Collitotrichium lindimuthianum,* but this latter may be distinguished by its making rather deep pits in the affected areas which are pinkish and produce spore-bearing pimples.

Eradication and Control.—Do not sow seed from diseased plants. Do not sow seed that is shrivelled or has a brown varnish on surface. Remove infected plants and burn them.

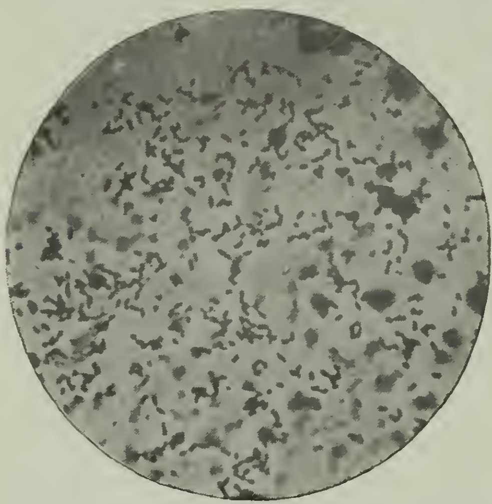
"Fire Blight," Pear Blight, Bacterial Blight of Apple, Pear and Quince Trees.

The disease which is known under the various names of Fire Blight, Twig Blight, Blight Canker, Pear Blight, and possibly others of local application, is of long standing on the North American continent. It has wholly destroyed many pear orchards, and has been very destructive to the apple and quince crops in nearly all parts of Canada and the United States, where these fruits are cultivated. Other trees besides the apple, pear and quince, both cultivated and wild varieties, subject to the disease, are the hawthorn (cratægus), June berry (Amelanchier) and the mountain ash (Pyrus).

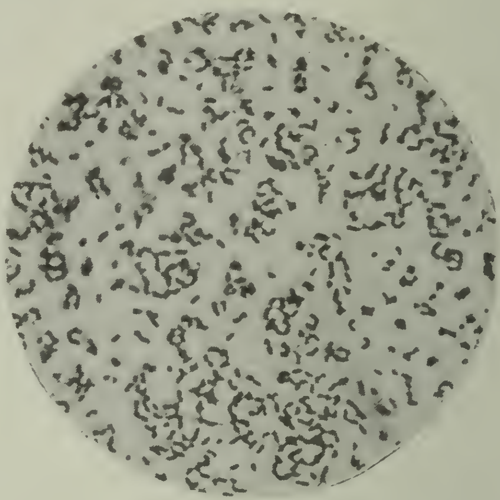
The disease is caused by *Bacillus amylovorus* (Burrill), and is confined mainly to the growing bark which becomes cankered and then dies as a result of the bacilli multiplying rapidly between the growing tissue cells and later within the cells of the affected area.

General Appearance of the Disease.—The disease may occur in the bark of the twig, fruit spur, branch or trunk of the tree and also in the fruit, more especially in immature fruit. Any one or all of these parts in the same tree may be affected, and the disease may spread from one part to another.

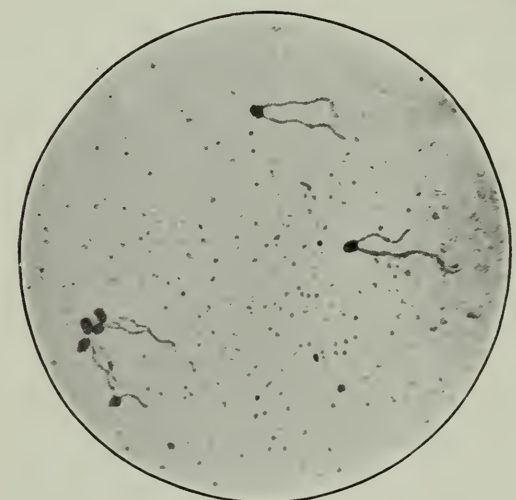
The disease is found on the apple tree more often in the form of twig blight, and on the pear tree in the form of body blight. Cases of body blight, however, occur in apple trees and cases of twig blight occur in pear trees. The reason that body blight is more common in pear trees appears to be because the bark of the pear tree is more spongy, thicker and more juicy than is the bark of the apple tree, and these conditions are most favorable for the rapid and continuous development of the organism. These conditions exist in the young growth, i.e., the twigs, water sprouts and suckers of the apple tree; hence when the organism finds entrance to these parts the disease develops there and passes up or down the affected part until it meets with adverse conditions, which it usually finds in the bark of the larger branches or the trunk of the tree at the end of the growing season. And so, as a rule, it is only the young growth of the apple tree that is destroyed by the disease, and the tree affected survives the repeated attack from year to year, until eventually it may become so impoverished from having its young growth annually killed that it will cease to be profitable and so call for removal. The disease, too, may find suitable conditions in the apple tree for its continued development in the bark of the large limbs and trunk where it causes large "blight cankers" com-



B. amylovorus, a smear preparation made by macerating a little of the inner bark of a diseased apple twig from which the viscid liquid was oozing.
Stained carbol fuchsin. X 1,000. (Original.)



B. amylovorus, smear stain from colony on agar four days old.
Stained carbol fuchsin. X 1,000. (Original.)



B. amylovorus stained to show flagella; made from an agar culture seven days old.

Moore's modification of Loeffler's flagella stain. X 1,000. (Original.)

Typical blight canker at the base of a water-sprout on the main limb of an apple tree, O.A.C. orchard. The water-sprout had been inoculated by aphids coming to it from a diseased tree. (Original.)

pletely girdling the affected parts and so destroying them, and thus causing the death of the tree. With the pear tree, on the other hand, as already stated, the disease, when once it gains entrance, usually spreads rapidly; it may destroy a tree in one season, and usually three years is the limit of life of a tree after it has once contracted the disease unless radical measures are taken to remove all affected parts.

The Disease in the Twig.—This phase of the disease is known as twig blight, or fire blight; the latter because a tree so affected looks as if it had been scorched by fire. It may occur in blossom twigs, foliage twigs, water-sprouts and suckers. The blossoms and leaves of affected twigs become discolored, turning light or dark brown, sometimes red, shrivel up and die, and remain attached to the twig sometimes throughout the winter.

This discoloration and death of the leaves and blossoms occurs comparatively suddenly, and may occur at any time from May to September. The suddenness of its appearance is somewhat disconcerting to the fruit grower, who may walk through the orchard one day and find his trees looking apparently all right, but in visiting them again a few days later he finds many blossoms and leaves dry, brown and shrivelled. This discoloration and death of the leaves and blossoms does not mark the beginning of the disease, but rather its last stages in those parts so affected, and the disease will have been present in such twigs several days, often a week or more, before it is noticed by the casual observer. Hence, the disease is not so sudden in its onslaught as is popularly supposed.

If the bark of twigs that bear the discolored leaves and blossoms be cut and examined, the affected area will be found to be shrunken and discolored a dark reddish brown, or purplish. Sometimes the bark will be blistered and often on such blistered areas there will be present the somewhat dried remains of a gummy exudate. This gummy exudate bursts through the blistering areas or oozes through the pores of the bark when the disease is actively progressing in an area that is well charged with sap. On first appearing, the exudate is transparent and almost colorless, but as the moisture evaporates from it, it becomes first amber color, then brown, and finally a dark reddish brown when dry.

This exudate is literally crowded with the germs of the disease, and if by any means, either by insect, workman's tools, or careless handling of diseased parts, it finds entrance to the bark of a healthy tree, there the disease will develop.

The disease usually begins at the tip of the twig or in the blossom and works downward. The bacillus lives in the intercellular spaces and cells of the inner bark, feeds on the cell contents, and, as it develops and multiplies, passes along from cell to cell, destroying the tissue as it progresses. It may travel down the twig at the rate of from a quarter of an inch to two inches a day, the rate of its progress depending largely upon the succulency of the twig and the atmospheric temperature. The more juicy the twig, the more rapid the development, and warm days are more favorable to the progress of the disease than cold days.

On reaching the base of the twig, the disease may pass into the branch bearing the twig and from this point it may progress both up and down the branch. It often girdles the branch, and when such girdling occurs the flow of sap is prevented from reaching the upper part of the branch, which consequently slowly dies for lack of nourishment. The appearance of the leaves, fruit, and bark of a branch so affected is different from that of the same parts on diseased areas themselves. The leaves slowly lose their green color, the fruit slowly dries up, does not become decayed, soft and pulpy, and the bark does not discolor and shrink so rapidly as does bark that is diseased. If a portion of diseased bark be stripped from the twig with a knife, the brown discoloration will be found to extend right through the bark, and the surface of the wood itself is usually stained the same hue. The bacteria will be found to extend in all directions within the bark some distance beyond the discolored area.

The Disease in the Fruit.—The disease is often found in immature, but seldom found in mature fruit. It may find entrance to the fruit by way of the peduncle from a diseased twig or fruit spur, in which case the disease would spread from the core outwards. Or it may find entrance by puncture of the skin by insect or other means, when the disease would work from without inward. Such cases have not been observed to be numerous, though some such were examined, and experiments in the laboratory showed that puncturing the skin of a young apple with a needle dipped into the gummy exudate from a diseased tree, or into a pure culture of the germ, resulted in the complete destruction of the fruit in from two to three weeks. Mere contact of the germ on the fruit, however, did not result

Blighted apple twig; inoculation through blossoms on the two end spurs, presumably by bees. Disease passed down pedicels to spur, then to twig, killing the end of the twig. Apples developed below the diseased area, but the disease later passing further down the twig would prevent their maturing. (Original.)

Apple twig with two blighted spurs. These inoculated through the blossom. The disease had passed from the spurs to the twig, and when photographed the twig was girdled by the disease near the spurs and the apples and leaves at the tip had ceased developing and would soon wither.

in the development of the disease. Several experiments were made to test this possible means of infection, e.g., the gummy exudate, and pure cultures of the germ were copiously smeared on the surface of sound fruits, but without success.

The exterior of a diseased young apple or pear will be discolored light brown at first, then dark brown, and finally black. As the disease progresses, the flesh will become soft and pulpy, and the skin will become somewhat wrinkled. If the fruit be sectioned, the diseased part of the flesh will be soft and present a slimy and decayed appearance, discolored any shade of brown to black. Microscopic smear preparations of this broken down tissue or of the slimy fluid reveal dense swarms of the bacillus, and paraffin sections show the cells to be impregnated with the germ. Sometimes this slimy liquid oozes through the pores or through insect punctures of the skin in the same way that the gummy exudate emerges from the diseased areas on the twigs, limbs or trunks of the trees. When so exposed, insects alighting on the fruit get contaminated with it, and, as it is crowded with the disease germs, when the insects fly away they carry the germs along with them, especially on their feet and mouth parts. The disease spreads rapidly in the tissue of a young fruit, but slowly in a fruit that is ripening. In the latter case, the diseased area does not become slimy, soft and pulpy, but becomes discolored brown, having somewhat the appearance of a bruise, but the discolored tissue is not tough, as is that of bruised tissue. As the spur, twig or branch bearing the diseased fruit dies from the disease, thus preventing the flow of sap to the fruit, such fruit slowly dries out, becomes deeply indented with wrinkles, turns black or dark gray, and dull, and becomes quite hard. Such fruit will often remain on the tree through the winter.

The Disease in the Main Limbs and Trunk.—1. *In the Apple Tree.*—Where the disease occurs in the main limbs or trunk of the apple tree, it is usually confined to a well-defined and limited area. This is the phase of the disease called "Blight Canker." Fully ninety per cent. of such infections are due to twigs, water-sprouts, and suckers being primarily inoculated. Down these latter the disease progresses until it reaches their base from which it usually spreads in all directions within the bark of the larger growth. So long as suitable conditions are obtained in the older growth, the disease will continue to spread there. While the disease is active, the bark affected will usually be a little darker in color than the healthy bark and will usually appear somewhat moist, as if water soaked. Sometimes it will be slightly raised and, if there be plenty of sap in the bark, it will usually blister, and the characteristic gummy matter loaded with the germs will exude. As soon as unfavorable conditions obtain, as, for instance, a diminution of the sap supply which may be induced by lack of cultivation, drought, or cold weather, the progress of the disease is checked, the germs present consume all the food material in the affected area, and being unable to get more owing to the resistance of the surrounding tissue to their invasion, they gradually die out from lack of nourishment. When the disease ceases to be active, the affected bark shrinks and subsides, and in doing so it is torn from the healthy tissue surrounding it and a crack is thus formed, usually entirely encircling the dead portion.

When cut with a knife, the diseased bark will appear brown, while the healthy bark surrounding it will be pale green or creamy white in color, and the line of demarcation between these is usually sharp and distinct. The dead bark is very tough. Sometimes germs will have pushed beyond the well-defined, cankered area, and will remain alive but not very active in the apparently healthy tissue until favorable conditions once more obtain, when they will resume their activity and another cankered area surrounding the old one will thus be produced. Sometimes a series of such cankered areas will develop, due to a repetition of the necessary conditions for growth, each crack separating one cankered area from the others, representing the termination of a period of activity. Blight canker may develop at the base of the trunk or crown, from infected suckers, also from injuries with contaminated cultivators.

2. *In the Pear Tree.*—As above intimated, while the disease does not cause so much loss by its development in the bark of the trunk and main limbs of apple

Cluster of water-sprouts on apple tree in which the blight is rapidly spreading, being carried from twig to twig by the aphids. (Original.)

Water-sprouts on apple tree in similar condition to those shown in preceding figure. (Original.)

trees as it does in the twigs and smaller branches of the same, with the pear it is the reverse conditions that prevail.

When once the germ finds entrance to the bark of a main limb or trunk of a pear tree, it seldom dies out until the whole tree is dead, unless the diseased area is radically removed. Especially is this the case with the choicer varieties of pears —the Duchess, Bartlett, Flemish Beauty, Clapp's Favorite and Clarigeau, for instance. When once these trees are attacked they seldom live more than three years if the disease is allowed to have its way.

The disease develops and spreads in the main limbs and trunks of pear trees in much the same manner as in the twigs. The exterior of the bark becomes discolored, sometimes brown and sometimes purplish. It often blisters and cracks and amber-colored gummy exudate emerges when the disease is most active. This may often be seen flowing slowly down the face of the diseased area. The disease

Large blight canker rapidly spreading in crotch of main limbs of Romenskœ apple tree, O.A.C. orchard. The whole of this canker developed in two months after inoculation by aphids through a water-sprout. Just above the centre of the picture is a small canker spreading at the base of a water-sprout also inoculated by aphids; and at the extreme right may be seen a long narrow sunken area running down the limb; this is a portion of a large canker formed at the base of a water-sprout, also aphid inoculated. (Original.)

is much less active during the winter than during the summer, though the complete cessation of its activity during the cold period is questionable. In the spring the tissue surrounding the dead cankered areas is teeming with the disease germs, which, on the flow of sap, begin rapidly to develop and spread farther afield. The disease is irregular in its progress. It may spread in any direction, and the cracks mark its periods of activity, and may be longitudinal or horizontal, but are seldom oval or circular as in the case of the apple. These periods of activity vary in duration, depending somewhat upon climatic and soil conditions which regulate the flow of sap—more sap, more disease, if the germ be in the tree.

It is this fact that is responsible for the idea that so largely prevails among pome fruit growers, that orchards under cultivation are more subject to the blight than are orchards in sod. The trees in orchards that are fertilized and cultivated naturally produce more young growth, and are more sappy than those in sod, and this condition being the most favorable for the rapid development of the organism, should it be present in the trees, the spread of the disease in these trees is much more noticeable than in trees that are less thrifty. Pear orchards may be in sod a number of years and the disease be present in the trees, but progressing so slowly as to be scarcely noticed by the owner. At length the owner decides to plough up the sod and cultivate. This results in the greater flow of sap in the trees, produces

Mature apple tree (Romenskœ) badly affected with twig blight. (Original.)

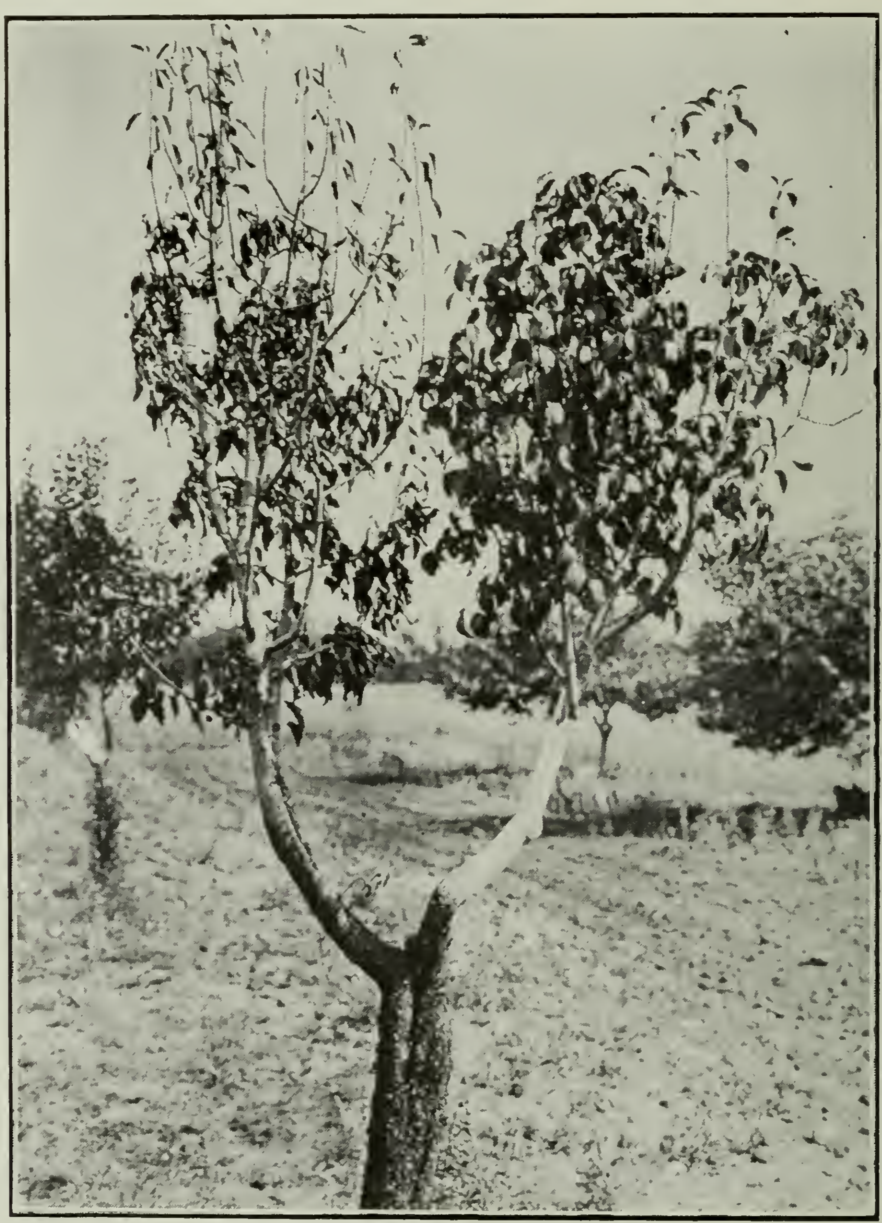
ideal conditions for the rapid development of the disease, and before the season is over, dead limbs and dead trees are seen in all directions. The owner, disgusted, destroys the dead material and allows the orchard to return once more to sod, deeming it better to have a decreased yield of fruit than to have the trees killed out wholesale. The spread of the disease slowly subsides, falls to proportions in which it is not very noticeable, and the owner decides that the attack of the disease

Cross section of a diseased young apple, showing cells filled with bacteria—*B. amylovorus*. Section 4 microns thick, stained carbol fuchsin. X 1,000. (Original.)

Cross section of a diseased young apple, showing bacteria within the cells. Section 4 microns thick, stained carbol fuchsin. X 1,000. (Original.)

was due to the cultivation, which, of course, indirectly it was. A number of such cases have come directly before our notice.

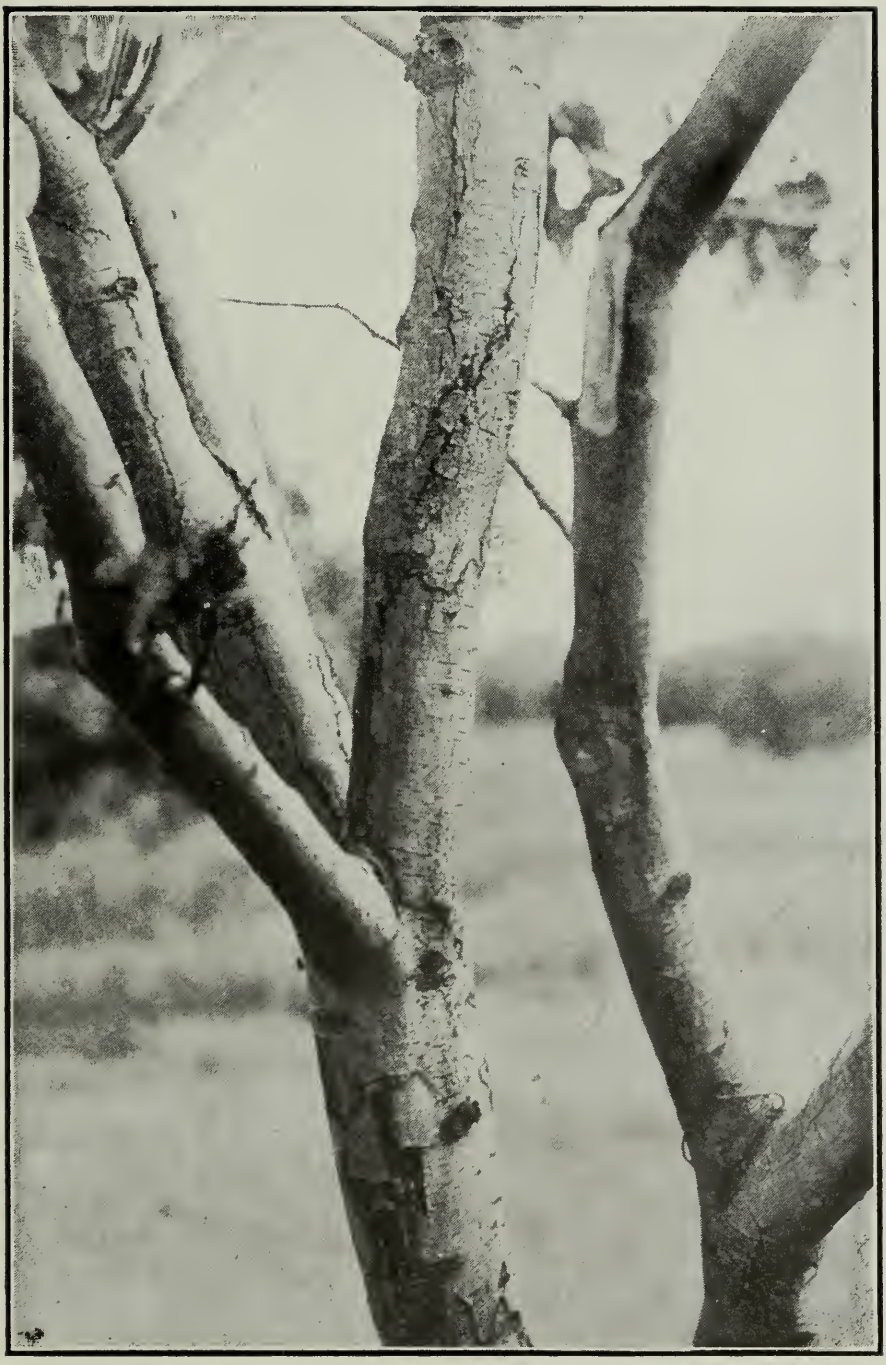
Sod, however, is not an ideal condition for an orchard. It means a diminished supply and an inferior quality of fruit, and it is a nursery for numerous of our insect pests. This being the case. what is the pome grower to do? The best thing is to find a more direct method of attacking the blight than merely diminishing its spread by leaving the orchard in sod.



Diseased Bartlett pear tree. Disease active in this tree four years; dead limbs cut away from time to time. (Limb to the left died this season. Limb to the right badly diseased. (Original.)

Dissemination of the Disease.—The disease is spread in various ways, e.g., by insects, pruning tools, cultivators, heavy rain storms. The most common way in which the disease is carried from tree to tree and from orchard to orchard is by insects.

I. Insects—(1) *Flower Visiting Insects.*—Bees, wasps and flies that visit the blossoms in search of nectar are responsible for most, if not all cases of blossom infection. A very large percentage of cases of the disease are due to infection



Main limbs of a Flemish Beauty pear tree, O.A.C. orchard, in which the blight is rapidly spreading. The limb to the right is practically dead. Notice the cracking and blistering of the bark, especially on the middle limb. All the disease above the crotch developed this season from the cankered area below the crotch. It spread throughout the bark very rapidly during June, July and August. Photo taken in September. (Original.)

through the blossom. These insects, after getting their mouth parts and legs contaminated with the bacteria from a diseased tree, carry the disease to the flowers of healthy trees, and as they burrow down into the flower to get the nectar, some of the bacteria are left in the nectaries of the flower. Here they find suitable food for their development and multiplication, and as they multiply they pass down the bark of the blossom peduncle to the bark of the fruit spur, killing tissue as they advance. They continue on down the bark of the fruit spur to the twig or branch on which the fruit spur is growing, and so the disease develops and kills the parts affected, as previously described.

(2) *Sucking Insects* that puncture the bark, such as aphids and jassids or plant lice, frequently spread the disease from branch to branch and from tree to tree in an orchard. These are responsible for many cases of the disease starting in suckers, water-sprouts, and young twigs that have no flowers, also for much of the infection of young trees in nurseries.

(3) *Boring Insects,* such as the shot-hole bark-boring beetle, have been shown to spread the disease among pear trees, both young and mature.

II. Pruning Saws, Knives and Shears.—Many cases of the disease in apple and pear trees have been established following innoculation of the pruning tools, by cutting through a diseased branch and then through a healthy branch, the latter becoming inoculated from the contaminated pruning tool.

Eradication and Control of the Disease.—The apple and pear blight at present is confined to the North American continent. Arguing from the point, no germ no disease, what is needed to stamp the disease out of existence is simply to destroy all the fire-blight germs in the country. This is very difficult to achieve, as the necessary concerted action on the part of all those growing fruits liable to the disease is practically impossible to obtain. However, concerted action on the part of all resident in a given district will be sufficient to so reduce the disease in that district that its presence will scarcely be noticed, if it is not indeed entirely stamped out.

1. *Cut out the Diseased Parts.*—In the first place, let it clearly be understood that when once the disease enters a tree, whether it be in twig, branch or trunk, there is no remedy for the part affected. The only measure to be adopted is to cut out the affected part and burn it right away. To cut off an infected twig will save the limb on which it grows; to cut out an affected large branch will save the trunk; and if the trunk be affected in only a limited area, the removal of the entire area of affected bark or canker will save a tree.

In cutting dead or diseased tissue from a tree, care must be taken to cut from several inches to a foot below the blighted area, so as to ensure the removal of all affected tissue. As previously pointed out, the germs are not confined to the visibly affected part, but are penetrating within the bark in all directions for varying distances beyond what can be seen to be affected. If only the visibly cankered area be removed, these germs are still left in the tree and the disease will continue to progress in the limb from which the cankered area is cut.

The best time to cut out blight is the first time it is seen. Every case of active blight is a potent source of infection for innumerable other cases. However, it is not always practicable to locate every case of blight as it occurs.

If systematic action in cutting out blight from an orchard be left until the regular pruning season, we would recommend that if one man is to do the pruning, he cut out all the diseased parts first before touching healthy limbs. Aso, that he disinfect his knife, shears or saw after every cut made on a diseased limb. This disinfection is easily accomplished by using a swab of cotton dipped in corrosive sublimate, strength 1-1000, which may be carried in a well-corked bottle. The swab may be on the end of a stick or piece of wire passing through the cork. If two men are engaged in the pruning operations, one of them should confine himself to removing the diseased limbs while the other operates only on the healthy limbs. All dead or diseased branches that are removed should be carefully gathered and burned at once.

Controlling Insects that Carry Fire Blight.—Not much can be done with regard to controlling the honey bees. In some of the Western States there has almost been war between the fruit men and honey men over this problem. It is not, however, the tame bee alone that is responsible for the dissemination of the disease among the blossoms, but the wild bees, wasps, ants, and other flower-visiting insects are found equally guilty. Then, of course, pollenation is brought about by the activities of these insects, and their services in this connection cannot be dispensed with.

If we are to prevent the flower-visiting insects from spreading the disease, the best way to do this is to remove all cases of the disease so that there shall not be any chance of the insects getting contaminated with the disease germs.

With aphids, however, the case is different. They are lawful enemies at all times. To keep them in check, destroy the eggs which are found on the twigs and smaller branches in the spring, by spraying with home-boiled lime sulphur, preferably of the strength of twenty-five pounds lime, twenty pounds sulphur, to forty gallons of water. As it is seldom possible to destroy all the eggs with any wash, it will be well to observe the buds as they are bursting, and see whether any of the little green insects are present. If so, use kerosene emulsion of the ordinary strength for summer wash. To get good results, thorough work must be done. In the fall of the year observe if any aphids are present on the water-sprouts, and if present, cut out the water-sprouts and burn them.

Many nursery trees are destroyed by fire-blight, after being inoculated by contaminated aphids. Therefore, as soon as aphids are observed in the nursery rows, carry a pail of kerosene emulsion along and dip the affected trees right into it.

To prevent the disease being spread by the shot-hole boring beetles, no dead or diseased wood should be allowed to remain in or near the orchard, but should be burned as soon as removed from the trees. The reason for this is that the beetles and their larvæ winter over in such wood, and unless destroyed will issue forth in the spring to attack trees in the orchard.

Crown Gall and Hairy Root of Plants.

Casual organism—*Ps. tumefaciens Smith.*

Crown Gall and Hairy Root are two forms of one bacterial plant disease. The disease affects many woody and herbaceous plants. It has caused heavy financial losses in the cultivation of almonds, peaches, apples, quinces, raspberries, grapes and roses, and is found present in many other species of plants. It is common in Europe, the United States, South America and Canada, and has also been reported from South Africa. It is probably present in other fruit-growing countries.

When the bacteria that cause the disease gain entrance to the root tissue, they cause the development of tumors or galls or else the production of tufts of thin fibrous hairy roots. These conditions interfere with the feeding activities of the roots, also the transfer of food from the roots to the rest of the plant, and so lower the value of the plant by cutting down its production, finally making the plant worthless.

The formation of the galls and hairy roots is due to an abnormal increase of the growing plant tissue cells where the bacteria are active. It is considered that the acids and other by-products of the bacterial development are responsible for stimulating the tissue cells to this abnormal multiplication.

The galls may be hard and woody, or they may be comparatively soft. The hard and woody galls are due to the presence of twisted and contorted vascular bundles and woody fibres within the body of the gall. The soft galls consist almost entirely of parenchymatous tissue with very little vascular tissue combined and this is very thin walled.

Crown gall and hairy root on young apple tree received in nursery stock. (Original).

The soft galls, or parts of them, may decay, crumble up and slough off at any period. This is considered to be due to the fact that owing to there being but little vascular tissue in the gall, and this being twisted irregularly through the mass, there is not sufficient moisture conveyed to the cells to keep them alive and growing, consequently, they die and crumble away. A portion of diseased tissue, however, is usually left, and this causes a recurrence of the gall. In the case of hard galls, this sloughing off is not so common. The areas from which the galls are sloughed is open to attack from other bacterial or fungus diseases.

The gall tissue is liable to spread in strands within the growing tissue of the plant and break out as secondary galls or tufts of root hairs on any part of the root, and secondary galls may also break out in the stem or branches or even leaves. In the main, however, the trouble is confined to the neighborhood of the roots.

The bacteria gain entrance to the root tissues from infected soil, mainly through wounds made when transplanting or cultivating or wounds made by the various root-infesting insects. The disease spreads rapidly through a patch of raspberry canes owing to the fact that during cultivation and thinning out the roots and runners are frequently cut or broken, thus enabling the bacteria to enter the tissue should the soil be infected.

The disease gets established in an orchard mainly through the planting of infected nursery stock. When planting out young trees, therefore, care should be taken not to plant any that show gall formation or hairy root. These should either be burned or returned to the nursery for exchange.

It is not much use to cut away a gall from an affected plant, as portions of the infection will almost invariably remain in the apparently healthy tissue adjoining the gall. If such an attempt is made, care should be taken to sterilize the knife or saw by wiping it with a solution of corrosive sublimate 1-1000, or some other disinfectant, before using it on any healthy plant.

How long the infection will remain in the soil after getting established there from infected stock has not been determined. It is recommended that at least two or three years be allowed to elapse after removing infected plants or trees before planting any varieties of plants that are liable to contract the disease.

INDEX

Animals, Infectious Diseases of, 38.
Apple, Bacterial Blight of, 85.
Asiatic Cholera, 52.
Anthrax, 53.

Bacteria, Nature and Description of, 1.
Bacteria, Wilt of Cruciferæ, 76, 77, 78.
Bacteria, Wilt of Curcubits, 81, 82.
Bacterial Soft Rot of Vegetables, 69.
Bean Blight, 83.
Bees, Foul Brood of, 68.
Blackhead of Turkeys, 67.
Blackleg of Cattle, 54.
Blackleg of Potatoes, 74.
Bubonic Plague, 53.
Butter, 35.

Cabbage, 70, 76.
Canker in Fowl, 65.
Canning, 25.
Cerebro-Spinal Meningitis, 50.
Cheese, 37.
Chicken Pox, 65.
Cholera, 52.
Contagious Abortion of Cattle, 55.
Contagious Abortion of Mares, 65.
Crown Gall of Plants, 97.
Cruciferæ, Bacterial Wilt of, 76.
Curcubits, Bacterial Wilt of, 81.

Diphtheria, 49.
Drying Fruit, 19.
Dysentery, 39.

Farcy, 62.
Fire Blight, 85.
Fire Fianging in Manure, 13.
Food Preservation, 19.
Foot and Mouth Disease, 61.
Foul Brood of Bees, 68.
Fowl Cholera, 64.
Fowl Diphtheria, 65.

Glanders, 62.
Gonorrhœa, 52.

Hairy Root, 97.
Hog Cholera, 57.

Infantile Paralysis, 50.
Infectious Diseases of Man and Animals, 38.
Influenza, 50.

Lactic Culture Starter, 36.
Legume Bacteria, 6.
Leprosy, 53.

Man, Infectious Diseases of, 37.
Manure Pile, 12.
Measles, 51.
Milk and Milk Products, 27.
Mumps, 51.

Nitrogen-fixing Bacteria, 6.

Pasteurization of Milk, 34.
Pear Blight, 85.
Plants, Diseases, 69.
Polluted Water Treatment, 15.
Poultry, Diseases, 74.
Potatoes, 74.
Preservation of Food, 19.

Quarter Evil, 54.

Roup, 65.

Scarlet Fever, 51.
Sewage Disposal, 17.
Smallpox, 49.
Soil Bacteria, 4, 10.
Spotted Liver, 67.
Syphilis, 52.

Tuberculosis, 39.
Turkeys, Blackhead of, 67.
Turnip, 71, 76.
Typhoid, 38.
Typhus, 51.

Vegetables, Bacterial Soft Rot of, 69, 74.
Vinegar Bacteria, 26.

Water Supply, quality and treatment, 13.
White Diarrhœa of Chickens, 63.

BULLETIN 266] [SEPTEMBER, 1918

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

Cheese and Butter Making

By the Staff of the Dairy School

INTRODUCTION.

H. H. DEAN.

The Dairy School Bulletin is unique among bulletins which have been published. It was first prepared in 1893 by Committees appointed during the first session of the Dairy School at the Ontario Agricultural College of that year. Since then it has been revised from time to time, and brought up-to-date by the Dairy School staff. The matter herein contained, was prepared by the staff of 1918, and is a revision of Bulletins Nos. 205 and 206. Thus for twenty-five years there has been a continuity in the matter as given in this bulletin.

The manufacture of butter and cheese are still the most important branches of dairying in Ontario, and these have received most attention in the present revision, as in past bulletins, but there are other branches of dairying which have come rapidly to the front during recent years, among which may be mentioned soft and fancy cheese, condensed and powder milks, ice cream, and town and city milk supply. Except for brief reference to ice cream making, and outlines of the more common fancy cheeses, these newer dairy problems have not been treated in the present dairy bulletin, largely because of lack of definite information on these subjects. The manufacture of condensed and powder milks is controlled largely by corporations which have what is practically a monopoly of these lines. So far as the writer knows, investigations of these branches of dairying have not been made anywhere in Canada, nor is there equipment for carrying on such, at any Experiment Station in the Dominion. The manufacturers of condensed and powdered milks utilize *all* of the milk solids as human food, whereas cheese and butter manufacturers are able to convert but one-half to one-third of these solids directly into food for human consumption. Because of this fact, the condenseries and milk powder factories are able to pay higher prices for milk than can factories which make cheese and butter in the ordinary way, and still have a large margin of profit—how large, no one outside these concerns is aware. We are facing conditions which will practically revolutionize dairying in Ontario during the next ten years. The wise dairyman will make preparations to meet these new conditions as rapidly as possible. Our Agricultural Colleges and Experiment Stations should be leaders in these progressive and more remunerative lines of dairy advancement.

WHEY BUTTER.

One of the signs of this new movement is the great interest displayed at present in the manufacture of butter from whey. Tons of milk-fat have been practically wasted in the whey tanks of the Province. The increased scarcity, and high price of fats of all kinds, especially milk-fat, has forcibly called attention to this matter. Many cheese factories, having 5,000 lbs. or more, of whey daily, are preparing to "skim the whey" and either sell the cream or make it into butter. On the average, about three pounds of butter may be made per 1,000 lbs. of whey, depending on the fat lost in the whey, skill of the maker, etc. This butter will usually sell at from two to four cents less per pound than first class creamery butter. Sometimes it will bring a price equal to the best dairy or creamery butter, depending on quality and scarcity. A cheese factory having an average of 10,000 lbs. whey daily for a season of 200 days would be able to make about three tons of whey butter, which at 40 cents per pound, would mean a revenue of $2,400. If the cost of manufacture were ten cents a pound, there would be a net revenue of $1,800 for the season. As a rule, it is better to pay the cheesemaker so much per pound for skimming the whey and making the butter. Where conditions are favorable, the whey-cream may be sold or sent to a central point for churning, thereby saving the cost of a churn and labor of churning. A better quality of butter is more likely to be made under such conditions, especially where the make is small and the whey-cream held for several days before churning.

The butter made for sale must be branded "Whey Butter."

Skim Milk and Buttermilk Cheese.

Another sign of the times is the outcry against the waste of skim milk and buttermilk even for feeding animals. It is claimed that these should be converted directly into human food instead of indirectly and wastefully through feeding these to hogs, calves, poultry, etc. Directions for making these by-products into cheese are given in this bulletin, but the labor involved is considerable, which means heavy expense in manufacturing an article for which the market is uncertain, and which lacks keeping quality. These facts make the business somewhat risky. However, it is likely that a method of separating the solids of skim milk and buttermilk by means of centrifugal force, will be perfected in the near future, thus reducing labor costs, and doubtless a harmless preservative may be used which will lengthen the time for marketing and consumption, which at present is not more than a week or ten days, under the best conditions.

Testing Cream.

There are many complaints regarding the testing of cream. Special attention is directed to what is said on this point in the bulletin. The practice of using a *milk* pipette for measuring the cream for a test, or the use of any pipette for cream testing over 30 per cent. fat is probably a chief cause of "low tests" for cream. If a pipette be used, it must measure 18 c.c., not 17.6 c.c., and if the sample is above 30 per cent. fat a fine balance should be used. Because of the value of skim milk as food and feed, more of it is retained on the farm than formerly, consequently the cream contains a higher percentage of fat, hence a balance ought to be used, in testing cream, and nine or eighteen grams weighed for a fat test.

The practice of testing each delivery of cream is recommended, though fairly accurate results can be got by composite sampling if the work be done carefully and the samples are kept sweet and free from mould.

Payment for Milk Used in Cheese Manufacture.

This question is still in an unsettled condition. The majority of the cheese factories in Ontario continue to pay by weight of milk delivered, regardless of what the milk tests for fat and casein, which are the two milk constituents that determine the relative values of milk used in cheese manufacture.

The principles underlying the three systems now in use may be briefly stated as follows:

1. Paying for milk according to its weight having no regard for its composition, assumes that all milks are of the same value, practically, for cheesemaking, or, if there be any difference, it is so slight that the matter is not worth bothering about. This assumption is correct, where there is little or no difference in the composition of the milk delivered by the individual patrons of a factory. But where there is a difference in the fat and casein constituents, the division of money proceeds from sales of cheese on what is commonly known as the "pooling system," is unfair. This is shown by the following table based on experiments made at the O. A. College:

Average per cent. fat in milk.	Pounds cheese per 1000 pounds milk.	Pounds milk per pound cheese.	Increased yield of cheese per 1000 lbs. milk.	Pounds cheese per pound fat in milk.
3.0	88.9	11.2	....	2.92
3.5	95.4	10.5	6.5	2.70
4.0	103.6	9.6	8.2	2.57
4.5	110.8	9.0	7.2	2.47
5.0	117.7	8.5	6.9	2.36

Two things stand out strikingly in this table: The increased yield of cheese with the higher testing milk; and the decreased yield of cheese per pound fat in the milk, as the percentage of fat in the milk increases. At first, these statements appear to be contradictory. Interpreted rightly they mean that though the richer milk produced a greater yield of cheese per 1,000 pounds of milk than did the poorer, or lower testing milk, this increase was not in proportion to the fat contained in the milk. The milks containing a lesser percentage of fat produced more cheese per pound of fat contained in the milk. This is explained by assuming that such milks contain more casein in proportion to the fat than do the richer milks, and consequently give greater yields of cheese according to the fat contained.

2. Because of this, the Dairy Department of the O. A. College recommends that milk casein, as well as milk-fat, should be considered when dividing money among patrons of cheese factories. This system is commonly known as "The per cent. fat plus two" plan, in which it is assumed that when the factor two, is added to the percentage of fat in milk used for the manufacture of cheese, we have for all practical purposes, included the *available fat and casein* in milk for cheese making.

As a result of 15,000 tests made for fat and casein at representative cheese factories in the Province of Ontario, it was found that the average percentage of fat was 3.5, and of casein, 2.2. Some fat and part of the casein is always lost in the making of cheese. The excess percentage of casein in milk over two, is represented by the fat and casein lost in the whey. The application of this method is very simple. In case the percentages of fat in the milk were, 3, 3.5, 4.0, 4.5, 5.0, the percentages of available fat and casein would be 3 + 2=5, 3.5 + 2=5.5, 4 + 2=6, 4.5 + 2=6.5, 5 + 2=7.

The total pounds of available fat and casein delivered by each patron, are found by multiplying the total pounds of milk delivered during any period, by the average percentage of fat for the period, plus two. To find the value of one pound fat-casein, divide the net proceeds of the sale of cheese, by the total pounds of fat-casein which entered into the cheese manufactured. To find the money due each patron, multiply the total pounds fat-casein delivered by him, by the value of one pound fat-casein. In this system the value of one pound fat-casein is unity, when making calculations. If paying according to weight of milk, one pound of milk is unity; and when "paying by test" or percentage of fat, one pound of fat is unity for calculating money values of milk for patrons.

3. The third system is known as the "relative value" plan, "test plan," "fat system," etc. This method assumes that milk is valuable for cheese manufacture in proportion to the fat contained, which fat is determined by what is known as the Babcock test.

In the eastern part of the Province of Ontario, milk is commonly valued at so much per "standard." A "standard" is three thousand pounds of milk, which probably had its origin in this being the weight of milk commonly given during the cheese factory season by one cow.

In the case of three patrons furnishing milk to a cheese factory, testing respectively 3, 3.5, and 4 per cent. fat, where the milk averages forty dollars per "standard," "pooling" or dividing money by weight of milk delivered, the amounts of money each would receive dividing according to weight, "fat plus two" and "the fat" methods, are as follows:

VALUE PER "STANDARD" (3,000 LBS.), DIVIDING ACCORDING TO

Per cent. fat in milk.	Weight of milk.	Per cent. fat plus two.	Per cent. fat.
3.0	$40.00	$36.36	$34.29
3.5	40.00	40.00	40.00
4.0	40.00	43.64	45.71

In this case, it makes no difference to the man sending milk testing 3.5 per cent. fat, which system is followed. The differences come in the patrons furnishing milk with the two extremes of fat percentage. In the method, "fat plus two" the differences in money received are not so great as by the "fat" system, and probably comes nearer to the actual cheese value of the milk, than paying by fat alone. Unfortunately, the weight of cheese produced per "standard" of milk testing the same percentages of fat and casein, is not constant, due to varying losses in manufacture, and varying percentages of moisture retained in the cheese. Because of these facts, there is no system of "pooling" or dividing proceeds among patrons of cheese factories which is, or can be, absolutely correct for all conditions. All that can be done is to adopt some system which is approximately correct, and which recognizes the principle that so far as the composition of milk is concerned, the fat and the casein are the two constituents which largely determine the relative values of milks for cheese manufacture.

Milk, Cream, Cheese and Butter Testing

MILK AND CREAM TESTING.

W. H. Sproule.

The commercial value of milk, whether used for manufacture into the various dairy products, for direct consumption, or for city milk trade, is largely dependent on its chemical composition. If the milk be used for buttermaking, the fat will be the index of its value, for it is the fat alone which is used for the manufacture of butter. Normal milk varies widely in composition, therefore in order to ascertain its market value, it is necessary to determine the relative amounts of its more important constituents. Chemical analysis will give the most accurate data, by which the value of milk may be estimated, but this method is too slow, and too expensive for use in commercial work.

The Babcock method of ascertaining the fat content in milk has solved the problem of a rapid, accurate and reliable method for testing milk and milk products for fat. It was invented by Dr. S. M. Babcock, of the Wisconsin Agricultural Experimental Station, and was made public in 1890. Since then, it has been the almost universal milk-fat test in America. It is an inexpensive test, and its accuracy is vouched for by chemists.

The cost of a small four bottle hand machine such as is used on many farms is $5.00 to $6.00. The price increases according to the capacity of the machine. Anyone with a little experience can obtain accurate results by exercising the necessary precautions and doing the work carefully and honestly.

The various details necessary to consider in making a Babcock test of a sample of milk are given systematically as follows:

1. Have the milk at a temperature of 60 deg. to 70 deg. F.

2. Mix the milk thoroughly by pouring it from one vessel to another, allowing it to run down the side of the vessel to prevent foaming. If the sample is not thoroughly mixed, a representative sample cannot be obtained.

3. With a 17.6 c.c. (cubic centimeter) pipette, measure this quantity of milk into a milk test bottle. To do this, suck the milk into the pipette, and quickly place the forefinger over the top to prevent the milk running out. Allow the milk to drop out until the surface of the milk is level with the 17.6 c.c. mark, which is on the stem above the bulb. Now place the tip of the pipette into the top of the bottle and allow the milk to run out slowly by removing the forefinger.

4. Add to the milk in the bottle 17.5 c.c. of commercial sulphuric acid at a temperature of 60 deg. to 70 deg. F., having a specific gravity of 1.82 to 1.83. Hold the bottle slanting and allow the acid to run down the side and under the milk. Use a graduate for this purpose. It is not a safe practice to use the pipette, as the acid may be drawn into the mouth, causing severe burning.

5. Mix the milk and acid thoroughly by giving a gentle rotary motion. Do not close the neck of the bottle while mixing.

6. Place the bottles in the machine, making sure they are properly balanced, and whirl at full speed for five minutes. The speed is indicated on the machine. Do not exceed the speed so marked.

7. Add hot water at a temperature of 160 deg. to 170 deg. F. to float the fat into the neck of the bottle.

8. Whirl again for two minutes.

9. Remove the bottles from the tester and set in a water bath, which reaches to the top of the fat, at a temperature of about 140 deg. F. for a few minutes before taking the reading.

Theory of the Babcock Test.

A 17.6 c.c. pipette will deliver, practically, 17.5 c.c. of milk.

17.5 c.c. at an average specific gravity of 1.032 = $(17.5 \times 1.032) = 18.06$ grams.

18 grams is the weight of the milk required for a test.

The volume of the neck of the milk test bottle between zero and 10 is 2 c.c.

2 c.c. of melted fat, at a specific gravity of .9= $(2 \times .9) = 1.8$ grams.

The relation of 1.8 is to 18, as 1 is to 10, or 10 per cent. of the original volume of the milk. This is why that weight or volume of milk is taken and why the neck of the bottle is divided into 10 equal parts.

Notes.

1. Always make sure that the bottles and pipettes are clean before using.

2. Be careful to get the exact measurement of milk for the test.

3. If the milk is covered with thick cream, or is partially churned, it may be prepared for sampling by heating, then pouring from one vessel to another. Heating to 100 deg. to 110 deg. F. is sufficient for this. When it is thoroughly mixed, take the sample as quickly as possible and cool to about 60 deg. F. before adding the acid.

4. If the sample is frozen, warm both the frozen and liquid parts and mix thoroughly. Never test a sample immediately after being drawn from the cow. Allow to stand at least one hour.

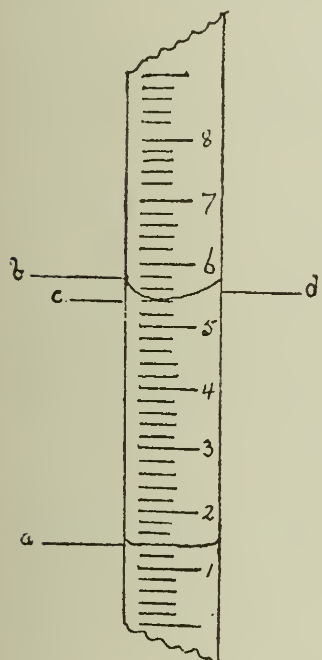
5. If the milk is sour or thickened, it is necessary to add an alkali to dissolve the casein. A small amount of strong ammonia or concentrated lye will answer, stirring and mixing it well until the sample has become liquid again.

6. The quantity of acid must vary with its strength. If it is too strong use less, if too weak use more, but if the acid is very much too weak or too strong, it should not be used. Weak acid is preferred to strong acid. Carboys or bottles containing acid should be stoppered with glass or earthenware stoppers, as the acid is very corrosive and will burn or eat stoppers made of organic material or metals.

7. Avoid pouring the acid directly on the milk. After the acid is in the bottle there should be two distinct layers—milk on top and acid underneath, with no charred material in between. Do not allow it to remain long in this condition.

8. The water added to the test bottles should be soft or distilled. If hard water is used the addition of about 8 or 10 cubic centimeters of sulphuric acid to the gallon will soften it. This will prevent foam above the fat.

9. It is advisable to use a pair of dividers or compasses for measuring the fat column. The points should be placed at the upper and lower limits of the column to get the length, and then place one point at zero and the position of the other point will show the percentage of fat in the sample tested. The accompanying illustration will show the correct method of reading milk tests when the fat is at 140 deg. F. Correct reading *a* to *b* not *c* or *d*.



10. Burnt or cloudy readings may be caused by:

(*a*) Having the temperature of the milk or acid too high.

(*b*) Using acid which is too strong, or using too much acid.

(*c*) Allowing acid to drop directly on and through the milk.

(*d*) Allowing the milk and acid to stand too long before mixing.

11. Light or cloudy readings or floating particles of curd are usually caused by:

(*a*) Temperature of milk or acid too low.

(*b*) Using too weak an acid or not enough acid.

(*c*) Careless mixing, or insufficient shaking to unite the milk and acid thoroughly.

12. The accuracy of the test bottles and pipettes used in Canada is provided for in an Act of the Dominion Parliament known as the Milk Test Act, which requires that all bottles and pipettes shall be tested for accuracy of graduation by the Standards Branch, Department of Inland Revenue at Ottawa, and that each bottle and pipette shall be marked at the time of testing with the letters G.R. (or first letter of reigning Sovereign) inside the Crown, thus: |G.R.|.

13. Carefulness and exactness are absolutely essential in every detail if accurate results are to be obtained in milk testing.

14. Sulphuric acid weighs about 18 lbs. to the gallon and costs 4 to 10 cents per lb. A gallon will make 250 to 260 tests.

Composite Samples.

A composite sample is a sample composed of a number of smaller samples taken from the same source at different times and kept by use of a preservative, the object being to obtain an average test of the number of smaller samples without the labor and expense involved in the testing of each lot separately. This method is used by cheese factories and creameries, and by Cow Testing Associations. In creameries and cheese factories a small sample is taken from each daily delivery of each patron and kept in bottles, one for each patron. Several kinds of preservatives are used, the most common being a mixture of five parts of potassium bichromate to one part of mercuric bichloride (corrosive sublimate). Potassium bichromate may be used alone if the samples are not kept longer than two weeks, enough being added to give the milk a lemon yellow color. If the mixture is used, it will require as much as will lie on a ten cent piece to preserve a pint for one month. Corrosive sublimate may be used, but it is rather dangerous, as it does not give any color to indicate that the milk contains poison. Formalin is sometimes used, about 20 drops (1 c.c.) per pint of milk, but it also is colorless. Tablets are now prepared and sold by the dairy supply houses, which may be used with excellent results. The amount of preservative used will depend to a certain extent upon the condition and size of the sample and the length of time over which the testing period extends, and also the manner in which it is treated. At the end of the period the mixture of samples may be tested with the Babcock test, and if the work of sampling has been done properly the test should be an average percentage of the fat in the different lots of milk.

Notes on Composite Sampling and Testing.

1. Pint or half pint milk bottles stoppered with cork or rubber stoppers answer fairly well for composite sample containers, although bottles fitted with glass stoppers are preferable, as they are not so likely to carry mould spores into the milk.

2. The bottles should be kept tightly stoppered to prevent evaporation of the moisture, which will cause the test to be too high.

3. Better results can be got by keeping the bottles in a cool place and out of direct sunlight.

4. It is absolutely necessary that each bottle should have a distinguishing mark—either name or number. Stovepipe, or bicycle enamel, answers very well for the purpose. Paint is not so lasting. Another method is to write the name or number on a gummed label, stick it on the bottle, and coat it over two or three times with shellac, or, the glass may be roughened with a whetstone or file, and the number written on with a lead pencil.

5. Place the preservative in the bottle before any milk is put in. It may be necessary to add a little more later if the sample shows indication of spoiling. Avoid using too much preservative as it hardens the caesin in the milk, making it difficult to test and oftentimes causing a burnt or charred reading.

6. The sample for the composite jar should be taken after the milk has been poured into the weigh can. An ounce or half-ounce dipper is often used for this purpose. A sampling tube, or milk "thief," is also very satisfactory. It is very difficult to accurately sample frozen milk, and patrons should be warned against sending milk in that condition.

7. Each time a fresh sample is added, the jar should be given a gentle rotary motion to mix the cream and the fresh milk with the part containing the preservative. Avoid shaking the jar violently, as that has a tendency to churn the contents.

8. To prepare composite samples for testing, heat the sample to 105 deg. to 110 deg. F. by placing in warm water, to loosen the fat adhering to the sides of the bottle, then mix thoroughly by pouring. Take the sample quickly and place in the test bottle. Set the test bottle in water at 60 deg. to cool the milk before adding the acid. Strict attention paid to this point of cooling will usually prevent burnt readings. Sulphuric acid appears to act more strongly on samples containing preservatives, therefore it is advisable to use slightly less acid. If difficulty is experienced with burnt readings caused by an excessive amount of preservative, it is recommended to add the hot water at two different times, filling to the bottom of the neck of the bottle and whirling one minute and then filling to about the 8 per cent. mark and whirling again for another minute.

9. To find the correct average test of the milk from a herd of cows, find the total pounds of fat and total pounds of milk, multiply the pounds of fat by one hundred and divide by the pounds of milk. There is often considerable difference between the correct average test found in this way and the test obtained by adding the different tests together and dividing by the number of cows tested.

Cream Testing.

The percentage of fat in cream can be obtained as easily and as accurately by the Babcock test as can the percentage of fat in milk.

Cream test bottles with specially graduated necks to contain 30, 40, or 50 per cent. of the weight taken are used.

The same weight of cream as of milk is necessary, namely, 18 grams, but since cream has less specific gravity, or is lighter than milk, due to the larger proportion of fat, it is necessary to use more than 17.6 cubic centimeters. Sweet cream testing 25 per cent. fat has a specific gravity similar to that of water, so that if an 18 c.c. pipette is used, and the pipette is rinsed with a small quantity of water, the weight of the cream will be nearly 18 grams. Although the testing of cream by volume or measurement is a rapid and convenient method, yet, the results obtained are only approximate, due to the fact that the cream which comes into the average creamery from different patrons will differ greatly in fat content thereby making a difference in the specific gravity. Furthermore, very rich cream, ripe, or gassy cream which has gone through partial ripening, or even fresh cream from a separator cannot be measured with an 18 c.c. pipette and obtain 18 grams in weight. During the ripening process, the fermentation gases developed are held in the cream in the same way as bread dough holds the gases generated by yeast, hence the weight of a certain volume of cream will be diminished. Therefore, because of the foregoing reasons the only proper method for taking cream samples for testing in a creamery is by weighing the samples in either a 9 or an 18 gram cream bottle.

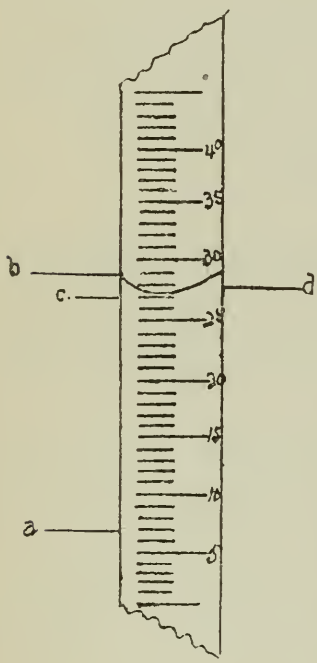
No definite amount of sulphuric acid can be given for testing cream, as some samples seem to require more than others in order to get satisfactory results, but as a rule less than 17.5 c.c. are required. A good guide is to notice the color of the mixture of cream and acid. It should be a dark chocolate color, but not black.

In milk testing, the bottles are whirled for five minutes before adding the water, but in cream testing this is not practised, as it usually results in cloudy readings.

The usual method is to add hot water immediately after mixing the cream and acid and whirl for five minutes; or better still, add the water at two different times, filling up to the neck of the bottle and whirling four minutes, and then filling nearly to the top and whirling again for two minutes. The fat column should be a bright, golden color.

Cream tests should be read at a temperature of 140 deg. F., and the fat measured to the bottom of the meniscus or curve at the top of the column. Errors due to expansion of fat amount to from one-half to one per cent., if the reading is taken immediately after whirling in a steam tester.

The accompanying illustration shows the correct method of reading the fat column in a 6-inch, 9 or 18-gram bottle. Correct reading *a* to *c*, not *b* or *d*.



Composite samples of cream are made and cared for similar to those of whole milk, but the sample for the composite bottle needs to be taken with greater care and accuracy.

The variation in the percentage of fat and the variation of the pounds of cream cause a wide range in the commercial value, therefore, it is necessary to take a proportionate, or aliquot, sample as well as a representative sample.

This is done very easily where the cream comes to the creamery in individual cans, by using a sampling tube, or a graduated pipette, and taking one cubic centimeter for every pound of cream delivered. Where the haulers take the sample at the time of collecting the cream, it is rather difficult to carry out this principle, and some buttermakers relieve the hauler entirely of this responsibility, and only ask that they take a representative sample, the buttermaker taking the proportionate sample from this when it arrives at the creamery.

The following tests show a comparison of weighed and measured tests from monthly composite samples :

Measured.	*Weighed.*	*Measured.*	*Weighed.*
17.5 p.c. fat.	18 p.c. fat	33.5 p.c. fat.	34 p.c. fat.
18.5 " "	19 " "	34 " "	35 " "
22 " "	22.5 " "	37 " "	38 " "
28 " "	29 " "	36.5 " "	37.5 " "
29.5 " "	30.5 " "	41 " "	42.5 " "

Skim Milk, Buttermilk and Whey.

As the percentage of fat in skim-milk, buttermilk and whey is usually very small, the best method of testing these is by the use of the double-neck test bottle. There are several different kinds of double-neck bottles in use, but those having the two necks joined together, and extending perpendicularly from the centre of the bottle, seem to give best results, as they are much stronger and less liable to give burnt readings.

The latest form of double-necked bottles are graduated to read in hundredths of one per cent. up to twenty-five hundredths, and the manufacturers claim that it is not necessary to add anything to the reading. The difficulty that was often encountered by having the contents foam and bubble over has been largely overcome by having a vent put in the tube in the bulb of the bottle. This also aids in emptying.

17.6 c.c. of skim milk, buttermilk, or whey are taken into a test bottle and the test is completed in the usual way. Very fine readings can be taken, as a small amount of fat can be made to extend over a long space in the small neck. Considerable difference of opinion exists amongst authorities on milk testing with regard to the correct method of reading the double-neck bottle; but chemical analyses indicate that the addition of .05 to the Babcock reading would give the most accurate results.

The fat column in the small neck can be raised or lowered slightly to assist in getting accurate readings by pressing the finger gently on the top of either neck.

It is recommended to use a little more than 17.5 c.c. of acid in testing skim milk; also to turn the tester a few revolutions faster per minute, and whirl for a longer time. Whey does not contain such a large percentage of solids as milk, and usually about 10 c.c. of acid are sufficient to cause a clean separation of fat.

The whole-milk bottle is not suitable for testing skim milk, buttermilk, or whey, as it is almost impossible to make an accurate reading of such a small amount of fat when it is extended over a broad surface. However, the whole-milk test bottle might be used to indicate whether or not much fat is being lost.

Testing Cheese for Fat.

1. Obtain a representative sample by cutting a slice from the outside to the centre of the cheese, or by taking plugs from different parts.

2. Cut the sample as finely as possible and weigh 2 grams or 5 grams into a milk-test bottle, or 9 grams into a cream bottle.

3. Add sufficient warm water at a temperature of 120 deg. F., to make about 18 grams in the bottle.

4. Keep the sample warm and mix occasionally, until the cheese and water form an emulsion.

5. Measure 17.5 c.c. of acid. Add a little at a time and continue mixing until the curd is all dissolved.

6. Sometimes, slightly more than 17.5 c.c. of acid are required for a test. Sufficient has been used when the mixture turns a dark chocolate color.

7. The hot water may be added before whirling in the tester.

8. To find the per cent. fat multiply the reading by 18 and divide by the number of grams used. For example : 5 grams give a reading of 8.5, the percentage of fat in the cheese $=\frac{8.5\times 18}{5}=30.6$.

Determination of the Per Cent. of Water in Cheese.

The percentage of moisture in cheese is determined by evaporating the moisture from a definite weight of cheese and calculating the per cent. from the loss in weight. The ordinary butter moisture scales may be used for weighing the sample.

The most satisfactory method of determining the percentage of moisture in cheese is by means of the high pressure steam oven which is constructed of cast-iron having the sides double jacketed. The space within the jacketed walls is fitted with a steam inlet, and an outlet to allow the condensed water to drain out. The interior or chamber is fitted with a perforated rack on which to place the samples and which permits free circulation of air around the samples. The temperature is regulated by adjusting the steam pressure applied in the hollow walls, and is read by means of a thermometer which extends into the chamber.

Making the Test.

The taking and preparing of a sample of cheese for a moisture test is outlined in the fat test for cheese and holds good in this case as well. The sample is thoroughly cut up, mixed and ten grams are weighed in an aluminum dish which has been thoroughly dried and balanced on the scale previously. The cheese must be spread as evenly as possible over the aluminum dish and as quickly as possible so as to avoid any escape of moisture due to evaporation. The ten grams sample is now placed in the oven, the door closed and 45 to 50 pounds steam pressure applied. This should give a temperature of 225 deg. F. to 250 deg. F. which is sufficient. The sample is heated until all the moisture has been evaporated. This is determined by successive weighings followed by further heating in the oven. The sample must always be allowed to cool before each weighing. When the sample ceases to lose weight, the evaporation of moisture has been completed. Ascertain the percentage of moisture from the loss in weight. For example:

If 10 grams of cheese lose 3.8 grams of moisture, 100 grams would lose $\frac{3.8}{10} \times 100 = 38$ per cent. The sample therefore contains 38 per cent. moisture.

Testing Butter for Moisture, Salt and Fat.

Butter-moisture Test.

The following is an outline of a method of determining the percentage of moisture in butter which is practised at the O. A. C. Department of Dairying. A number of tests for this purpose have been devised which are practicable and sufficiently accurate for commercial work. Like all other tests, accuracy and care must be exercised in order to obtain satisfactory results.

The method consists of weighing a definite, representative portion of the butter, evaporating the moisture and calculating the percentage of moisture from the loss in weight. A form of scales is especially constructed for this work which gives the percentage of water directly from the beam used to balance the scale after the water is evaporated.

Equipment Necessary.

(*a*) Scales.

(*b*) Aluminum cup.

(*c*) Wire device to hold cup while heating.

(*d*) An alcohol lamp.

Sampling and Preparing Butter for Testing.

A representative sample of the butter must be obtained. This is done by taking small portions from different parts of the whole mass. If sampling solids, use a trier and take three or more plugs from different parts of the whole mass.

In the case of pound prints which have been wrapped in parchment paper, the outer portion which has been in contact with the paper, should be sliced off, as the paper will absorb moisture to a greater or less extent from the butter with which it is in contact. When taking a sample from the churn, the surface of the mass should be cut away with a spade and a number of small samples taken from different parts of the interior of the whole mass.

The preparation of the sample requires considerable care. The butter is placed in a clean glass container with a lid to prevent any moisture from evaporating while heating. Heat slowly to a thick, creamy constituency. Too much precaution cannot be observed at this point as it would be detrimental to heat the sample until it becomes oily, because the water and salt would settle to the bottom. Water and fat do not readily mix and it would therefore be difficult to get the water evenly distributed through the sample for weighing.

Making the Test.

The aluminum cup in which the sample is weighed, is first dried thoroughly over the alcohol flame and placed on the pan of the scales. The cup is balanced by adjusting the weight on the tare beam and ten grams of the butter is then weighed. The cup is now heated slowly over the flame to evaporate the moisture. This process should be slow and with a constant gentle agitation to prevent any of the fat from becoming charred. Care is also taken not to allow any fat to splash out of the cup. Continue to apply heat until the butter has given up all its moisture which is indicated by the foam subsiding and the sample changing to a slightly brown color. A continuance of heat at this point would result in the volatilization of some of the butter and would be detrimental.

When the heating is concluded the sample is allowed to cool and is then re-weighed. The beam remains down as the sample is lighter than before. The weight is then moved and the percentage of moisture on the special balance is read directly.

The beam on which the moisture content is read is marked in tenths of one per cent. Where scales of this construction cannot be obtained the percentage of moisture is easily figured from the original weight of the butter used and the loss in weight from evaporation. Example:

Ten grams of a sample of butter were taken; after evaporating the moisture, the sample weighed 8.5 grams.

10 grams of the sample contained 1.5 grams of moisture.

1 gram of the sample contained $\frac{1.5}{10}$ grams of moisture.

100 grams of the sample contained $\frac{1.5}{10} \times 100 = 15$ grams.

Therefore butter contained 15 per cent. of moisture.

Determination of the Per Cent. of Salt in Butter.

The determination of the percentage of salt in butter is based upon the fact that salt and silver nitrate will neutralize each other in definite proportions. The reagents used are, silver nitrate solution and potassium chromate solution. The former is prepared by dissolving 2.906 grams of chemically pure silver nitrate crystals in a litre of distilled water (1 c.c. of a silver nitrate solution of this strength will neutralize .001 grams of sodium chloride or common salt). This solution must not be exposed to sunlight as it will weaken. The potassium chromate solution which is used as an indicator is prepared by dissolving 7.25 grams of potassium chromate in 25 cubic centimeters of distilled water.

The Apparatus Required.

(*a*) A scale or fine balance for weighing the sample of butter. The moisture scale may be used for this purpose.

(*b*) A cylindrical measuring glass, 1½ inches in diameter graduated to hold 250 c.c.

(*c*) A 25 c.c. pipette.

(*d*) A glass beaker and stirring rod.

(*e*) A burette graduated to 1/10 of one cubic centimeter, and clamp for holding the burette.

(*f*) A dropper bottle for the potassium chromate indicator.

(*g*) A pint bottle with wide mouth.

Making the Test.

A sample of butter is taken and prepared as previously described in the moisture test. Weigh ten grams of the prepared sample of butter on a small piece of parchment paper which has been previously balanced on the scale or in the aluminum cup used in the moisture test. (If a moisture test was made on ten grams of the butter, the substance remaining in the cup may be used for the salt test.)

The paper and butter are then transferred to the pint bottle and 250 cubic centimeters of water (preferably soft or distilled) at a temperature of 110 deg. F. to 120 deg. F. are measured and added to the bottle containing the butter. The bottle is thoroughly shaken to melt the butter and wash out the salt. After allowing the bottle to stand a few minutes it is again shaken to ensure an even distribution of the salt throughout the water. It is then allowed to stand until the fat rises to the surface. Twenty-five cubic centimeters of the salt solution is then measured, taking precaution not to include any of the fat in the measurement, and transferred to a glass beaker. One or two drops of potassium chromate is then added to the salt solution in the beaker from the dropper bottle. The burette is then filled with silver nitrate solution, care being taken not to allow any air bubbles to remain in the top of the burette. The silver nitrate solution is added slowly, drop by drop into the salt solution in the beaker until the neutral point is reached. The salt and the nitrate solutions are constantly stirred with the stirring rod to mix the salt and silver nitrate. The neutral point is indicated by the mixture turning a permanent faint, reddish-brown color. By reading the number of cubic centimeters used on the burette of silver nitrate we are able to ascertain the percentage of salt in the butter, as each cubic centimeter of silver nitrate required to neutralize the salt equals 1/10 or .1 per cent. of salt in the butter. For example, if 32 c.c. of the silver nitrate solution were used, the sample of butter contained 3.2 per cent. of salt.

Fat Test for Butter.

1. Secure a representative sample by taking small pieces from different parts of the whole mass of butter, or by taking a plug from end to end of a print, or from top to bottom of solids.

2. Put the samples in an airtight container and heat at intervals until the butter becomes a thin paste. The preparation of the sample as outlined in the moisture test, holds good in this test.

3. Weigh 4.5 grams, or 9 grams into an 18-gram cream bottle.

4. Add enough water at 70 deg. F. to make 18 grams.

5. Complete the test in the same way as for testing cream.

6. Per cent. of fat $= \dfrac{\text{Reading} \times 18.}{\text{Number grams used.}}$

Example:

4.5 grams butter taken.
Reading=21.
Per cent. fat=21 × 18÷4.5=84.

Two Methods of Testing Ice Cream for Fat.

It is necessary for the ice cream maker to test his ice cream occasionally to guard against any errors in standardizing methods. Ice cream cannot be tested for fat in the same way as the ordinary cream, on account of the large percentage of sugar which it contains. The following methods will give satisfactory results if carefully carried out.

The Glacial Acetic and Hydrochloric Acid Test.

A representative sample of the ice cream is taken and melted and thoroughly mixed, a 9-gram sample is weighed into an 18-gram Babcock cream-test bottle. A mixture is prepared using equal parts of glacial acetic acid and concentrated hydrochloric acid. Twenty cubic centimeters of this acid mixture is added to the 9-gram sample of ice cream in the test bottle and then all is well shaken. The bottle is placed in a water bath of 120 deg. F. to 130 deg. F., and shaken at intervals until a brown color appears. It is then placed in the Babcock centrifuge and the test completed in the same way as for testing cream and the reading multiplied by 2.

The Sulphuric Acid Test.

To make the test with sulphuric acid, a 9-gram sample is weighed into an 18-gram test bottle. About 9 cubic centimeters of luke-warm water is then added to dilute the sample in order to have about 18 cubic centimeters of mixture in the bottle. The sulphuric acid is then added slowly, a little at a time, at minute intervals, shaking well after each addition until a chocolate-brown color appears in the bottle. No definite amount of acid can be stated as the quantity will vary with different ice creams. As soon as the chocolate-brown color appears in the ice cream a little cold water may be added to check the action of the acid. The bottle is then placed in the centrifuge and the test completed in the usual way. The reading is multiplied by 2.

The Lactometer and the Detection of Adulterations in Milk.

The lactometer is a special form of hydrometer used to determine the specific gravity (sp. gr.) of milk. The term specific gravity means the weight of a certain volume of any liquid or solid substance compared with the weight of the same volume of pure water at 4 deg. C.

There are different kinds of lactometers, but the Quevenne is the most suitable for milk testing. By means of it we can determine rapidly the relative weights of milk and water.

The Quevenne lactometer is standardized at a temperature of 60 deg. F. If the milk to be tested varies from this, corrections may be made according to the following rule: For each degree in temperature *above* 60, add .1 ($\frac{1}{10}$) to the lactometer reading, and for each degree *below* 60, subtract .1 ($\frac{1}{10}$) from the lactometer reading. This rule is practically correct, if the temperature is kept within a range of from 50 deg. to 70 deg. F. It can be readily recalled when we remember that the density of milk *increases* with a *reduction* of temperature and decreases with a rise in temperature. The scale on the lactometer is graduated from 15 to 40, and indicates a specific gravity of from 1.015 to 1.040.

Note. The correct lactometer reading (or L.R. at 60 deg. F.) + 1,000 ÷ 1,000 indicates the specific gravity.

The lactometer reading of whole milk usually ranges from 29 to 34, although it may fall as low as 27, or go as high as 35. The lactometer reading of skim milk varies from 33 to 38. The reading should be taken soon after placing the instrument in the milk; if cream be allowed to rise on the milk, the reading will be too high, as the bulb of the lactometer will be floating in partially skimmed milk. Milk should be cooled and allowed to stand some time (one to three hours) after being milked before taking the lactometer reading. Otherwise the readings will be too low.

The composition of milk is about as follows:

Fat	3.6 per cent.	
Casein	2.5 " "	solids 8.9 not fat.
Albumin	.7 " "	
Sugar	5.0 " "	
Ash	.7 " "	
Water	87.5 " "	
	100.00	

It is the solids-not-fat in milk that cause its specific gravity to exceed that of water, and consequently its lactometer reading to be greater.

A number of different rules have been prepared for the calculation of milk solids when the lactometer reading and the percentage of fat are known. Of these, the following has been quite generally adopted. To find the per cent. of solids-not-fat in a sample of milk, add two-tenths of the per cent. of fat to one-quarter of the lactometer reading; and to find the per cent. of total solids add one and two-tenth times the per cent. of fat to one-quarter of the lactometer reading.

The following rule also is sufficiently accurate for practical purposes and has simplicity to recommend it. To determine the per cent. solids-not-fat, add the lactometer reading at 60 degrees and the per cent. of fat together and divide by four (4). Example: L. R.=32, fat 4% $\frac{32+4}{4}=9\%$ S.N.F.

Determination of Extent of Watering Milk.

By the use of the Babcock test in conjunction with the lactometer, we are enabled to determine both the nature and the extent of an adulteration.

The percentage of fat in milk varies and can also be influenced by skimming, therefore the lactometer alone is of little use in determining adulterations. The solids-not-fat are fairly constant, and thus afford a means of detecting adulterations.

Watered Milk. To find the per cent. of pure milk in a watered sample, multiply the per cent. S.N.F. in it by 100 and divide by the per cent. S.N.F. in the pure milk. This subtracted from 100 will give the per cent. of extraneous water in the watered sample. To take an example:

The per cent. of solids-not-fat in a sample of pure milk is 9; but after being watered the per cent. of solids-not-fat in the watered sample is 7.2. Find the per cent. of pure milk in the watered sample.

Per cent. of pure milk in watered sample, $\frac{7.2 \times 100}{9} = 80$.

Per cent. of extraneous water $= 100 - 80 = 20$

Determination of Extent of Adulteration of Milk by Both Watering and Skimming.

In case a sample of milk has been both watered and skimmed, the percentage of foreign water may be found according to the foregoing formula.

However, if we have an adulterated sample showing 2.4 per cent. fat, L. R. of 23, and 6 per cent. S.N.F., and a control showing 4.4 per cent. fat, L. R. of 32, and 9 per cent. S.N.F., it is plainly seen that the adulterated sample has been both watered and skimmed, as the fat is reduced in greater proportion than either the L. R. or the S.N.F.

By the previous formula we may calculate the percentage of foreign water as follows:

$$100 - \left(\frac{6 \times 100}{9}\right) = 100 - 66.6 = 33.4.$$

The fat abstracted by skimming does not to any extent affect the per cent. of solids-not-fat, while watering reduces both the fat and solids-not-fat in equal proportions.

Therefore the percentage of fat abstracted in a watered and skimmed sample may be ascertained by the following formula:

Per cent. fat in pure sample —

$$\frac{\text{Per cent. fat in adulterated sample} \times \text{per cent. solids-not-fat in pure sample}}{\text{Per cent. solids-not-fat in adulterated sample.}}$$

Using the above example we have:

$$4.4 - \left(\frac{2.4 \times 9}{6}\right) = 3.6 \text{ per cent.}$$

That is, the sample was skimmed to the extent of $4.4 - 3.6 = .8$ per cent.; the water added, reduced the solids-not-fat from 9 per cent. to 6 per cent., and also reduced the fat from 3.6 per cent. to 2.4 per cent., or 33⅓ per cent. water is responsible for reducing the fat, $3.6 - 2.4 = 1.2$ per cent.

Lactometer Notes.

1. Have the temperature of the milk uniform throughout, and as near 60 deg. F. as possible when taking the lactometer reading.

2. Always mix the milk well before taking a lactometer reading.

3. Do not have milk on the upper part of the stem of the lactometer when reading, as this weighs the lactometer down and causes the reading to be too low.

4. Have the lactometer free from the side of the vessel and perfectly still when taking a reading.

5. Watering is indicated by:

    Low lactometer reading.
    Low per cent. fat.
    Low per cent. solids-not-fat.

  All three being reduced in equal proportion.

    e.g., L.R. 25; S.N.F. 6.75 per cent.; fat 2.5 per cent.

6. Skimming is indicated by:

    High lactometer reading.
    Low per cent. fat.
    High or normal per cent. solids-not-fat.
    e.g., L.R. 34; S.N.F. 9 per cent.; fat 2.7 per cent.

7. Watering and skimming are indicated by:

    Lactometer reading may be normal or slightly low.
    Low per cent. fat.
    Low per cent. solids-not-fat.

The fat is reduced in greater proportion than either the lactometer reading or the solids-not-fat.

    e.g., L.R. 27; S.N.F. 6; fat 2 per cent.

The Hart Casein Test.

This is a simple test for determining the casein content of milk. The test has been introduced by Dr. E. B. Hart, of the Wisconsin Experiment Station, and its development and use is likely to prove of considerable value to the cheese branch of the dairy industry. No more ability or skill is required to make a casein test than is necessary in making a Babcock test for fat, and the test can be completed in a few minutes.

The principles involved in this method as outlined by Dr. Hart are:

1. The construction of a special bottle, with a graduated scale whereby the percentage of casein can be read when a definite volume of milk is used for a test.

2. The agitation of the precipitate with chloroform to dissolve the fat.

3. The precipitation of the casein by dilute acetic acid.

4. The application of a definite centrifugal force in order to mass the casein into a pellet.

5. Reading the per cent. of casein.

The details connected with the determination of casein are briefly as follows:

1. Measure 2 c.c. of chloroform into the test bottle.

2. Add to this, 20 c.c. of a .25 per cent. solution of acetic acid at a temperature of 70 deg. F.

3. Measure accurately 5 c.c. of sweet milk at a temperature of 70 deg.

4. Place the thumb over the opening of the bottle, turn the bottle over by rotating the hand and shake the contents vigorously for fifteen to twenty seconds.

5. Place the tests in the centrifuge and whirl for 7½ to 8 minutes at a speed of 2,000 revolutions per minute for a 15-inch diameter machine.

6. After whirling, allow the tests to remain for ten minutes to allow the pellets to relax slightly, before taking the readings.

Notes on the Casein Test.

1. Use only the best quality of chloroform.

2. See that the temperature of the milk and acid is as nearly 70 deg. F. as possible.

3. Use a watch to take the time in shaking the test and do not mix more than 20 seconds.

4. Make sure that the speed of the tester is correct. It is advisable to use a metronome for this purpose when the whirling is done by hand power.

5. Curdled samples of milk cannot be tested for casein.

6. Composite samples preserved with bichromate of potash for from three to four days can be tested more or less satisfactorily, but samples containing other preservative and those with bichromate of potash which are kept for a longer time, do not appear to give reliable results. Therefore, the test will need to be improved in this particular before it will be suitable for factory conditions.

7. A comparison of the results of the casein test with those of chemical analysis, conducted at the Ontario Agricultural College shows the casein test to be quite accurate. The average percentage of fat in 22 samples of sweet milk was 3.72. The average percentage of casein in these samples as determined by the Hart method was 2.395, and by a chemical analysis 2.415—a difference of only .02 per cent.

THE ALKALINE SOLUTION: ITS PREPARATION AND USE.

R. Harcourt, B.S.A., Professor of Chemistry.

Causes of Acidity in Milk.

The development of acid is caused by the breaking down of milk sugar into lactic acid, through the influence of certain acid-forming ferments in the milk. But even sweet milk, immediately after it is drawn from the udder, will have an acid reaction with certain indicators. This acidity is not due to lactic acid nor any free acid in the milk, but to the acid nature of the ash constituents, possibly also to the carbonic acid gas it contains, and to the acid nature of the casein. When phenolphthalein is used as an indicator, freshly drawn milk will generally show as much as .10 per cent. of acid and immediately after exposure to the atmosphere, lactic acid germs commence breaking down the milk sugar. At a temperature of 70 deg. to 90 deg. F., these germs multiply at an enormous rate, consequently lactic acid will develop very rapidly in milk during a warm or sultry day or night. Cooling retards the action, but even at a temperature of 40 deg. to 50 deg. F. they will multiply and considerable lactic acid will be formed. Milk intended for cheesemaking should not contain more than .20 per cent. acid when delivered at the factory; whereas it does not usually smell or taste sour until it contains .30 to .35 per cent. A further development of acid will cause the milk to curdle, or, in other words, will produce coagulation of the casein. There is, however, a limit to the development of acid; for, after a certain point, the germs which break down the milk sugar are destroyed by the acid they produce, and there is no further increase in acidity.

In many ways a knowledge of the acid contents of milk or its products is of value. In most cases, a determination of the percentage of acid in the milk when delivered at the factory will indicate the care the milk has received previous to that time. The acid test may be of value in selecting milk best adapted for pasteurization, or for retail trade, or manufacture of high-grade products. At the present time, however, the chief uses made of the alkaline solution in dairy work are to determine the acid in cream intended for churning, and the acid in milk and whey in the various steps in the process of the manufacture of cheese. Both in ripening cream and in cheesemaking, acid is developed, and the alkaline solution is now frequently used to measure the amount of acid present and thus control the work.

How to Measure the Acidity.

The measurement of the amount of acid or alkali in a solution depends upon the fact that it always takes a definite quantity of alkali to neutralize a definite quantity of acid. Thus, for instance, it always takes a definite quantity of caustic soda to neutralize a definite quantity of lactic acid, sulphuric acid, or any other acid. If, then, we know the strength of a given caustic soda solution and measure the amount of it used to render a definite amount of milk or cream neither acid nor alkaline, but neutral, we can figure the amount of acid in the sample taken. To make such a determination we require the following:

1. A standard solution of caustic soda, usually made of the strength known as .111 normal.

2. An indicator—some chemical which, added to the milk, indicates by change of color when enough of the alkaline solution has been added to render the milk neutral. Phenolphthalein is the one most commonly used for this purpose. It is made by dissolving 10 grams of phenolphthalein in 300 c.c. of 80 per cent. alcohol.

3. A burette, graduated to 1-10 of a cubic centimeter, in which to measure the amount of the solution used.

4. A pipette, to measure the milk or cream.

5. A glass or porcelain cup, and a stirring rod. A complete outfit suitable for use in butter and cheese factories may now be procured from almost any of the dairy supply firms.

For the information of those who want to make their own alkaline solution or who may wish to check the strength of a solution on hand, the following directions are given:

Preparation of Solutions.

The caustic soda solution may be prepared by a druggist or one who has a delicate balance at hand by carefully weighing out 4.4 grams of pure sodium hydroxide and dissolving in one litre (1,000 c.c.) of water. But impurities in the sodium hydroxide and lack of delicate enough balance make this method unreliable.

The most accurate way of preparing this solution is by standardizing it against an acid diluted to the same strength as the alkaline solution wanted. As it requires an experienced chemist to prepare this acid of the strength required, it is important that it be got from a reliable source.

Having on hand, then, a .111 normal solution of acid, the object is to make a solution of the alkali, 1 c.c. of which will exactly neutralize 1 c.c. of the acid. For this purpose, dissolve 5 grams sodium hydroxide ($NaOH$) in one litre of water. If the soda contains much carbonate, it must be removed by adding a little of a solution of barium hydroxide, boiling, and filtering off the precipitated carbonates. The relative strength of the acid and alkali solution is next determined. This is done as follows:

Rinse out a clean burette two or three times with the acid solution, and then fill it with the same. Note the exact point at which the surface of the liquid stands in the burette; measure out 10 c.c. of the alkaline solution and deliver into a clean beaker, glass or porcelain cup. Dilute with about 50 c.c. of water, add three or four drops of the phenolphthalein indicator, and then stirring all the time, let the acid from the burette drop slowly into the alkaline solution, until the color first produced by the indicator is just destroyed. This is the neutral point. Now, again note the exact point at which the surface of the liquid stands in the burette. The difference between the two readings is the amount of acid required to neutralize the 10 c.c. of alkali. If care be taken in coming to the neutral point slowly, it will be seen that one drop finally destroys the last of the light pink color. This work should be repeated until accuracy is assured. The following is an example of results:

1. 10 c.c. of alkali required 11.5 c.c. of acid for neutralization.

2. 10 c.c. of alkali required 11.45 c.c. of acid for neutralization.

3. 10 c.c. of alkali required 11.5 c.c. of acid for neutralization.

In this case, we would accept 10 to 11.5 as the relative strength of the two solutions. The alkali is, therefore, the stronger, and must be diluted. If 1.5 c.c. of water be added to 10 c.c. of the alkali solution, 1 c.c. of the alkali ought to exactly neutralize 1 c.c. of the acid. Therefore, for every 10 c.c. of the alkali solution add 1.5 c.c. of water. Measure out the amount of the solution and pour into a clean dry bottle. Calculate the amount of water required to dilute the alkali to the proper strength, and add it to the contents of the bottle. Mix well, and test correctness of work by proving that 10 c.c. of the one solution will exactly neutralize 10 c.c. of the other. If it does this, the solution is correct.

Testing the Acidity of Milk or Cream.

By means of a pipette (a 10 c.c. is a convenient size) measure out a definite quantity of the milk or cream to be tested and deliver into a beaker or cup. If distilled or rain water is handy rinse out a pipette once, and add the rinsings to the sample. Dilute with 50 c.c. of water, and add three or four drops of the indicator. Now, having the alkaline solution in the burette, carefully note the point at which the surface of the liquid stands in the burette and then cautiously let it drop into the cream or milk being tested. Keep the sample well stirred while adding the alkali. The acid in the sample will gradually be neutralized by the alkali added until at last a uniform pink color appears, which will slowly fade away. The most delicate point is the first change to the uniform pink color, which the sample shows when the acid contained therein has been just neutralized. Because of the influence of carbonic acid of the atmosphere the pink color is not permanent unless a slight excess of alkali solution has been added. The operator should not, therefore, be led to believe by the disappearance of the color after a short time, that the neutral point has not been reached. Having decided on the neutral point, again read the burette at the surface of the liquid, and the difference between this reading and the first is the amount of alkali solution used to neutralize the acid in the sample taken.

The calculation of the per cent. of acid is simple. The alkaline solution used is of such a strength that when a 10 c.c. pipette is used, the number of cubic centimeters of alkaline solution required to neutralize the acid in the milk or cream has simply to be multiplied by 0.1. Thus, if 5.6 cubic centimeters of the alkali be used then $5.6 \times 0.1 = .56$ per cent. acid.

To insure accuracy the utmost care and cleanliness must be observed in every detail of the work. All water used with the milk or cream or in making the alkaline solution should be either distilled or pure rain water. The burette and pipette, after being washed, must be rinsed out two or three times with the solution they are intended to measure.

The knowledge the operator may gain from such tests will not only make it possible for him to turn out more uniform products, but it will also enable him to act with confidence and more intelligently to pursue the work he may have on hand.

Boilers, Engines, Steam-fitting

GEO. TRAVIS.

Of all the apparatus necessary for the manufacturing of cheese and butter, the steam boiler seems to be the most essential. From it we get steam power for operating the other machinery, and steam for regulating the temperature of the milk and cream, and for other heating purposes as well; hence the selection, setting and care of the boiler, coupled with the construction of the arch and chimney so as to get the best results from the economic viewpoint, are matters of great importance to cheese and butter manufacturers.

SELECTING A BOILER.

When selecting a boiler, get one of sufficient capacity to furnish all the steam required without forcing the fire under it. A boiler cannot be forced beyond its capacity without injuring it. There would also be a waste of time and fuel forcing a steam boiler.

SETTING BOILER.

In setting a boiler a good substantial foundation for the arch or furnace should be provided. The arch is really a part of the boiler and unless it is properly built, good results cannot be obtained.

It is best to get a plan for building an arch from some reliable boiler maker. Then have the masonry done by an expert. Provide good fire brick for lining and have them laid with fire clay. Make the side walls of the arch thick with good common brick. This will make it more substantial and retain the heat longer, thus lessening the cost of fuel.

CHIMNEY.

Where coal is being used for fuel the chimney should be built of brick. The area should be at least one-fifth greater than the combined area of all the flues. The height depends largely upon its location—the higher the better.

FIRING THE BOILER.

Boilers newly set should not have fires put under them until the mortar of the brickwork has had time to harden naturally. When fire is started, heat very slowly and let the steam go through all the pipes before any pressure is put on them.

CARE OF BOILER.

Before lighting the fire in the morning, care should be taken to see that the boiler has sufficient water in it. The glass gauge in the water column cannot always be depended on at sight, therefore it is best to open the tap at the bottom of the glass to make sure that the pipes leading to, or from it, are not stopped with scale or mud. See that the safety valve is in working order. This is the most important valve in connection with the boiler. Every boiler should have a blow-off pipe at the bottom. In addition to this, it should have a surface blow-off or some "scumming" apparatus. Nearly all foreign matter held in solution in water on first becoming separated by boiling, rises to the top in the form of what is commonly called "scum," in which condition much of it may be removed by the surface blow-off. If not removed, however, the heavier particles will be attracted to each other until they have become sufficiently dense to fall to the bottom, where they will be deposited in the form of scale, covering the whole internal surface of the boiler below the water line, with a more or less perfect non-conductor of heat. Where the water is very hard, some good boiler compound may be used with good results. Different waters require different treatments. For ordinary water "sal soda" is all that is necessary.

The blow-off at the bottom should be opened enough each day to let any lime or mud that might have accumulated, escape. If this is not done, there is danger of the pipe being filled with dirt, thus excluding the water from the pipe. Then there is a danger of it becoming hot and bursting, causing a great deal of trouble.

If the pipe from the pump or injector which feeds the water into the boiler be attached so that the water will be fed in through the blow-off pipe, this danger will be largely overcome.

Pipe Fitting.

As there are also more or less steam pipes about the factory that need repairing, it is quite necessary that the maker should know how to do his own pipe fitting.

For ordinary work the tools required are, pipe, tongs, cutter, vise, and stock and dies. With these at hand any pipes or joints that may be leaking can be quickly repaired and will save the expense of sending out for a steamfitter. Steam escaping from bad joints or leaking valves makes a disagreeable noise, and money is evaporating into the air.

Engine.

The engine bed or foundation should be solid. If possible have the engine in a room separate from the boiler, as there is always more or less ashes and dust from the furnace and flues. This makes it difficult to keep clean. Any sand or grit lodging on the slides helps to wear them out sooner than it otherwise would.

Some of the chief points to be observed are: See that it is kept clean, well oiled, and properly packed to prevent steam from leaking.

Before starting the engine, open the taps of the cylinder to let the water out, turn the fly-wheel over once, then open the throttle valve gradually until the engine gets in full motion.

Pulleys and Belting.

The following rules for finding the size of pulleys and the required length of belting will be found useful in fitting up a creamery or in placing additional machinery.

To find the diameter of a driven pulley, multiply the diameter of the driver by its number of revolutions, and divide the product by the number of revolutions the driven pulley should go. The result will be the diameter of the driven pulley.

Example.—Diameter of pulley on the engine, 40 inches; speed of engine, 160 revolutions ; speed of main shaft, 200 revolutions : $40 \times 160 \div 200 = 32$, which is the diameter in inches required for the driven pulley.

To find the required size of a driving pulley, multiply the diameter of the driven pulley by the number of revolutions it should make, and divide the product by the revolutions of the driver.

Example.—Diameter of the pulley in intermediate is 4 inches, which is required to run 900 revolutions per minute; revolutions of shaft, 200: $4 \times 900 \div 200 = 18$, which is the diameter in inches of the pulley required to drive the intermediate at proper speed.

To find the length of belt for any two pulleys, add the diameter of the two pulleys together, divide this sum by 2, and multiply the quotient by $3\frac{1}{4}$. Add the product to twice the distance between the centres of shafting, and the result will be the required length of belt.

Example.—Two pulleys are 8 and 24 inches in diameter, and 8 feet is the distance between the centres of shafting. $8 + 24 = 32$, $32 \div 2 = 16$, $16 \times 3\frac{1}{4} = 52$ inches $=$ 4 feet 4 inches, and 4 feet 4 inches $+$ 16 (twice the distance between the centres and the shafting) $=$ 20 feet 4 inches, which is the length of the belt required.

Rules.—To find the circumference of a circle multiply the diameter by 3.1416. To find the diameter of a circle, multiply the circumference by .31831. To find the area of a circle multiply square of diameter by .7854. Doubling the diameter of a pipe increases its capacity four times.

Separators and the Separation of Milk

Geo. Travis.

Factory or power separators may be divided into two classes—the steam or turbine, and the belt machine. A book of directions is furnished with each new separator, therefore general directions only can be given.

Turbine Separator.

In setting it up, a solid foundation should be provided. It does not matter how solid a wooden floor is, it will vibrate more or less from the running of a churn or other machinery. With a stone, brick or cement foundation a separator is independent of any vibration from other machinery and will run much better, and for a longer time. If setting the separator on a cement floor probably the most permanent method of fastening it down is as follows: First mark the exact location for the holes. With a square, draw a line through the centre where the holes should be, then drill the cement to the desired depth (6 or 7 inches). To do this a common cold-chisel may be used providing the bit is wide enough for the body of the chisel, though a pointed chisel for this purpose is preferable. The dust may be removed from the hole while drilling by a small bellows, or blowing through a small rubber or glass tube. Have the bolt head somewhat rounded and place the bolt in the hole with the threaded end up, making sure to have it perpendicular and in line, and the necessary height above the floor, then pour melted lead in the hole around the bolt. If a method is desired whereby the bolts can be removed from the floor, drill holes as above, plug with wood, bore with a bit at least one-eighth of an inch smaller than the lag screws used and fasten down with lag screws. Another method whereby separators may be changed without drilling new holes is to drill the holes in the cement nearer to the centre than any separator will be likely to require, fasten a 2-inch by 4-inch piece of wood to the floor and bolt the separator to it.

In putting down a cement floor to be used for separators, it is well to have a pier built about two inches higher than the floor and about the size of the separator base. This tends to prevent dirt from lodging under the separator when scrubbing the floor.

If a pier has to be built, the nature of the soil will determine the depth to excavate, and the size of the frame or base of the separator will determine the length and breadth. The exact specifications are given in the book of instructions furnished with the separator.

Place the separator in position, being careful to have the separator frame perfectly level every way. Determine this by placing the spirit level upon the planed top of the frame.

The pipe to convey the steam to the separator may be the same size as the fittings of the separator, provided the distance from the boiler is not over twenty-five feet. When the distance is more than this, the size of the pipe should be one-quarter inch larger for every twenty-five feet of piping, to overcome the effects of friction and condensation of steam.

Exhaust pipes are usually made of galvanized iron, and should never be reduced in size at any point smaller than the outlet on the separator, and should be put up as straight as possible to convey the steam from the separator. It may be carried out at the side of the building. In either case, a piece extending upwards should be put up to cause a draught. Placing the exhaust pipe out through the roof is preferable when the surroundings will permit it. Have the pipe long enough to be higher than any part of the roof, in order that the draught may not be interfered with by change of wind. A drain pipe must be provided in any case at the lowest point on the pipe, to allow water to escape readily. If this should be in the making-room, a trap to prevent annoyance from escaping steam may be put on the drain pipe.

Belt Separator.

The directions given for the foundation of a turbine will apply to this. First, place the separator in position. This should be at an angle of at least 45 degrees in front or behind the driving shaft. The pulley provided for the driving shaft should be of sufficient width to allow the belt to be shifted from the tight to the loose pulley of the separator and of the proper size to give the exact speed required. Line the separator pulley with the pulley on the driving shaft. Level the separator in all directions by placing the level on the planed top of the frame. The separator bowl should revolve to the right, or with the sun, the same as the hands on a watch.

Wipe all the bearings well with a cloth, to remove all grit and dust. A little coal oil upon the cloth will be found helpful where any coating of dried oil is met with. See that all oil tubes are clear and free to feed oil. Wash the bowl and all parts that the milk comes in contact with. If everything has been properly attended to as directed it is ready to start. If a turbine, turn on steam very gradually to allow the water to get out of the steam pipes, when the required amount of steam may be turned on. When speed has been reached, start the feed of milk.

If a belt machine, start the engine at full speed, then shift the belt from the loose pulley part way on to the tight pulley, moving it at intervals until on full. From 6 to 10 minutes should be required to get up speed. Full speed is ascertained by means of speed indicators. A 100-notch wheel should be counted for one minute, and a 50-notch wheel for one-half minute, in order to know the number of hundred revolutions the bowl is revolving per minute. After speed has been reached, the milk should be turned on full speed, until both cream and skim-milk flow from the respective spouts; then it should be closed off until the cream is of the desired thickness. The cream should be the guide in operating the separator.

The cream left in the bowl when all the whole milk has been put through should be forced out with warm water. From one to two pails will be needed for this purpose. Shut off the feed-tap for a few seconds when about half the quantity has gone through; then turn it on again, allowing the remainder to complete the operation. Pure warm water is preferable to skim milk, as it is nearer the specific gravity of the cream, and consequently displaces it more readily.

Allow the bowl to stop of its own accord after the power has been removed. Remove the solid matter found at the extreme outside of the bowl and burn it at once. Clean out all milk tubes with the spiral provided; wash with tepid water thoroughly; scald with steam or boiling water; then place on a draining rack where the bowl and its parts may dry. Never close the bowl when wet inside, as it will cause it to rust. Leave it open when not in use so it will be thoroughly dry.

In ordering the parts for the separator always specify exactly what is wanted by the use of the proper name and number of the same. This can be found by consulting the book of instructions furnished with all machines. A duplicate set of the delicate or wearing parts of any machine should be kept on hand for emergencies.

Milk fresh and warm from the cow is in the best possible condition for a perfect separation. The difference in specific gravity between the fat and other portions of the milk is then greatest, and it is also more fluid, as there is no development of lactic acid, nor chemical changes due to its exposure to the air. At the creamery, it is not met with in this favorable condition; consequently it is necessary to produce artificially as many of the favorable conditions as possible to get the best results. When milk is received at a temperature below 85 deg. it should be heated to from 90 deg. to 100 deg.

A tempering vat should be elevated at a suitable height to allow the milk to flow into the separator; and it should contain enough milk to employ the separator for at least four minutes. If large bodies of milk are heated to the desired temperature in a vat before separating, acid develops too rapidly and clogging of the separator bowl is likely to follow. Should any accident happen whereby the separator is stopped, the milk would likely develop acid enough to thicken, when it could not be separated.

HAND CREAM SEPARATORS.

At present there seems to be an unlimited market for sweet cream of good quality. Since cream is a perishable product, that cannot retain its good flavor for any definite length of time, it is necessary to adopt methods for creaming, most favorable for the production of the desired article.

Where milk is properly cared for at the farm, good cream can be produced for buttermaking by means of the shallow pans or deep setting system, but on account of the length of time required to produce cream by this method it is not practicable for the sweet cream trade.

The best known method for creaming at the farm is the hand centrifuge, more commonly known as the cream separator.

Some of the advantages of the cream separator over the old style gravity systems are:

The milk may be put through the separator immediately after it has been drawn from the cow, at which stage conditions for efficient creaming are most favorable, and the skim-milk is then in the best condition for feeding purposes.

The richness of the cream may be regulated to the desired consistency by adjusting the cream screw. By this means it is possible to extract more of the milk serum from the cream, thus reducing the quantity to be cared for.

There are many other advantages which might be enumerated, such as: Less ice needed for cooling, fewer utensils to be washed, etc.

The chief objections to the hand separator are: the initial cost and the labor involved in turning and washing the machine, but when it is taken into consideration that the increased product made from the saving in loss of fat in the skim milk over the best of other methods of creaming, these objections may be overlooked.

In choosing a separator it is advisable to select one with sufficient capacity for the amount of milk produced; one which is simple in construction, strong and durable with reasonable care, and one having all parts, which come in contact with the milk, easily washed. The manufacturers should guarantee that the machine will do good work, or no pay.

There are many different makes of separators on the market, but which is the best, it is impossible to say, as no one separator possesses all the points of merit that the ideal might possess. The best separator might be described as that best suited to the special conditions under which it is to be used. For example, the closest skimming separator may be more difficult to operate, or possess other disadvantages in its construction less desirable than a machine which skims less closely, and these disadvantages may more than counterbalance its closer skimming qualities. It would be a very poor separator indeed that did not have some good points, and it would be the ideal if it did not have some weak points. A hand separator may be considered as doing good work when, running at its full capacity, it will produce a cream testing from 30 to 40 per cent. fat, and not leave more than .05 per cent. fat in the skim milk. To a certain extent the reputation of a separator as to its efficiency for creaming milk will depend upon the one who operates it.

With each separator is sent a book containing full directions for setting up, and operating the machine. These instructions should be strictly followed unless you know of something better, which you have proven to be so by practice.

Select a suitable place in which to locate the machine, where a pure atmosphere can at all times be assured. A well-built milk room in the barn that can be kept free from dust and stable odors, easily kept clean and tidy, may be most convenient, but it is advisable to have a separate milk house built in such a manner that it will be easily kept in a sanitary condition, with good ventilation and plenty of sunlight, not too far from where the cows are milked, so that the milk does not require to be carried a great distance.

The foundation on which the machine is to be fastened must be solid, and the part of the frame which carries the bowl must be level every way. Before putting the different parts of the machine together each part should be thoroughly cleaned by using a cloth made damp with kerosene or gasoline.

After the machine has been properly put together, before starting, see that the oil cups are properly delivering the oil to each bearing. If at any time the bearings appear to be gummed, a little coal oil may be used with good results.

The number of revolutions required to give the proper speed is usually tabulated on the crank of the machine. Two or three minutes should be taken to get up full speed. The supply tank or feed can should contain sufficient water, at a temperature of 110 degrees, to fill the bowl. This should be put through the machine first to warm the skimming device and prevent the milk from sticking. The milk then should be turned on full flow, and the supply can kept well filled until the milk is all in. The speed should be kept as uniform as possible. If the separator is to yield cream of uniform richness, it must be given the same speed at each time of using. Unless the operator times himself by counting the revolutions of the crank per minute, or by the use of some other speed indicator, there will be a tendency to run the machine at too low a speed.

The "metronome" is a very simple, inexpensive and practical device to time the speed of the separator. It works automatically and can be adjusted to mark time for any separator.

The rate of the inflow and the temperature of the milk will also cause a variation in the richness of the cream. The best practical temperature at which to separate the milk on the farm is from 90 deg. to 100 deg. F.

Milk is never in better condition for separation than immediately after it has been drawn from the cow. If the milk is allowed to cool, as is the case in winter, when the separator is used only once a day, or once in two days, the milk should be warmed to at least 90 deg. F. before it is run through the separator, otherwise there will be a considerable variation in the cream test and also an increased loss of fat in the skim-milk. This increase in the richness of the cream and the excessive loss of fat in the skim milk, resulting from the separation of cold milk, will occur no matter what make of separator is used.

The practice of leaving the separator unwashed from time to time after using cannot be too strongly condemned. Only a clean separator can deliver cream that is pure, sweet, and of a desirable flavor, hence it is very important that all movable parts of the bowl should be taken apart and thoroughly cleansed after each separation. All remnants of milk, cream and slime, should be washed off with tepid water, after which they should be scalded and left exposed to the sunlight if possible until required for further use.

After each separation, the can containing the cream should be set in cold water, and the cream cooled immediately to a temperature as low as possible. The cream should remain in the cool condition until it leaves the farm. This will prevent souring in the summer and freezing in the winter.

When different lots of cream are to be mixed, the fresh cream should always be thoroughly cooled before it is put in with the old cream. Adding fresh, warm cream to cream that has been separated and held for some time causes the development of lactic acid, which if not properly controlled, will cause undesirable flavors in the cream and butter.

Creamery Buttermaking

D. McMillan.

Owing to the fact that the cream-gathering system of operating a creamery is almost universally adopted in Ontario, this part on buttermaking will pertain largely to the above-mentioned system.

How to Prepare a Culture.

The preparation of a culture is described under cheese-making in this bulletin, and as the preparation for both cheese and butter cultures is the same, the method of preparing a culture will be found under the above heading.

Transportation of Cream.

It is very important that the cream should be delivered frequently, and be protected from the sun and dust while in transit to the creamery. Where possible, the best method of getting the cream from the farm to the creamery is for the patron to deliver his own cream. This plan saves the hauling cost, which is one of the big items of expense in operating a creamery. Also, by this method, the patron and maker are brought more in contact with each other, hence better co-operation.

Where patrons are unable to deliver their own cream, it should be collected in individual cans. By this method each patron's cream reaches the creamery unmixed with that of the other patrons, and the maker is able to inspect the cream, and to assist those who are sending poor cream in improving the quality.

Also, the weighing and sampling are directly under the maker's control. Where cream is mixed in large cans or tanks, the weighing and sampling must be done by the cream-haulers, which is sometimes very unsatisfactory.

Receiving the Cream.

Where patrons deliver their own cream, or where individual cans are used, each can should be carefully weighed and sampled and the weight recorded on a cream report sheet. The sampling should receive careful attention.

In case large cans are used, which necessitates the hauler doing the weighing and sampling, the hauler's load should be weighed when it reaches the creamery. The weight of the load is then compared with the total weight recorded on the hauler's cream-book. This is a check on the hauler's weighing. To check the accuracy of his sampling, his samples should be tested occasionally, and the total fat which he has on his cream-book figured out. Then by taking a representative sample of his load of cream the total fat on his wagon may be found. In this way the fat on his wagon and the fat credited to patrons on his cream-book, can be compared and the accuracy of his work determined.

Cream Grading.

As the quality of the butter depends on the quality of the cream from which it is made more than on any other factor in connection with its production, it is very important that the cream be of the very best quality, if uniformity and high prices are to be secured. Pasteurization and the addition of a good culture will, it is true, make a great improvement on the quality of the finished butter, but pasteurization and the addition of a good culture will not make finest butter from cream of poor quality.

At the present time there is a lack of uniformity in the quality of the cream delivered to our creameries, and the best solution of this problem appears to be the grading, and paying for cream, according to quality. This is a just system, since it pays the producer for the quality of the product which he delivers.

Where individual cans are used, the grading of the cream is not very difficult, but where large cans or tanks are used and the cream is graded from the haulers' samples, the work is more complicated and a few precautions are necessary.

(1) Where the small sample bottle with the screw top is used, it should be well washed and scalded and the top left off as long as possible; where the long sample bottle with the cork is used, it should be well washed and scalded and both bottle and cork allowed to dry before placing the corks into the bottles.

(2) Care should be taken to see that all samples are carried in a clean sample case, protected from the sun, and kept as cool as possible while in transit.

(3) Immediately on arrival at the creamery, the samples should be graded by first removing the cream from the sample bottle into a clean container. A small cup is suitable for this work.

Note.—Cream for grade No. 1, must have a good clean flavor, a smooth appearance, and test not less than 30 per cent. fat, and not more than .27 per cent. acidity.

Grade No. 2, will include cream which is lumpy or slightly off in flavor, but not stale, and which in the opinion of the grader, will not make first class butter.

Cream which is very sour, low in fat, and showing old or stale flavors will, if accepted, grade No. 3.

Pasteurizing and Ripening.

As soon as the cream is received, it should be pasteurized. The chief object in pasteurization is to destroy most of the bacteria present in the cream. This enables the buttermaker to more completely control the nature of the fermentation, by the addition of a pure lactic acid culture. In this way it is possible to secure a more uniform product.

Pasteurization also improves the flavor, and the keeping quality of the butter. There are two methods of pasteurizing in use—the "flash" or "continuous," and the "holder" or "vat." By the flash method the cream is heated while passing through the pasteurizer, to a temperature of 180 deg. F. to 185 deg. F. It is then passed over a cooler and cooled to ripening or churning temperature. At the present time the vat method has almost entirely replaced the "flash" method of pasteurizing cream for buttermaking.

By the "vat" method, the cream is put into a vat pasteurizer, heated to a temperature of 145 deg. F. to 150 deg. F., and this temperature is maintained for a period of twenty to thirty minutes. As the efficiency of pasteurization is dependent largely on temperature, it is very important that the proper temperature be used, and, with the vat method, that it be maintained for the full holding period. The cream should then be cooled as quickly as possible to the ripening temperature of 60 deg. F. to 70 deg. F.

Adding the Culture.

As soon as the cream is cooled to ripening temperature, the culture should be added. The amount of culture to add will depend on the quality of the cream. With cream of good quality 5 to 10 per cent. will be sufficient, but with cream of poor quality, add a larger amount of culture. When the desired amount of acidity has developed, cool the cream to churning temperature, and hold at this temperature for several hours before churning. It is a well-known fact that the butter fat in cream needs several hours of thorough chilling prior to churning, if good body and grain are to be attained. It is also known that butter made from cream churned immediately after cooling will be much softer in body than the same butter would have been, had the cream remained cold for several hours immediately prior to churning. Under conditions where cream is received in the afternoon, the usual practice is to pasteurize, ripen and cool to churning temperature, then hold the cream at this temperature until next morning.

Under present conditions, and especially during the summer months, most of the cream is ripe enough for churning before it reaches the creamery; pasteurization of this kind of cream will produce a more desirable flavor and a more uniform quality of butter than if not pasteurized.

If pasteurization is not practicable the cream should be cooled to the churning temperature as quickly as possible after delivery at the creamery.

Creamery Churning.

Churning is the process of separating the butter fat from the other constituents in the cream. The time required to complete this process is affected by many factors, chief of which are:

The percentage of fat in the cream, the temperature of the cream, the speed of the churn, the amount of cream in the churn, the acidity of the cream, the nature of the agitation, the size and nature of the fat globules.

The fat globules exist in the cream in large numbers, and the richer the cream the more closely they will come into contact with each other; for this reason, rich cream will churn more easily than poor cream. Under ordinary conditions, a cream containing 30 to 35 per cent. of fat is the most satisfactory for churning. A cream much richer than this, will adhere to the sides of the churn, which reduces the amount of concussion. The addition of water to the cream will overcome this, and cause the butter to come in a reasonable length of time. It is better, however, to avoid an excessive richness in the cream. The temperature of the cream is an important factor in determining its churnability. Other conditions being equal, the higher the temperature the sooner the churning process will be complete; however, it should always be well below the melting point of the butter fat. If the temperature is too high, there will be a large loss of fat in the buttermilk, the butter will have a greasy texture, and too much buttermilk may also be incorporated in the butter. On the other hand, if the temperature be too low, the churning process will be very difficult to accomplish, the butter granules will be too small, and there will also be a loss of time and power. Churning temperature is of great importance, and will vary considerably under different conditions. The proper temperature to use must be determined by the buttermaker based on his knowledge of local conditions, but under normal conditions, the proper churning temperature will be between 48 deg. F. and 58 deg. F.

The speed at which the churn is revolved has a marked effect on the time required for churning and varies with the construction of the churn. For this reason, no definite directions can be given as to speed, but it should be such as to give the greatest degree of agitation to the churn. Should it be too rapid, the force will hold the cream against the inner surface of the churn and it will receive very little agitation. If the speed be too slow, the cream will not be carried up the sides of the churn from which it falls, before reaching the top.

The acidity of the cream affects its ease of churning. This is due to the fact that the development of the lactic acid reduces the viscosity of the cream, and the ease with which the fat globules travel in the cream becomes greater, the less the viscosity.

The ease with which cream may be churned is affected by both size and quality of the fat globules. The character of the fat is influenced by the breed of the cows, the period of lactation, and the feed given to the cows.

In case the churn is too full, there will be little opportunity for the cream to fall, hence little agitation, and a large loss of fat in the buttermilk; on the other hand, if too small an amount of cream be used, it may adhere to the sides of the churn and receive little or no agitation. Best results will be obtained if the churn is from one-third to one-half full of cream. With this amount, other conditions being correct, the churning process should take place in approximately forty-five minutes.

Churning Operations.

Before adding the cream, the churn should be scalded, and thoroughly cooled with cold water. This will freshen the churn and fill the pores of the wood so that the butter will not stick to the inside of the churn.

All cream should be carefully strained into the churn, as this removes the particles of curd which, if allowed to enter the churn, will cause specks to appear in the butter.

Adding Color.

If color is necessary, it should be added to the cream before starting the churn. The amount of color to add will depend on the natural color of the cream, and the market demands.

Starting the Churn.

Before starting the churn, care should be taken to see that all vents are closed, and during the first five minutes of churning the churn should be stopped several times and the vent opened to relieve the air pressure developed inside.

When to Stop the Churn.

When butter granules appear in the buttermilk and are about the size of small peas, the churning process is completed. The two things aimed at are, the completeness of the churning and the removal of the buttermilk. If the granules are too large, buttermilk will be incorporated in them and cannot be washed out. As soon as the churning has been completed, the buttermilk should be drawn off into a fine strainer to prevent the loss of small particles of butter.

Washing the Butter.

The purpose of washing the butter is to remove the buttermilk, and, under some conditions, modify the hardness or softness of the butter fat. The amount of washing which the butter should receive will depend on the quality of the cream. Having the cream of good quality, spraying and one washing will be sufficient; but with cream of poor quality, the butter should be washed twice. Nothing but pure water should be used. The amount of water should be equal ordinarily to the amount of cream in the churn. In the case of over-churned butter, add a large amount of water. The churn should then be revolved a few times at churning speed. (Eight to ten revolutions are sufficient.) Under normal conditions the temperature of the wash water should be similar to that of the temperature of the cream. but if the room temperature is high and the butter is soft, water a few degrees lower than the temperature of the butter should be added and this allowed to stand until the butter is cooled to the temperature of the water. If the butter is too hard, it can be softened by adding water a few degrees warmer than the temperature of the butter.

Salting the Butter.

The rate at which the butter should be salted depends on the requirements of the market, and may vary from nothing, to four per cent., in the finished butter. It is well to remember, however, that for general trade, a mild-salted butter is usually preferred. Nothing but the best grades of dairy salt should be used. It should be sifted through a fine sieve, and if very dry, it should be moistened before applying it to the butter. After the wash-water has been removed, the butter should be salted. Apply evenly over the surface of the butter while in the granular form, about one-half the amount of salt, then, with the Success or Simplex type of churn, give the churn one-half revolution which will turn the butter over; with the Alpha or Victor type of churn, give the churn one revolution with the rolls stationary; apply the remainder of the salt and adjust the worker.

Working the Butter.

The objects of working butter are, to evenly incorporate the salt, and to give the butter a close texture. The butter should be worked just enough to give it a firm, even body, and to prevent the appearance of mottles after it is printed or packed. Just how much working this requires, every buttermaker must determine for himself, for the reason that there are a number of conditions which cause a variation in the length of time required to work the butter properly. These conditions are: (1) the amount of butter in the churn; (2) temperature of the butter; (3) the size of the granules; (4) the condition of the salt. When there is a fairly large amount of butter in the churn, fewer revolutions will be required than with a small amount, for the reason that the small amount of butter will receive little or no pressure while passing through the rolls and it will be difficult to distribute the salt evenly; on the other hand, if the capacity of the churn is overtaxed, satisfactory working cannot be secured.

The butter should have sufficient firmness to stand the pressure required to work it properly. Hard, cold butter is difficult to work, because the particles will not knead together. If too soft, it will receive little or no pressure, resulting in a poor body and too much free moisture.

If the butter is over-churned, it will require more working because of the greater difficulty of distributing the salt.

Cold, dry salt will be hard to dissolve and require more working.

While it is important that the butter should be worked sufficiently to give it a smooth, firm body, overworking will break down the body and give a greasy texture. Where conditions will permit, the churn should be allowed to stand for a few minutes during the working period. This will aid in dissolving the salt, and lessen the danger of mottles appearing in the finished butter. If the churn has been stopped at the right time and the butter properly washed, no special effort will be required to remove an excess of moisture.

Packing and Printing.

Butter is usually in the best condition for packing immediately after it has been worked. The form in which the butter is finished will depend on the market demands. When made for immediate use, the one-pound print is usually preferred; but if it is intended for export, or to be put into cold storage, the 56-pound box is required.

Printing.

There are two methods in common use for making one-pound prints—the hand printer, and the printing machine. Where the hand printer is used, the butter should be handled at such a temperature as not to affect its body, the prints should have square corners, be free from holes or finger marks, and be neatly wrapped in good quality parchment paper. They should weigh 16¼ ounces (with wet wrapper) to allow for shrinkage. When filling 90-pound boxes for the printing machine, care should be taken to have the butter well packed into the box and when about half full, press the butter spade down between the butter and the inner surface of the box until it reaches the bottom; repeat this operation when the box is nearly full. This will lessen the danger of air holes and give the butter a smoother surface when pressed out of the box.

If the butter be put into 56-pound boxes, the box should be new, well paraffined on the inside, and lined with good parchment paper. The parchment paper should be soaked for at least 24 hours before using, in a strong brine solution, containing a small amount of formalin, to prevent mould. After lining the box, and before adding the butter, each box should be weighed and the weight marked on the side of the box. The butter should be carefully packed into the box and the top neatly finished. A 56-pound box should contain from one-half to one pound butter extra, to allow for shrinkage. The date and the number of the churning should be placed on the side of each box.

Storing and Shipping.

As soon as the butter is printed or packed it should be put into the refrigerator. The refrigerator should be kept clean and tidy, and be whitewashed frequently to keep it fresh and sweet. It should be kept at as low a temperature as possible. Where the ice is stored above the refrigerator, the ice chamber should be kept well filled with ice. If round cylinders are used for cooling, they also should be kept well filled with ice. The addition of salt to these, will help reduce the temperature. It is well to remember that butter is a perishable article, and unless stored in a temperature below freezing the quality will deteriorate very rapidly.

When shipping, see that the boxes are handled carefully, kept clean, and protected from the sun while in transit to the refrigerator car.

Care of Churns, Cream Vats and Other Utensils.

After the butter has been removed, the churns should be washed first, with moderately hot water, then twice with boiling water, after which allow plenty of pure air to circulate through the churn, as this will dry the inside and prevent musty odors. Once a week the churn should be given a wash with lime water, to keep it fresh and sweet. The gear and outside of the churn should receive careful attention and be kept clean and tidy.

Cream vats, pasteurizers, and other creamery utensils, should be first rinsed with warm water, then washed with hot water and a brush. (A small amount of good washing compound may be added to the wash water.) Then thoroughly scald with boiling water. Boiling water and human labor are both expensive yet both are essential for cleanliness.

Ice Cream

D. McMillan.

Although the history of ice cream dates back to the seventeenth century, until recently, its development has been rather slow. This is no doubt due to the fact that it was eaten largely on account of its pleasant taste and as a luxury, rather than as food. Conditions change, however, and after a thorough investigation, it is now claimed by some, that a considerable quantity is eaten primarily for its food value. Whether eaten solely for its pleasure-giving properties, or as a food, ice cream, when properly made, has not only a pleasant taste, but it also contains considerable food value.

In recent years, the production of ice cream has become quite an important branch of the dairy industry of this country. As the bulk of it is made during the summer months, or in other words, at a time when there is usually a surplus of milk and cream, the manufacture of ice cream fits in very nicely with the city creamery or city milk plant. A number of these have added ice cream making as a branch of their business. There are also a number of large plants, devoted almost exclusively to its manufacture, which should insure a more uniform product, made under good sanitary conditions.

It is not the intention in this bulletin to go into all the details of ice cream manufacture; there are, however, in this, as in all other dairy practices, certain phases of the work which require careful attention. The quality of the cream to be used in ice cream making is an important factor. It should contain a liberal amount of butter fat, and above everything else, it should be free from all contaminations.

Care of Cream.

First standardize the cream to the desired percentage of fat. If necessary, pasteurize by heating the cream to 145 deg. F., and hold it at this temperature for a period of twenty-five minutes; then cool as quickly as possible to a temperature close to, but above freezing, hold at this temperature for at least twenty-four hours before being made into ice cream. This should be done for several reasons—at this temperature it will remain sweet longer than if held warmer; its viscosity is increased; and a better bodied ice cream may be made when the fat has been cooled for a sufficient length of time to allow a thorough hardening. Perhaps the most efficient method of holding or cooling cream with ice, is to set the filled cans into an insulated tank of water in which the ice is floating. This will ensure thorough chilling without the danger of freezing. If the cream be allowed to freeze during the holding period, the properties which give body and yield, will, to some extent, be injured.

Standardizing Cream for Ice Cream Making.

It is very desirable that a uniform fat percentage be maintained in the cream used from day to day. Hence, there should be some means at hand for standardization. The most accurate method of standardizing cream to any desired percentage of butter fat, is the following:

Example 1. Given a 36 per cent. cream and skim milk to be mixed to produce a 20 per cent. cream. The weights to be used can be determined in the following way:

1. Subtract the figures representing the desired quality from the known per cent. of fat in the cream. This will give the weight of skim milk to be used.

2. Subtract the per cent. of fat in the milk (which in skim milk is 0) from the desired percentage of the mixture to obtain the weight of cream to be used.

This can be best illustrated by placing the figures as shown in the square.

36		20	(20 - 0=20)
	20		
0		16	(36 - 20=16)
		36	

It will be noticed that by mixing twenty pounds of 36 per cent. cream and sixteen pounds of skim milk, there will be obtained thirty-six pounds of twenty per cent. cream. Suppose we require 220 pounds of 20 per cent. cream, 220 × 16 ÷ 36, will give the weight of skim milk required; and 220 × 20 ÷ 36 will give the weight of 36 per cent. cream required to make 220 lbs. of 20 per cent. cream.

Example 2. Given 367 lbs. of 38 per cent. cream to be reduced by skim milk to an 18 per cent. cream, the square will be:

38		18	(18 - 0=18)
	18		
0		20	(38 - 18=20)

367 × 20 ÷ 18 will give the weight of skim milk required.

Example 3. Given a 26 per cent. cream and a 4 per cent. milk to be mixed to produce a 16 per cent. cream the square will be:

26	12	(16 - 4 = 12)
16		
4	10	(26 - 16 = 10)
	22	

Thus, we see that by mixing 12 lbs. of 26 per cent. cream and 10 lbs. of 4 per cent. milk, there will be obtained 22 lbs. of 16 per cent. cream. But supposing we require 110 lbs. of 16 per cent. cream, 110 $\times$ 10 $\div$ 22 will give the weight of 26 per cent. cream required to make 110 lbs. of 16 per cent. cream.

Example 4. Given 264 lbs. of 34 per cent. cream to be reduced by 3.5 per cent. milk to a 22 per cent. cream, the square will be:

34	18.5	(22 - 3.5 = 18.5)
22		
3.5	12	(34 - 22 = 12.)

264 $\times$ 12 $\div$ 18.5 will give the weight of 3.5 per cent. milk required.

Note.—It will be found that one of the four examples described above, will be suitable for any condition which may arise in connection with the standardization of cream. Also, if found more convenient, gallons, quarts, or pints may be used instead of pounds.

Preparation of the Mix.

There should be no place in the up-to-date ice cream plant for guess-work. Accuracy in the preparation of the mix is essential, if a uniform product is to be secured. The cream and sugar should be carefully weighed, and the flavoring measured. As the capacity of most brine freezers is rated on the wine-gallon basis, it is necessary to arrange formulas to suit the capacity of the freezer. The ten-gallon formula is the most convenient. A formula for ten wine-gallons of vanilla ice cream is, 44 to 48 lbs. of cream (depending on the fat content) 8 lbs. of sugar, and 4 oz. of vanilla extract. This will make approximately eight imperial gallons of finished ice cream.

When fruits, nuts, or other solid materials are used, they should be added after the ice cream has become partly frozen, otherwise they will settle and remain at the bottom of the freezer. If fresh fruit of any kind is to be put into the cream, it should be well chopped or crushed, and sweetened, suitable for table use, some time before using.

Probably the strawberry is the most popular of fruit ice creams. A formula for ten wine-gallons is: 44 lbs. of cream, 8 lbs. of sugar, and 64 oz. of strawberry syrup. After the ice cream is partly frozen, add one-half gallon of preserved strawberries.

The Freezing Process.

The length of time required to freeze a batch of ice cream will depend on the temperature of the mix, the temperature of the brine, and the amount of sugar used. If the mix be placed in the freezer at a temperature of 50 deg. F. to 60 deg. F., there is danger of churning. It will also require several minutes to cool the cream to the whipping point, and from 5 to 10 minutes to finish the freezing process. It is, of course, possible to freeze it more quickly, in which event the cream passes through the whipping temperatures too rapidly to insure thorough whipping. If the mix be put into the freezer at 34 deg. to 37 deg. F. it may be frozen in from seven to ten minutes and ample time is allowed for whipping. So far as "swell" is concerned, it practically all takes place during the time the cream is cooling from 35 deg. F. to 28 deg. F. Sugar is a resistant of freezing, and ice cream sweetened to the average taste contains approximately 13 to 17 per cent. of added sugar, and has a freezing point of about 28.5 deg. F. to 27.5 deg. F. Remove the ice cream from the freezer when it has reached the consistency of extra heavy condensed milk. So far as possible, all handling of the finished product should be done while it is in this semi-solid condition. If placed in large containers and hardened, then later removed and packed into small containers, there will be a loss of volume.

Where ice cream bricks are hardened in a mixture of salt and ice, care should be taken to see that the moulds are well filled with ice cream, otherwise the salt brine will work into the moulds and spoil the contents.

Factory Cheddar Cheese Making

T. J. McKinney.

The Curd Test.

Provide pint glass jars or porcelain cups sufficient in number to test the milk of at least the number of patrons supplying milk to the factory. A convenient size for the porcelain cup is two inches in diameter and three inches deep. Each jar or cup should be plainly numbered or tagged. Provide a tin or galvanized iron box with a neat-fitting cover, large enough to hold the jars or cups. This box should have both water and steam connections. When taking the sample for making the test, place the milk in the cup or jar with the same number as is opposite the patron's name. Place them in the box, adding water to the depth of the milk in the jars or cups. Raise the temperature of the samples to 86 deg. F. When transferring the thermometer from one cup to the other, special care must be taken to sterilize the thermometer each time. When the milk has reached a temperature of 86 deg. F., add one dram of a diluted rennet solution made of one part rennet to twenty-four parts water. The rennet may be stirred in by using a knife with a solid metal handle, or by giving the cup a rotary motion. Care should be taken if a knife be used, to sterilize the knife between the stirring of each sample so as not to contaminate one sample from another. When the samples are firm enough, cut into small pieces with the same knife as was used for stirring in the rennet using the same precautions to sterilize between the cutting of each sample. Raise the temperature to 98 deg. F. Stir the curd at intervals, sufficiently to keep it from matting, for three-quarters of an hour.

When the cubes are quite firm, pour off the whey and allow the curd to mat in the bottom of the jars. After the samples stand for awhile, more whey can be poured off the curd. The water around the jars should be kept at a temperature of 98 deg. F. for five or six hours. By smelling the curd, bad flavors can be detected which could not be found in the milk. This test is valuable in helping to convince patrons that their milk is not in good condition for cheese-making.

The Preparation and Use of a Culture.

First provide suitable cans of good tin, which are well soldered, and about twenty inches deep and eight inches in diameter. It is better to have a duplicate set, as this gives a better opportunity for keeping them in good condition. When the milk is in small lots it can be more readily heated and cooled than if kept in larger quantities. For convenience in heating and cooling, a special box large enough to hold the cans containing the culture for one day's use should be provided. This box should be made of wood, or if made of metal, should be insulated, so as to maintain a constant temperature while the culture is setting. This is essential if best results are to be obtained. The box should be supplied with steam and cold water connections.

Better results may be obtained by using the milk from the same source each day, as we are more likely to get a uniform flavor and acidity from day to day by so doing. After selecting the milk, place the cans in the tank with cold water, and cover the cans with a granite plate, thus guarding against contamination from outside sources. Heat gradually to a temperature of 185 deg. F. This may be done without stirring the milk. Hold at this temperature for a few minutes to make sure that the milk in the cans has reached this temperature. Then run off the hot water and turn on cold water, and cool (in the same manner without stirring the milk), to a temperature of about 60 deg. F. In case proper means for heating and cooling, such as described, are not available, then stirring will be necessary. Now add a small amount of the mother culture sufficient to give the desired acid at the time required for use. In our work we find that about one ounce (by measure) to ten pounds of milk gives very good results. In starting a culture it is advisable to use a commercial, or pure culture. These may be obtained from the Bacteriological Department of the College, or from any of the dairy supply houses. Special temperatures are required for the first propagation of these cultures. Empty the mother culture into a quart of pasteurized milk cooled to a temperature of 75 deg. to 80 deg. F., and allow to stand until coagulation takes place. It is advisable to propagate a commercial culture at least two or three times before using. If the culture is to be kept more than 24 hours, it is advisable to set accordingly, by using a lower temperature and using less of the mother culture. Aim to produce the same acidity from day to day. When the culture is first broken up, take out a small quantity to propagate the culture for next day. A glass sealer should be provided for this purpose. The indications of a good culture are as follows: The whole mass is coagulated, no liquid is found on top, and it has a mild acid flavor, pleasant to the taste and smell.

A culture may be used to advantage when the milk is maturing slowly, or when it is tainted or gassy. One-half of one per cent. is the greatest quantity that should be used, and this only when the milk is known to be in sweet condition.

Milk should be set slightly sweeter when culture is used. With gassy milk its use is especially beneficial. Culture with bad flavor or with too high an acidity should not be used. All utensils must be thoroughly cleansed and sterilized before using in culture making.

Co-operation Between Maker and Patron.

That there has been a marked improvement in the milk delivered to the factory for cheese-making is quite apparent from the improved quality of the cheese produced, but there is still room for more co-operation between the maker and his patrons; first by the maker keeping his factory and its surroundings in a better condition as to cleanliness and sanitation, thereby making it a more attractive place, which the farmer can look at with pride instead of disgust; secondly, by returning the by-product, whey, in better condition. This latter can be accomplished only by the pasteurization of the whey and the proper cleaning of the tank. It is useless heating the whey unless it is all removed each day and the tank thoroughly washed.

There can be no hard and fast rules given for heating the whey, as this must be varied according to the conditions at the factory, although there are a few general principles which must be observed if this work is to be done successfully and profitably. The heating should be commenced as soon as possible after the first whey is put into the tank. This should be done for two reasons—first, to take advantage of the temperature the whey is already at; and second, to prevent the further development of acidity. The whey should be heated to at least 150 deg. F. in order to obtain the best results. Care should be taken not to exceed 160 deg. F., as heating above this temperature will cause the whey to become slimy.

The benefits to be derived from pasteurizing whey are: It conserves the food value of the whey in preventing the development of acid; it ensures a more even distribution of the fat in the whey; it also prevents the spread of contagious disease through the whey when being returned to the farm and fed to young stock; the sweet whey is not so hard on the cans as is sour whey, and the cans are more easily cleaned when the whey is kept clean and sweet. According to experiments made, the whey may be heated at a cost of from 50c. to $1.00 per ton of cheese, according to the efficiency of the equipment of the factory.

Milk for Cheese-making.

To obtain the best results, it is necessary to have the milk delivered at the factory clean, sweet, and of good flavor. The evening milk should be cooled to 60 deg. F., or under, and the morning's milk cooled before mixing with the evening's milk. The maker who accepts other than good milk is not acting fairly with the other patrons who furnish a first class quality of milk for cheese manufacture.

Testing for Ripeness.

Rennet Test.

The rennet test should always be made after the color is added to the milk. When a number of tests are made, and afterwards poured into the vat without having the color added, white specks are most likely to appear in the cheese.

To make the test, measure exactly eight ounces of milk in an eight-ounce glass, at a temperature of 86 deg. F. Place a piece of match or wood in the milk, then add one dram of rennet, note the time on the second hand of a watch or clock, stir the rennet into the milk for ten seconds, count the time from adding the rennet until the match, or piece of wood stopped. When the milk has the required acid, this will take from twenty to twenty-four seconds.

Acidimeter.

The ripeness or acidity of milk may be tested also with the acidimeter. No definite degree of acidity can be given as a hard and fast rule to go by. The best rule, is to set at that acidity which will allow the curd to remain in the whey from $2\frac{1}{2}$ to 3 hours from the time of adding the rennet, until the whey is removed with the right degree of acidity developed. This is usually about .17 per cent. on the acidimeter.

If using the acidimeter and making colored cheese, the acidity should be ascertained before adding the color to the milk, as it is more difficult to detect the neutral point with the color added to the milk.

Another point to note carefully when using the acidimeter is, the effect of the presence of rainwater in the milk. When the milk is diluted, less milk is taken in the sample, and will show a less degree of acidity than is contained in the milk to the extent of the percentage of dilution, thereby misleading the cheesemaker.

The Use of Pepsin or Other Substitutes for Rennet.

Pepsin in powder, or solid form is prepared by dissolving about one-quarter ounce of pepsin in eight ounces of pure water. This solution is then added to one thousand pounds of milk or sufficient of it to coagulate the milk in from twenty-five to thirty minutes.

Liquid rennet substitutes are already prepared for use and the directions are given by the manufacturer. The quantities usually recommended are from four to five ounces to one thousand pounds of milk. Pepsin does not seem to work so well in very sweet milk as does rennet.

If setting a vat of milk at .17 per cent. acidity by using rennet, for pepsin or other rennet substitutes, the milk should have .18 or .185 per cent. acidity in order to obtain similar results. Care should be taken not to develop too much acid on the milk, as it will injure the quality of the cheese.

Spring Cheese.

If color is used it should be thoroughly mixed with the milk before the rennet is added, using one to one and one-half ounces of color per thousand pounds of milk. Add color in amount as the market may require. The use of cheese coloring should be discouraged, as it is a needless expense.

When making early spring cheese it is usually necessary to make a quick-curing cheese in order to reach an early market.

To make this class of cheese it is advisable to use a large quantity of rennet and a small quantity of salt, as this hastens the ripening process and overcomes the tendency of milk at this time to make a dry, hard cheese due to the low per cent. of fat in the milk and the tendency of this class of milk to develop acid rapidly. Heat the milk to 86 deg. F., and stir slowly while heating. When the desired acidity is obtained, add the rennet, using four or five ounces per thousand pounds of milk, or sufficient to coagulate the milk firm enough for cutting in fifteen or twenty minutes.

Commence to cut early, using the horizontal knife first, cutting slowly lengthwise of the vat.

Then with the perpendicular knife cut crosswise and afterwards lengthwise of the vat. We would advise strongly the use of the $\frac{1}{4}$-inch wire knife, as this leaves the curd in better condition for the moisture to escape with the least possible loss in the whey, as the cubes are smaller, and more uniform, and are not so easily broken as the larger ones.

Commence stirring at once with agitators or the McPherson rake. Stir carefully for ten or fifteen minutes, then see that the curd is free from the sides of the vat before applying heat. This loosening of the curd from the sides of the vat can be done at this stage with less loss than if done immediately after cutting, as the curd has become somewhat firmer and does not break up so readily. Curds should be handled carefully and in such a manner that the cubes will not be broken, nor allowed to mat together. Rough handling or breaking of the curd causes a serious loss to both quality and quantity.

Heat to a temperature of 98 deg. F. in 1½ hours from the time of setting. We formerly advised taking the agitators out soon after heating was completed with the idea that we were able to firm the curd better with the small rake, but since the introduction of the ¼-inch knife, we have found that we get better results, with less labor, by allowing the agitators to run for a longer time.

There is nothing gained by harsh treatment of the curd, as such treatment will allow the moisture to escape only in so far as it breaks the curd. It is much better to allow the curd to firm by natural agencies, namely, acid development, heat, and rennet action. Acid usually develops very rapidly in the spring, therefore it is necessary to be prepared to remove the whey quickly when sufficient acid has been developed, which may be from .16 to .19 per cent. as shown by the acidimeter. Curds at this stage should be nice and firm (not hard or harsh), and be kept in a loose, open condition in the sink a sufficient length of time to allow the free moisture to escape, as the moisture can be removed at this stage with very much less loss than it can later on. Leave the curd about 8 inches deep in the curd sink. When it is well matted, cut into strips 6 to 8 inches wide and turn upside down, and in about fifteen minutes turn again, piling two deep. Continue turning every fifteen minutes until the curd is ready to mill. When the curd is well matted and flaky and shows .7 to .8 per cent. of acid it should be milled, and well stirred afterwards. This stirring should be repeated often enough to prevent the curd matting until ready to salt. This will be when the curd has mellowed down nicely and shows 1 to 1.2 per cent. of acid. Stir and air the curd well before adding the salt, as this improves the texture and flavor of the cheese. Salt at the rate of 1½ to 2 pounds of salt to 1,000 pounds of milk. It is important that the temperature of the curd from dipping to milling should not go below 94 deg. F. After milling allow the curd to cool gradually to about 85 deg. F. when ready to salt. Put to press at a temperature of 82 deg. to 84 deg. F. Weigh the curd into the hoop, tighten the press gradually and leave the cheese 45 minutes before taking out to dress. When dressing, use plenty of clean, hot water and what are commonly called "skirts." These cloths help to make a good rind on the cheese, keep them clean, and cause the cheese to come out of the hoop more readily. Turn all the cheese in the hoops every morning, and allow no cheese to be taken to the curing-room that do not present a clean, neat appearance.

Summer Cheese.

In making summer cheese one ounce of color to one thousand pounds of milk is usually sufficient, but this may be varied according to requirements of the market. Use from 3 to 3½ ounces of rennet extract per thousand pounds of milk, or sufficient to coagulate the milk for cutting in 25 to 30 minutes. If this limit is exceeded we have too great a loss in the whey. The cutting and firming of the curd is the same as given for spring cheese.

It may be necessary to raise the cooking temperature slightly higher, as we may be dealing with milk of a different composition from that used in the spring. The acidity should be allowed to develop to such a point that is found from day to day to give the best results in the working of the curd later in the process, aiming to have the curd with good body, well matted and in a flaky condition when ready to mill. At this time it should have an acidity of .7 to .8 per cent. in about two hours from the time of dipping. The curd should be well stirred after milling, and, if cut crosswise of the grain, the stirring may be done better and with much less labor. Curd should be well matured, stirred, aired thoroughly and cooled to a temperature of 85 deg. F. before salting. Use from 2 to 2½ pounds of salt on the curd from one thousand pounds of milk.

Fall Cheese.

When making fall cheese it is a mistake to use too much culture or to ripen the milk too much, giving the cheese the appearance of having been made from over-ripe milk, which is very objectionable in fall cheese; rather use a smaller amount of culture, not more than one-quarter of one per cent., and add it to the milk when there is a small quantity in the vat, as it starts a gradual fermentation which continues all through the process. Always heat the milk to at least the temperature of the culture before the culture is added. Set slightly sweeter than usual, as we are able to work closer to the "sweet line" all the way through, owing to the fact that we receive the milk in better condition.

Gassy Milk.

The presence of gas in the milk retards the development of acid, and as acid is necessary in the manufacture of cheese, we should make the conditions as favorable for its development as possible without injury to the body of the curd. To do this, use ¼ to ½ per cent. of good culture, as by so doing we introduce into the milk an abundance of lactic acid bacteria, which will, under favorable conditions, overcome the gas-producing bacteria.

The next step is to ripen the milk slightly more than usual before setting. When cutting, aim to have the cubes as even in size as possible. Allow the acid to develop slightly further before applying the heat, stir carefully, and heat slowly, aiming to have the curd in normal condition at dipping. Use the same temperature for cooking and the same acid for dipping as with a normal curd. A gassy curd does not require so much stirring as a normal curd, because the moisture leaves it more readily. Mill as soon as the curd is well matted and the acidity has developed to .8 to .85 per cent. About half way between milling and salting, commence piling the curd. Allow it to stand 15 or 20 minutes, then spread it out, stir and pile again. Continue to do this until the curd feels mellow. Give plenty of fresh air before salting. Use a normal amount of salt and put to press at a temperature of about 80 deg. F., if possible.

Over-ripe Milk.

What is over-ripe milk? It is milk with one of the agents used in cheese-making out of proportion; or milk with the lactic acid developed in too great a degree in order to obtain the very best results in converting the milk into cheese. What are the agents used in separating the solids from the moisture or water content of the milk? They are rennet, heat, and acid development, together with the cutting of the curd to get it into a convenient condition for the escape of the moisture. The heat should not be applied until enough milk is in sight to fill the vat. Why? Because as we raise the temperature, we make more favorable conditions for the development of acid. Heat as quickly as possible to 82 deg. or 83 deg. F., and after testing for acidity, set at this temperature. Why?

Because, first, 82 deg. is less favorable for acid development than 86 deg. F., and the time for heating to 86 deg. is saved; and what is more important, you are able to get the rennet in sooner and a larger quantity of it, thereby getting the acid under control more quickly; if not under control, it is difficult to get it to work in conjunction with the other agents which contract and expel moisture from the curd. In handling over-ripe milk it is always advisable to use more rennet—at least one ounce more, per thousand pounds of milk, for several reasons: first, that it may coagulate the milk more quickly; second, it gives a firmer curd more quickly, and renders the curd less liable to be broken when handling it, thereby saving to a great extent the great loss which usually is sustained from making over-ripe milk into cheese. It also helps to break down the caseous matter in the cheese, giving it a better texture. Commence cutting the curd early and cut rapidly so as to keep pace with the rapid firming of the curd. If this is not done the curd will get into a condition which makes it very hard to cut properly. Use the ¼-inch knife rather than cut the curd four times, as it leaves the curd more uniform and in better condition than when it is chopped finely. Heat quickly, and if necessary, raise the temperature two or three degrees higher than for normal milk.

A great many cheesemakers make a mistake at this point, by stopping the stirring and running off part of the whey when the curd is quite soft; while the whey is running off, the curd is matting, then they go at it with a little rake and break it all up, thereby liberating a lot of the milk solids, giving them a high acid reaction in the whey, and the result is, they have a sweet curd and a sweet cheese. The natural tendency for this kind of curd is to run together, so the best way is to keep it stirred in all the whey until it firms up a little. Hard raking does not firm the curd, except in so far as it breaks the cubes. If agitators are used, the curd can be kept apart and the whey lowered quite soon enough without resorting to this rough handling. One can readily see that if the whey be lowered quite close to the curd while it is in a soft condition that it will be quite difficult to keep it from matting; and while you are keeping it apart with a small rake, you are breaking it up, causing a loss, and also causing rough texture in the cheese. It is always advisable to have the whey run down shortly before the dipping point is reached to avoid being caught with too much acid. When the curd is in a soft condition it is advisable to dip with slightly less acid and to keep it in a loose, open condition in the curd sinks until all the surplus moisture is drained from the curd. If the curd is still a little weak, mill slightly earlier than usual. If not, treat as a normal curd. Mature the curd well before salting.

Ripening or Curing Cheese.

The ripening or curing of cheese is one of the most important points in the process, as no matter how well a cheese is made, if the curing is not properly done the quality cannot be the finest. Therefore it is necessary to provide a room where the temperature can be controlled at all times. It is important that some means be provided to control the moisture in the room so as to prevent the growth of mould, which occurs where too much moisture is present. An excessive shrinkage takes place if there is too little moisture in the room. Proper temperature and moisture may be obtained by building an ice chamber in connection with the curing-room and having a free circulation of air over the ice. This cools the air and causes a deposit of moisture on the ice. In putting the cheese in the curing-room, place them straight and even on the shelves and turn them every morning except Sunday. Keep the room well swept and looking clean and tidy. Use good strong cheese-boxes, have them dry, and of such a size as to fit the cheese nicely.

Weigh carefully, and stencil the weights neatly on the boxes. Load the cheese on clean wagons, and provide canvas covers to protect them from rain and heat while on the way to the station.

If the cheese are to be kept for two weeks, or longer, at the factory, it will pay to dip the cheese in paraffine wax. A small outfit for this purpose can be bought for about thirty-five dollars. The saving in shrinkage of the cheese will soon pay for the tank and wax used. The cheese should be coated when about one week old.

Farm Buttermaking

BELLA MILLAR.

A dairy instructor once said "Buttermaking begins in the stable, but it does not end until the finished product reaches the table of the consumer." Realizing the truth of that statement, care should be exercised in every step of the work and the dairyman's watchword "Cleanliness" should be adopted.

In any line of work it is necessary to have good raw material in order to make a first-class article. In the manufacture of butter, if the raw material, the milk, does not receive proper care, the most skilful maker cannot produce the best quality of butter.

"Prevention is better than cure," thus every effort should be made to keep dust and dirt out of the milk pail. As soon as possible after milking, remove the milk from the stable and strain it through a strainer that is perfectly clean and sufficiently fine to prevent tiny particles being carried through.

CREAMING THE MILK.

Cream separators are very largely used in our farms to-day, and have many advantages over the gravity system of creaming milk. However, some still use shallow pans and deep cans for creaming purposes.

Shallow Pans.

When using shallow pans, the milk should be strained into the pans as soon as possible after milking, and then be allowed to stand perfectly still in a pure air, free from draughts, at a temperature of about 50 deg. to 60 deg. F. for 24 to 48 hours.

Remove the cream while sweet by first loosening the cream from the pans by means of a thin-bladed knife; then tip the pan and allow just enough skim milk to run over to wet the tin before gliding the layer of cream into the cream can.

Deep Setting System.

The day is past for the use of the shallow pan system for creaming milk. If you have not a separator, then use the deep setting system. When using this method, the cans of milk should be placed in cold water and kept at a temperature of 45 deg. F., or lower, for 24 to 36 hours. By this system ice is required, unless the water be cold enough to cool the milk to, and maintain it at, 45 deg. F. while creaming. If the cans are not provided with taps at the bottom, a cone-shaped dipper should be used for removing the cream. Loosen the cream from the can with a knife. Dip the skimmer in skim milk or water, then lower it, point first, into the can, and allow the cream to flow evenly into it.

The loss of fat in the skim milk by gravity creaming, even under the best conditions, is much greater than when centrifugal force by means of a cream separator, is applied.

Cream Separators.

The surroundings of a separator, as well as all its parts, should be kept clean.

Immediately after separating, the cream should be allowed to cool quickly to at least 55 deg. before adding it to the cream can.

The cream should be of such a richness that from 3 to 3½ lbs. of butter can be made from one gallon of cream, or the cream should contain from 25 to 30 per cent. butter fat. This can be regulated by the screw on the separator bowl.

Taking a rich cream for buttermaking means less labor, lower churning temperatures, and less loss in the buttermilk.

Care and Ripening of Cream.

The cream can should be large enough to hold the cream for one churning and should be provided with a cover.

A simple and cheap cream stirrer consists of a saucer-shaped piece of tin about three inches in diameter with a long handle of heavy iron (tinned) fastened to the centre of it.

When collecting cream for a churning, care should be taken to keep it in a clean, cool place, and to stir it thoroughly from the bottom of the can every time fresh cream is added.

Cream Ripening.

Natural Ripening.

In farm buttermaking, cream is very often ripened naturally, that is, no "culture" or "starter" is added, but the lactic acid bacteria present in the cream are allowed to develop. This method may be used, if the flavor is satisfactory.

Ripening by Using Cultures.

A culture may be obtained from the Bacteriological Department at the College, or from a dairy supply house and directions for its propagation and use are sent out with it.

To carry on a culture from day to day: pasteurize some skim milk by heating it to 180 or 185 deg. F., hold it at that temperature for 30 minutes, then cool it to 60 or 65 deg. and add from one to two ounces of culture for each ten pounds of milk.

Let it stand undisturbed until next day when it should be nicely coagulated and ready for use.

By using a culture to assist in cream ripening, the buttermaker has more control of the flavor and is able to make a more uniform product.

In farm dairy work some sour cream, sour skim milk, or buttermilk may be used, if the flavor is alright. One method is to add one or two cupfuls of culture to the cream can when beginning to collect cream for churning. By doing this the sweet cream becomes inoculated with bacteria that will produce a desirable flavor.

Another method is to keep the cream sweet until twenty-four hours before churning, then heat it to 65 deg. F. and add from one cup to one pint of culture for each gallon of cream. When the cream begins to thicken, cool it to churning temperature, or lower, and hold it at that temperature over night.

Pasteurize and Add Culture.

This method of cream ripening is commonly used in creamery practice. By it we have the greatest control of the flavors, but more labor is involved.

Place the can of cream in a vessel of hot water on the stove. Bring the cream to a temperature of 145 deg. to 150 deg. F. Hold it at that temperature for twenty minutes, then cool rapidly to 60 deg. or 65 deg., and add a culture to ripen the cream.

Cream from cows that have been a long time in milk is sometimes difficult to churn and can be rendered churnable by means of pasteurization. Bad flavors are, to a certain extent, eliminated by this treatment.

Sometimes cream held at a low temperature develops a bitter flavor. The trouble may be kept in check by keeping the cream at a higher temperature to encourage the development of the lactic acid bacteria, which cause the souring; or, pasteurization may be resorted to.

Cream when ready for churning should have a pleasant acid taste and smell. It should be smooth and glossy and perfectly free from lumps. Cream should not be allowed to become over-ripe before churning. If for any reason a churning is put off for a day, the development of acid can be checked by lowering the temperature of the cream.

There will be an excessive loss of fat in the buttermilk if sweet cream is added to the ripened cream just before churning.

Although a mild-flavored butter is in demand, only a limited amount of sweet-cream butter is required for the Ontario markets at the present time. Those catering to this trade should cool the cream and churn at the temperature that will give an exhaustive churning.

Churning.

On many thermometers at 62 deg. the word "Churning" is printed. If the manufacturers placed it there as a guide, many have mistaken it for a rule.

There is no standard temperature for churning, as conditions vary and many things should be taken into consideration; for example, low churning temperatures may be used when we have such conditions as rich cream, not too much in the churn, succulent feed, and cows fresh in milk.

Choose the temperature that will bring the butter in nice, firm granules in from 20 to 30 minutes.

A range of temperatures that will cover most farm conditions would be—54 to 58 deg. F. in summer, and 56 to 64 deg. in winter.

Always strain the cream into the churn, using a perforated tin strainer dipper. The small white specks sometimes seen in butter are caused by particles of curd which should not have been in the cream and would not have been in the churn if a strainer had been used. These particles injure both the appearance and keeping quality of the butter.

In farm dairies the barrel churn is used and having it about one-third full will make the work easier. A great many of the long churnings are caused by having too much cream in the churn. Another cause of long churning is having the cream too cold. If after churning about thirty minutes, there is no sign of butter coming, raise the temperature of the cream a few degrees. Take the cream from the churn, place the can in a vessel of warm water and stir the cream until the required temperature is reached.

With very thin cream it is difficult to gather the butter and it may be necessary to draw off part of the buttermilk and continue the work, revolving the churn slowly.

If the butter breaks and will not gather, but remains about the size of clover seed, take the temperature of the contents of the churn, add a quart or two of water a few degrees warmer, revolve the churn a few times, let it stand a minute or two, then draw off part of the diluted buttermilk, and continue the churning.

If a rich cream thickens during the process of churning and concussion ceases, add enough water at the same temperature to dilute it so that it will drop again.

Difficult churnings are caused in a number of ways but can be avoided if a little thought is given to the question.

When the granules of butter are about one-half the size of wheat grains, add a couple of quarts of water several degrees colder than the temperature of the cream and continue churning until the granules are the size of wheat grains, when the churning as a rule is completed.

If butter comes with the first drawn buttermilk, it is a sign that the churning is not quite completed. Give a few more turns to the churn.

Washing the Butter.

After drawing the buttermilk, rinse the butter with two or three quarts of water before putting on the wash water.

In winter, it is necessary to temper the wash water, taking into consideration the condition of the butter and the temperature of the room. Choose such a temperature that the butter will be in a nice condition for working.

Always put in plenty of water, revolve the churn quickly about a dozen times, then allow the wash water to drain. One wash water will be sufficient, if the water comes away clear, and the butter is firm.

Salting and Working the Butter.

Salt to suit the customer, or market, using a good dairy salt. Although some markets require three-fourths of an ounce to the pound of butter, others prefer less.

The butter may be salted on the worker or in the churn.

Salting on the Worker.

The lever butter worker is inexpensive and suitable for farm dairy work. It consists of a V-shaped table, simple in construction, and a pole or lever for pressing the butter.

Spread the butter evenly over the worker. Sift on the salt, fold over the butter, and work, by using only gentle pressure. Other methods, such as a sliding or cutting movement, injure the texture of the butter.

If the butter is too hard or too soft, give but a small amount of working, put the butter in a suitable place until it is of proper firmness, then finish the working.

The salt should be evenly distributed, otherwise the butter will be uneven in color.

Salting in the Churn.

Have the butter in an even layer over the bottom of the churn. Sift over it one-half the amount of salt required, tip the churn forward to cause the butter to lap over. Sift on some more of the salt, tip the churn backward to cause the butter to fall over, then add the remainder of the salt. Tip the churn back and forth a few times, then put on the lid, and give a few revolutions, very slowly.

If possible, allow the butter to stand for an hour or two before working. If this plan cannot be followed, it may be worked immediately. The amount of salt required can be estimated from previous churnings. Use a little more salt than when salting on the worker, as more drains off.

Printing and Packing Butter.

All butter packages should be put up neatly and attractively. The one pound brick print is the style most used. It is filled by pressing the printer down into the butter, then cutting off the surplus butter with a ladle. The prints should weigh 16¼ oz. when made.

The parchment paper should be of good quality, of proper size, and should be dipped in cold water before wrapping it on the butter.

On the average farm it requires more than one churning to fill a large butter package, therefore great care should be taken in order that the flavor, color, and salt shall be uniform throughout the tub, box or crock. Line tubs and boxes with heavy parchment paper. Crocks should be well glazed, having no breaks or cracks.

As large packages are often held for some time, endeavor to make the best quality of butter for packing. Pasteurizing the cream, and washing and working the butter twice are means that may be employed in the manufacture of butter for packing.

The place of storage is important, and should be clean, cool, and of even temperature.

Protect the packages in transit from sun, dust, and rain.

The object should be to get the butter to the consumer in the best condition possible.

The Care of the Dairy Utensils.

Dairy tinware should be rinsed in luke-warm water, then be washed in hot water containing a little washing soda, using a brush on both the inside and outside. Next, scald thoroughly with boiling water, and place where they will drain and dry. Sunshine and fresh air are beneficial.

The churn should be scalded with boiling water, then cooled with cold water before using. After using, remove particles of butter with hot water. Wash with hot water that contains a little washing soda, then scald with boiling water. Leave the lid off when not in use.

The butter worker, ladle, and printer should be scalded with hot water, scoured with salt, and cooled with cold water before using. After using, remove any butter with hot water, scour with salt, and scald with boiling water. Place the woodenware where it will dry, but do not put it in the sun, or it will warp and crack.

Farm Dairy Cheese

Bella Millar.

A cheese of the "Cheddar" type is a suitable kind to make on the farm when a long-keeping cheese is desired.

Proper appliances for cheese-making lessen the labor to a great extent but cheese can be made in the home with the utensils on hand.

It will be necessary to secure a few ounces of rennet extract and a strong cheese hoop or mould.

For every ten pounds of cheese required, take 100 lbs. of milk (10 gallons). The milk should be of good quality, clean and sweet, as it is impossible to make the cheese of any better quality than the milk from which it is made.

Take the fresh morning's milk and mix it with the night's milk in a vat, or some vessel suitable for holding milk; a clean wash boiler will answer the purpose.

Heat the milk to 86 deg. F. by placing a clean can of hot water in it, or by setting the vessel containing the milk on the stove and stirring until the desired temperature is reached.

If colored cheese is wanted, use one teaspoonful of cheese coloring for each 100 lbs. of milk. Add the coloring to a dipperful of milk and mix it thoroughly with the milk in the vat before adding the rennet.

Use one teaspoonful of rennet for every 25 lbs. of milk. Dilute the rennet with a pint of cold water and mix it thoroughly through the milk by stirring with a dipper for about three minutes.

Cover the vat until coagulation takes place, which will be in about twenty minutes, depending on the ripeness of the milk; the sweeter the milk, the longer the time required.

To ascertain when the curd is sufficiently coagulated for cutting, push the forefinger into the curd at an angle of 45 deg., until the thumb touches it, make a slight break in the curd with the thumb, then gently move the finger forward. If the curd breaks clean across the finger without any flakes remaining on it, it is ready to be cut.

For cutting, regular curd knives are best. Use the horizontal knife first cutting lengthwise of the vat, then cut both lengthwise and crosswise with the perpendicular knife. This gives small cubes of even size.

When curd knives are not available, a long-bladed knife may be used, cutting the curd lengthwise and crosswise of the vat in strips about one-third of an inch wide, then cut horizontally. By this method it is difficult to cut the curd evenly.

After the curd has been cut, it should be gently stirred with the hand, or with a small, wooden rake for ten minutes before applying heat.

Heat the curd to 98 deg., taking about 30 minutes to do so. Continue stirring until the curd is ready for dipping; this is usually about 2¾ to 3 hours, from the time the vat was set.

When the curd becomes firm and springy and falls apart when a handful is pressed together, it is ready to have the whey removed.

After drawing off the whey, stir the curd over once, then pile it evenly at one end of the vat and cover it with a heavy cotton cover.

In about 20 minutes the curd will be well matted and should be cut into blocks about four inches square and turned over.

Turn the blocks every 20 minutes until the curd becomes flaky when it is ready for milling (this usually takes about one and one-half hours after dipping).

A knife may be used instead of a curd mill cutting the curd into strips about the thickness of your finger. Stir the curd well, then apply salt at the rate of one ounce for each 25 pounds of milk used. Sprinkle the salt well over the curd, mix it thoroughly, and when the salt is dissolved, the curd will be ready to put to press. Between 80 and 84 deg. F. will be a suitable temperature to have the curd at this stage.

The cheese hoop, or hoops, should be made of heavy tin with two handles on the outside. A suitable size for home use would be 7 or 8 inches in diameter and 12 or 14 inches high. It is also necessary to have a wooden follower, which will fit nicely on the inside of the hoop.

Place a piece of cotton at the bottom of the hoop, as a temporary cap, then put the cheesecloth bandage inside the hoop. Carefully pack in the curd, fold over the end of the bandage, place on top a piece of cotton similar to the one at the bottom, then put on the wooden follower and put to press.

If a press with a screw is not available use a lever press. Take a piece of scantling 10 or 12 feet long for a lever. Place the cheese hoop on a strong box about three feet from the wall. Nail to the wall a piece of scantling, and under it put one end of the lever. Put a block of wood on top of the follower for the lever to rest on. A pail containing stones or iron may be used for the weight. Do not apply full pressure at first.

In three-quarters of an hour the cheese may be taken from the press, the bandages wet with hot water, pulled up smoothly, and trimmed neatly, allowing one-half inch to lap at the ends. Cover the ends with circles of stiffened cheese-cloth; over that place a piece of cotton dipped in hot water. Return the cheese to the press until the following morning, when they should be turned in the hoops and pressure continued a few hours longer.

After removing the cheese from the press, place them in a cool, dry cellar to ripen.

Turn the cheese end for end on the shelf every day for a month and afterwards occasionally. These cheese will be ready for use in about 6 or 8 weeks.

To prevent the cheese moulding and to keep them from drying too much they may be dipped in hot, melted paraffine wax. Another method to prevent mould is to put a double cloth on the cheese until ready for use. The mould will be on the extra cloth, leaving the cheese clean when it is removed.

Soft Cheese Making

Bella Millar.

Soft cheese is made from cream, whole milk, skim-milk, and buttermilk, and by making slight variations in the method of manufacture a great variety may be made.

These cheese contain a high percentage of moisture and will not keep long, therefore, it is necessary to have a ready market for them.

It is well to have, "Keep in a cool place until used," and "Use while fresh" printed on the soft cheese wrappers.

Fresh Camembert Cheese.

Apparatus Required.

½ pint bottle of rennet.
1 measuring cylinder graduated in c.c.'s or 1 teaspoon.
1 thermometer. 1 dipper.
1 granite pail of convenient size to hold the milk.
Straw mats, size 13 inches by 9 inches.
Boards 14 inches by 8 inches, ½ inch thick.
Moulds, small size, 4 inches high, 4 inches in diameter.
Moulds, large size, 5 inches high, 5 inches in diameter.

Process of Manufacture.

Five pounds, or two quarts of new milk are required to make one large size, or two small size Camembert cheese.

First add a small quantity of culture ("starter") if required. No culture is needed where good, clean, sweet milk can be obtained. The milk is now regulated to a temperature of 86 deg. F. and rennetted at the rate of 1 c.c.

or 20 drops to 10 lbs. of milk, the rennet being diluted in ten times its volume of water, before adding to milk. Stir the rennet in for five minutes and then stir over the surface with a wooden paddle for two minutes, as this prevents the cream from rising, which causes the cheese to break after they are made.

Cover the pail and leave till coagulation has taken place, which will be in about one hour. The correct stage is when the curd breaks easily over the finger.

Scald the required number of straw mats, boards, and moulds, then cool them in water. Place the boards on a drainer with the straw mats and moulds on top. Next ladle out with the dipper a little curd into each mould, and repeat the same every 20 minutes, until all the curd is transferred and the moulds are full. In ladling the curd care should be taken not to break it, but obtain it in thin slices. When all the curd has been filled into the moulds, turn the cheese, by putting a straw mat and board on top and turning over.

Leave the cheese on the drainer till the whey has drained off and the cheese are firm enough to turn by hand. After turning, the cheese is left in the mould for six hours longer, when the mould can be removed, and in another six hours the cheese is ready to salt.

Salting is done by rubbing about ½ oz. of salt on the outside of each large cheese and ¼ oz. for the small size. After salting, the cheese are left on the straw mats for 12 hours, where further draining takes place. When the cheese is sold fresh, it is now ready to pack and send away.

NOTE.—The room in which the cheese are made should have a temperature from 62 deg. to 70 deg. F.

GERVAIS CREAM CHEESE.

Apparatus Required.

½ pint bottle rennet.

1 measuring cylinder graduated in c.c.'s, or 1 teaspoon.

1 thermometer. 1 dipper.

1 granite pail of convenient size, to hold milk and cream.

Moulds—2½ inches high by 2⅛ inches in diameter, in a group of six.

Straw mat and board as in Camembert cheese.

Strips of blotting paper 2½ inches by 7½ inches.

Cloths made of duck material 27 inches square.

Process of Manufacture.

This dainty little cheese is made from a mixture of new milk and cream, the mixture being in the proportion of two parts milk to one of cream, testing 22 per cent. to 30 per cent. fat.

Take the required quantity of this mixture and bring to a temperature of 70 deg. to 80 deg. F., depending on the temperature of the room. Add the required quantity of culture—no culture being needed where the milk and cream is sweet and clean. Rennet, at the rate of 1 c.c. or 20 drops to 10 lbs. of the mixture, is added, but first dilute the rennet in 10 times its volume of cold water.

In about five or six hours after the rennet has been added, the coagulation is firm enough to dip the curd with a dipper into the cloth, previously wet, which should be placed over a basin. The cloths should then be hung up by the four corners and left to drain.

After the curd has been draining for a few hours, open out the cloths and scrape down the sides to aid draining. Repeat the scraping at intervals of a few hours, until the cheese is firm enough to salt.

Turn the curd out of the cloths into a basin and salt at the rate of 1 oz. to 3 lbs. of curd. The salt, which should be fine dairy salt, must be worked in well with a spoon and the cheese left for a short time for the salt to dissolve before putting it into the moulds. The moulds should be lined with clean, white blotting paper and placed on a scalded straw mat, or cloth, and the cheese pressed in with a bone spoon. The cheese may then be taken out of the mould, wrapped, and sold.

NOTE.—Coloring may be done by adding cheese annatto, which somewhat improves the look of the cheese. Use about 1 c.c. or 20 drops coloring for each gallon of milk and cream.

DOUBLE CREAM CHEESE.

Apparatus Required.

½ pint bottle of rennet.
½ pint bottle of cheese annatto.
Suitable pail for holding cream.
1 thermometer. 1 dipper.
1 measuring cylinder graduated in c.c.'s or 1 teaspoon.
Moulds—size 2 inches by 3½ inches, 1¼ inches deep.
Cloths of duck material, size 27 inches square.
Butter muslin, grease-proof paper, boards and weights.

Process of Manufacture.

Take any quantity of cream testing about 22 per cent. fat. Have the cream at a temperature of between 70 deg. and 80 deg., depending on the room in which the cheese is to be set. When the cream is at the correct temperature, add the required quantity of culture, if the cream is likely to develop bad flavors. Cheese color may then be added if required. (About 1 c.c. or 20 drops of color to 10 lbs. of cream will usually give satisfaction.)

Rennet is next added at the rate of 3½ c.c. or 1 small teaspoonful to 10 lbs. of cream, after diluting it in ten times its volume of cold water. Stir into the cream.

In about five or six hours, when the cream has thickened, ladle into dry cloths and hang up in a dry place. It is advisable not to put too much into one cloth, as it will be likely to develop too much acid before draining.

A few hours later open the cloths and scrape the sides to facilitate draining, then hang up again. Repeat the scraping at intervals of about three hours, until the curd is fairly firm. Then turn the curd out into butter muslin (used double thick), and salt the curd by adding 1 oz. of salt to every 3 lbs. and mixing it well into the curd. Fold the muslin over the curd, place on a board having another board and weight on top.

When the curd is ready to mould, it should be of a thick, pasty consistency but not sticky. Line the tin mould with wax paper and press the cheese in with a knife or bone spoon, making the curd quite flat on top. Fold over the ends of the paper and shake the cheese out of the mould, they are then ready to be eaten; if kept, they should be put in a refrigerator or cold storage until used.

GENERAL NOTES.

The rennet and color are the same as are used in factory cheese-making.

10 lbs. of milk or cream = approximately, 1 gallon.
1 c.c. = 20 drops.
3½ c.c. = 1 dram.

As regards packing for shipment, we use ordinary rice paper to wrap the cheese in, and then place them in pasteboard boxes of proper size.

When keeping the above-mentioned soft cheese they should be kept in as cold and dry an atmosphere as possible, the best temperature being just above freezing.

Neufchatel Cheese.

This cheese is made from whole milk or whole milk with cream added to bring the test up to between 4 per cent. and 5 per cent. fat.

In the morning, pasteurize the milk by heating to a temperature of from 140 deg. F. to 150 deg. F., and hold it at that temperature for 20 to 30 minutes, then cool to 70 deg. F.

To each ten pounds of milk add 2 c.c. (about half a teaspoonful) of culture, or good-flavored, sour skim milk. Late in the afternoon add the rennet at the rate of ¼ of a c.c. or five drops to each ten pounds of milk.

If the milk has cooled, bring it to a temperature of 70 deg. F. Dilute the rennet with cold water, and add it to the milk, stirring for a few minutes to ensure even distribution. Cover the vessel containing the milk and leave undisturbed until next morning. In the morning the curd should be firmly coagulated and ready for cutting. Cut the curd in squares with a knife, then ladle it out on a rack covered with cheesecloth. When the free whey has drained away, apply pressure very lightly at first and increase the pressure as the curd becomes firmer.

When sufficiently drained, put the curd through a food chopper to break it up finely and make it more creamy. Add the salt at the rate of 1 oz. to 3 lbs. of cheese and mix thoroughly. When the salt is dissolved the cheese is ready to be put in packages suitable for the market.

Fancy Cream Cheese.

Neufchatel cheese is used as a base for a variety of fancy cheese by adding such flavorings as pimentos, olives, or nuts. These should be chopped finely and well mixed through the cheese.

Cottage Cheese with Rennet.

This cheese is made from skim milk. The method outlined for Neufchatel cheese is followed, but a small amount of cream is added at the time of salting, usually about 1 oz. cream to a pound of cheese. Salt at the rate of 1 oz. to 4 or 5 lbs. of cheese.

Cottage Cheese by Heating.

Pasteurize skim milk, then cool to 60 deg. or 65 deg. F., and add from one to two ounces of culture to each ten pounds of skim milk. Next morning the curd will be nicely coagulated and ready to make into cottage cheese.

Stir the curd to break it up, then place the can of milk in a vessel containing hot water. Stir gently until the curd and whey separate. This usually takes place between 85 deg. F. and 100 deg. F. If the separation is not complete at 100 deg. F., do not heat higher but allow the cans to stand until the whey is clear. High temperatures give a dry, grainy curd.

Drain the curd by hanging it up in cotton bags or putting it on a draining rack covered with cheesecloth.

When sufficiently drained, salt and cream are added as in "Cottage Cheese with Rennet."

Buttermilk Cheese.

Buttermilk cheese is made by heating the buttermilk to a temperature of 130 to 140 deg. F., holding at that temperature for about an hour, then draining off the whey.

During the heating process the buttermilk should be stirred just enough to ensure even heating. After leaving it undisturbed for about an hour it should be dipped or poured out on a draining rack which is covered with a cotton cloth.

When sufficiently drained the curd should be salted at the rate of 1 oz. of salt to 4 or 5 lbs. of curd. The addition of about 1 oz. of cream to each pound of curd makes a richer cheese.

These directions are suitable for raw-cream buttermilk, or for buttermilk from cream that was sweet when it was pasteurized and afterwards ripened.

If the buttermilk is from cream that was ripe when it was pasteurized the curd particles will be very fine and it is necessary to use a different method of making in order to have good results. This was worked out by the Wisconsin Agricultural Experiment Station, and is valuable for creamerymen.

Add a caustic soda solution to the buttermilk to completely neutralize the acid and then acidulate it with hydrochloric acid before applying heat.

The caustic soda is first dissolved in an equal weight of water by adding the dry alkali to the water. The acid is also diluted in an equal volume of cold water.

First test the buttermilk for acidity in order to know how much of the alkali solution will be required.

Forty parts by weight of dry alkali will neutralize ninety parts by weight of lactic acid. For example, 1,000 lbs. of buttermilk testing .75 per cent. acidity contains 7.5 lbs. of lactic acid. For neutralizing 7.5 lbs. of lactic acid it will require 3.3 lbs. of caustic soda, or 6.6 lbs. of the caustic soda solution.

Try a small amount in a cup, and if the buttermilk shows a permanent pink color when a few drops of phenolphthalein indicator are added, enough alkali has been used.

It will require two and a half to three times as much dilute acid as alkali used. To determine if enough has been added, take a small amount of buttermilk in a shallow dish and hold it for a few minutes in water about 145 to 150 deg. F. Enough acid has been added if the whey separates clear. If the whey is not clear more acid should be added in small amounts until a clear separation is obtained. The buttermilk is now ready for heating and the directions already given for heating, draining, and salting should be followed.

Club Cheese.

This is a very popular variety of fancy cheese, and is made from ripened cheddar cheese.

Take one pound of cheese, remove the rind, then cut the cheese in pieces and put it through a food chopper.

To this, add two level tablespoonfuls of butter and put it through the chopper again.

Add ¼ cup of cream and mix thoroughly. Pack the cheese in small jars, or put it up in small blocks and wrap them in tinfoil.

Either butter or cream may be used alone, and the amounts may be varied to suit conditions, such as the dryness of the cheese or the preference of the consumer.

BULLETIN 267] [OCTOBER, 1918

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

The Farm Water Supply and Sewage Disposal

WHY PURE WELL WATER PAYS.

The desirability and importance of an ample supply of pure water on every farm can hardly be over-emphasized. Perhaps more than any other food element, it determines the healthy and robust development of the body. Inversely, deadly disease germs finding access to poorly protected or unfortunately located wells may bring death, with little warning, into the family circle. Without great expense the water supply on the average farm may be so protected as to prevent contamination and it surely seems the part of wisdom in every case to ensure an abundant supply of pure water for man and beast—and to have lavish use made of it.

But even though the water be pure there are obstacles in thousands of cases, which prevent its convenient use. Where the household supply is drawn from a well or a stream at some distance from the dwelling the physical labor involved is great. It may be assumed that when no plumbing is installed ten gallons per person per day for all purposes is necessary. With a family of four, some one—often the housewife—must carry 400 pounds of water a day, or over one ton a week. Considerable danger from exposure during inclement weather is also involved, especially when in the haste of the housework, womenfolk leave hot kitchens to carry in water without taking sufficient precaution against the cold.

In the stable much the same conditions exist. The task of pumping water by hand for a large number of live stock is slow and arduous—wasteful of time and trying to the temper. And in cold, stormy weather the stock, when driven to an outside tank or an ice-covered stream, will rarely drink sufficient for their best performance or development. Indeed, so generally are these facts realized, that thousands of stables have been equipped in latter years with modern water systems which provide the stock with an abundant supply under the most favorable conditions. It is unfortunate that far fewer houses than stables are thus equipped. Water systems in each case pay their way in dollars as well as in convenience, comfort and health.

This latter argument has been well developed by a practical farmer, who also has lived in a city, and whose experiences in this regard were published recently in an Ontario farm journal. He writes as follows:—

"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. Our city installation cost us $225, a large part of which was plumbers' bills. Our farm bathroom represents an outlay of not more than $150.

"The difference in cost as between city and country is due to two factors—the cost of equipment and reduced labor charges. When we installed our country system we first sent a rough sketch of the proposed installation to a couple of supply houses and to a well known mail order house in Toronto. The latter firm gave us quotations from 25 to 50 per cent. lower than we could have secured from the nearest retailer, and they paid the freight in addition. Through the same source we purchased a pipe wrench, pipe cutter and stocks and dies for threading pipe. We did practically all of the work

Washing Dishes. Hot water on tap at sink.

ourselves. Home plumbing is not so difficult as it once was. It is now possible to buy equipment that can be installed complete with iron pipe and threaded joints.

"And what a comfort is a bathroom. I enjoy it to the full. I wouldn't be without it if the cost were twice as great. But the women folks are the chief beneficiaries. No more longings for the comforts of the old city home. They have them right on the farm. I don't 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."

The question of cost which this farmer mentions is important. There are few indeed but will admit that a complete water system for the farm is highly desirable; but many are deterred because of the expense involved. Many improvements may be made, however, such as safeguarding the well from pollution, installing an hydraulic ram, septic tank, gravity system, etc., which are not very expensive. And when the farmer is able to do a good deal of the work himself the cost is reduced to a point where thousands can afford the installations. Many different systems and devices, or modifications of these, may also be used according to local requirements and the peculiar circumstances of each case. With a practical working knowledge of the principles of farm water supply, water systems, equipment and sewage disposal, few indeed who have impure well water and are without household and stable water conveniences but can make improvements of a most beneficial nature and at a cost which they can afford to pay.

Winter scene without water system.

To give such information is the purpose of this bulletin now presented to the farm public of Ontario. Practical information, as complete as possible and so arranged as to enable each reader to find quickly the particular problem he is most interested in, is given regarding every phase of the water question. To further assist those who may wish to make improvements or installations the authors of this bulletin will gladly give personal attention to any question or problem which may be sent to them. All are invited to make use of the appendices at the back of the bulletin, to fill them out carefully and to forward them as directed.

The Farm Water Supply

W. H. Day and R. R. Graham.

WELLS, PUMPS, POWER PUMPING AND WATER SYSTEMS.

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 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. Secondly, an impervious layer of clay, hardpan or shale rock. Thirdly, 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 sources we do not know, nor their outlets.

Locating Underground Streams.

These subterranean streams usually provide the very best supplies of water, both as to quality and quantity. The difficulty is that the striking of them is

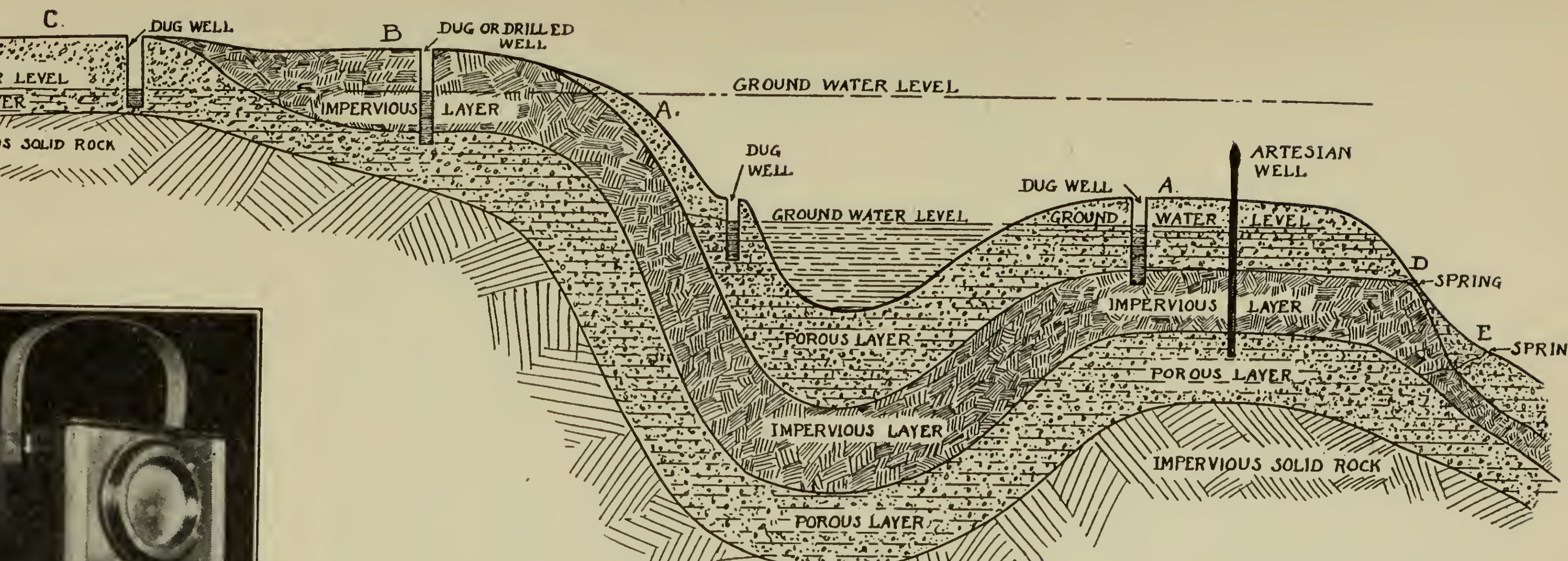


Fig. 1.—Showing soil layers, ground water levels, wells and springs.

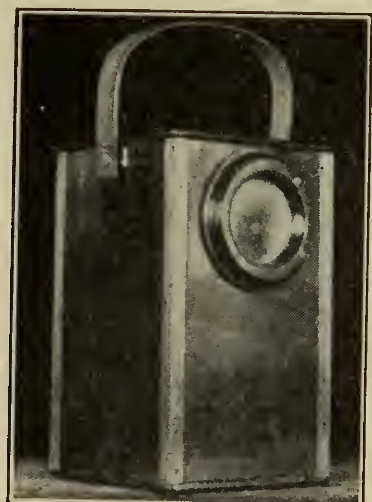


Fig. 2.—Face water finder, about 12 inches high.

generally a matter of pure accident. From early ages certain individuals have claimed the power of being able to locate such streams by aid of a forked twig from various trees, such as plum, cherry, hazel, etc. And it is undeniable that in many instances phenomenal wells have been struck by digging or drilling on sites selected by these " water diviners " in spite of previous failures in the locality. For many years scientists as a class have stoutly denied the possibility of there being any virtue in this method of locating water, but in recent years as the result of some investigation on the subject a considerable change has come about, many not only admitting the possibility of the method being genuine, but actually expressing their belief in it. We understand the French Department of Agriculture has a staff of diviners, whose services are available on application. So also has the Department of Lands in Queensland, Australia.

Another method has come into vogue recently, viz., by using an instrument known as a water-finder, a photograph of which is shown in Fig. 2. This is an electromagnetic instrument, patented by an English firm. In the lower compartment, according to the English letters patent, is a coil of fine iron wire about six inches long and five inches in diameter. The coil has no metallic core. The ends of the wire are free. The layers are separated by paraffin wax and interspersed occasionally by sheets of lead foil. In the upper chamber is a very slender delicate magnet five inches long turning on a pivot at its centre. It is magnetized so as to have a north pole at each end, one being the least shade stronger than the other. This method of magnetizing the needle is patented. When preparing for a test the coil is set by a compass with axis north and south. The needle is then placed on the pivot and points in a northern and southern direction when it becomes steady. If no underground stream runs below, the needle will lie almost motionless, but if there is a stream underground then the needle will suddenly swing out to one side and then oscillate back and forth, the oscillations gradually diminishing in amplitude. It may come back to rest or may receive another impulse before doing so. There is no regularity of impulses either in time or strength.

The principle of the instrument apparently is not definitely established. Those who have studied it are pretty well agreed that the action is in some way due to fluctuations in the earth currents of electricity which follow the underground streams of water. Some believe that these fluctuations cause momentary changes in the magnetism of the coil, which disturb the magnetic equilibrium of the needle, causing the oscillations. The makers of the instrument claim that the oscillations are due to " earth air currents of electricity "—perhaps electric waves would be a better term—originating in the fluctuations of the electric current in the stream. And some even claim that there is no virtue in the instrument whatever. Water Supply Paper 416, U. S. Geological Survey, Washington, pages 23-25, concludes with this opinion: " In the present state of knowledge any claim that the oscillations of a magnetic needle indicate the occurrence of available ground water is purely speculative." If the author of this paper had related details of tests with the water-finder made by himself or others and which resulted negatively his opinion would have carried more conviction. One thing is certain, the needle does oscillate in some locations and not in others—we have proven that over and over again by actual trial. And in India, under the direction of Dr. Harold H. Mann, Principal of the Poona Agricultural College, at least sixteen wells have been sunk on sites selected by the instrument in the Trap Region of Western India where water is proverbially hard to find, water being struck in every one of the sixteen, and Dr. Mann's conclusions, quoted from his

Bulletin No. 72, of 1915, entitled "Experiments with the Automatic Water-Finder," is as follows:

"The position, as a result of our work, is, therefore, that in a country where at least forty per cent. of wells under normal circumstances are failures even in selected sites, wherever the automatic water-finder has indicated water, and a careful test, including boring, has been made, water has been found. As a rule the supply indicated has been within the depth of well sinking; in a few cases, sub-artesian water has been found by boring, at depths varying up to 126 feet. Only one criticism can be made of these results, I think, and that is, that similar boring would, under almost all circumstances, reach a water supply of some sort. Other borings, in what were considered likely sites, do not justify this conclusion. These have only given 66 per cent. of successes, as against complete success when the water-finder has been used and has indicated water.

"It must be confessed, however, that we have so far found no method of using the instrument which enables us to say with certainty the depth at which the water will be found, or its quantity. Messrs. Mansfield & Co., the makers of the instrument we have used, state that they can tell, within small limits, the quantity of water to be obtained, but we have not been able to do this.

"It would seem, however, sufficiently proved that under the conditions which prevail in the trap areas of Western India, where underground water occurs in well-defined streams flowing in rock fissures, sometimes under little or no pressure, and sometimes under considerable pressure, the automatic water-finder can be used with advantage in locating streams of water which can be tapped, either by well-digging or by boring."

In June, 1918, Dr. Mann, writing the authors of this bulletin, says that after many additional borings in the interval the situation remains as stated in his bulletin. He also says that with extended use they are able to form a pretty close estimate of the depth to the water.

Mr. G. B. Brooks, of the Department of Agriculture, Queensland, Australia, has also done some very interesting work with the water-finder, combining it with the divining rod method, and tracing underground streams by both. In spite of the fact that water is very scarce in the areas where the water-finder has been used by him, no failures are recorded on sites selected by the instrument. So successful was his work that the Department of Lands appointed two officers solely as water diviners.

The Department of Physics at the Ontario Agricultural College has one of these instruments, with which it is intended to make tests for those wishing such, the party for whom the tests are made paying the travelling expenses of the operator. It is not an instrument that can be loaned.

DIFFERENT TYPES OF WELLS.

Throughout the rural districts of Ontario the almost universal source of water is a well of one type or another. There are three types in common use, viz., the dug, the driven and the drilled well, each adapted to conditions with certain characteristics.

Shallow Dug Well.

The dug well is suitable where water is available at shallow depths, the surface layer being soil. It has the advantage of always having a considerable reserve of water available. On the other hand, being shallow, and therefore frequently drawing its supply of water from soil near the surface, there is great danger of contamination from barnyards, privies, cess pools, etc. To be pure it is generally considered that water should filter through at least ten feet of soil, and even this may be insufficient if a strong supply of polluted liquid is constantly seeping into the same soil, as from a cesspool. Hence great care should be exercised in locating the dug well. It should be on higher land than any possible source of pollution and at least 100 feet from them. And even this is not sufficient precaution: The well after being dug should be so curbed, and so finished above ground that no surface water can enter it. And the top should be tight so that earthworms, toads, frogs, etc., cannot enter.

Fig. 3 shows two dug wells, that on the left poorly located and poorly protected, that on the right well located and protected.

Regarding the poor well note:

1. It is located in a hollow, so that surface water flows towards it.
2. The curbing is open so that water from the soil may enter anywhere below the surface, possibly having filtered through only a few inches of soil.
3. The top is open, admitting any vermin that may happen along.

Regarding the good well note:

1. It is located on high land, so that surface water flows away from it.

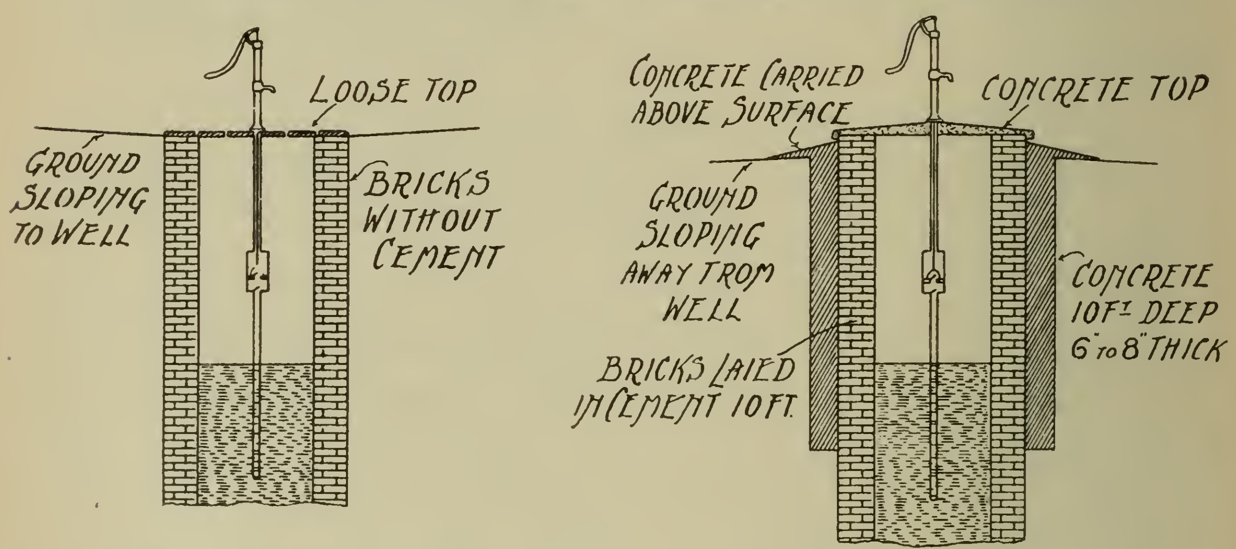


Fig. 3.—(*a*) Poor dug well. (*b*) Good dug well.

2. The curbing extends above ground, and the top ten feet is laid with cement mortar, making it impervious to water, the curbing lower down being open to admit the water.
3. The top ten feet of curbing is surrounded by a shell of concrete, slush, mixed, and tamped in so as to make close contact with the soil and prevent surface water trickling down to enter the well through the open curbing below. Puddled clay is sometimes used for backing instead of the concrete.
4. The top is elevated above ground, being tight and curved, thus excluding vermin and shedding any water that may be spilled.

Pump in Kitchen or Stable.

The good dug well may sometimes be rendered even better by the simple device of placing the pump some distance to one side of the well. It may be located anywhere provided neither the sucker nor any point in the pipe line be more than 25 feet above the surface of the water. (See section on pumps, page 15.) This may be turned to great convenience by placing the pump in the kitchen or stable, while the well is a hundred feet or so away. And when so placed the well itself is free from danger of pollution by impurities being washed from the cover into the well. In fact, all the surroundings may be kept much more sanitary than is frequently the case when the pump is placed directly over the well. In days gone by many wells have been dug in barnyards, and in other improper locations in order to have the pump near the stable or yard, when in reality sanitary sites might just as well have been chosen some distance away and the pumps even more conveniently located. This arrangement saves much labor, time and severe exposure for those carrying the water, especially in the wintertime. If the pump is in good order, and a check valve attached to the suction pipe in the well, one can easily draw the water 200 or 300 feet by hand pumping, much farther of course if power be used.

Improving Poor Wells.

Poor wells may be improved by correcting the mistakes made in their original construction. If the lining is bad it may be removed and replaced by a new one as described above. If this is not practicable, another lining may be put inside the old one, leaving a space between them, the top ten feet of this lining being laid in cement. The space between is then filled up to the cemented portion with coarse gravel and the rest of the way with sand. Sewer tile, either glazed or concrete, make a good inner lining. In either case the top should be properly protected. Should neither of these methods be applicable the well may be drilled deeper as described later under drilled wells.

Driven Wells.

Where the strata of the earth 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. 4) is procured.
2. The point is screwed on a pipe of the proper size, and a drive cap on the top of the pipe. Usually 1¼ or 1½-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.
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 pipe 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 described under dug wells. If there is danger of freezing, a shallow dry-well 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 bottom. This dry-well for the pump should be curbed and a tight cover provided as described above, but the curbing 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 further by means of the drill and sand pump.

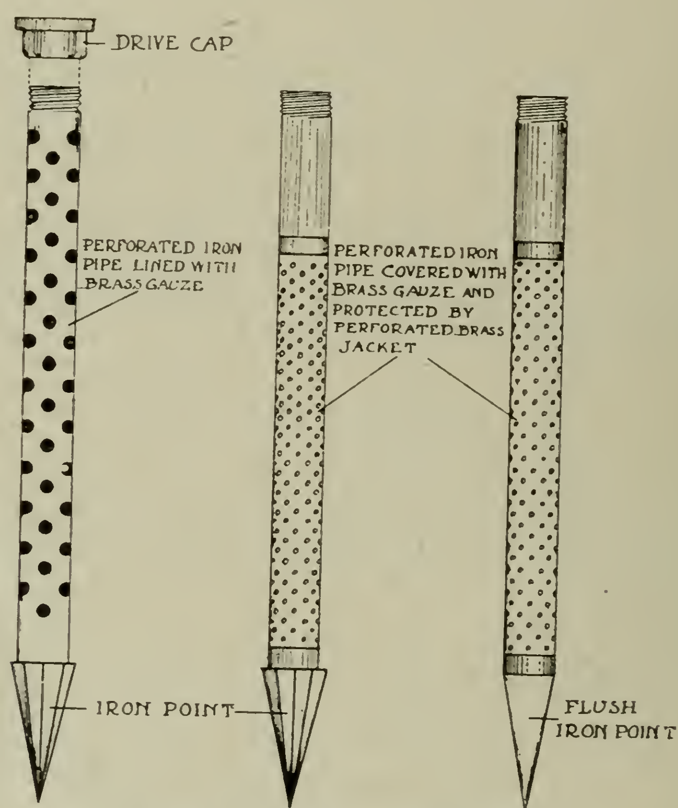


Fig. 4.—Types of well points.

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:

1. Its cheapness.

2. Its sanitary qualities. Surface water cannot reach the point without filtering through twenty to twenty-five feet of soil.

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. 5. The filter is

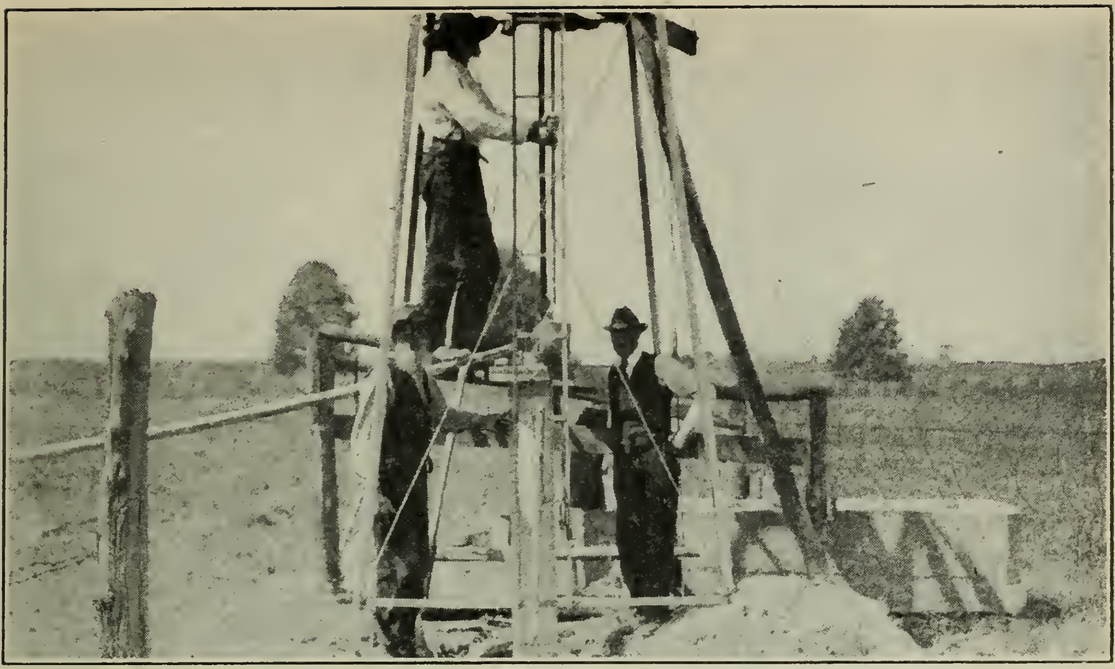


Fig. 5.—(*a*) Sinking the open 10-inch drive pipe.

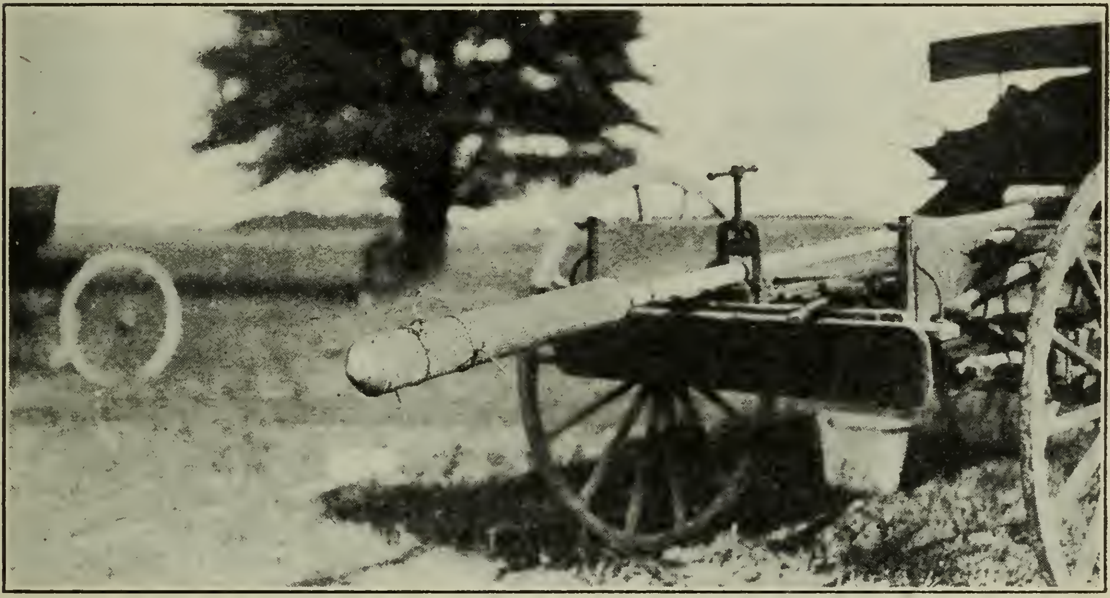


Fig. 5.—(*b*) Sand filter, to be placed in open drive pipe.

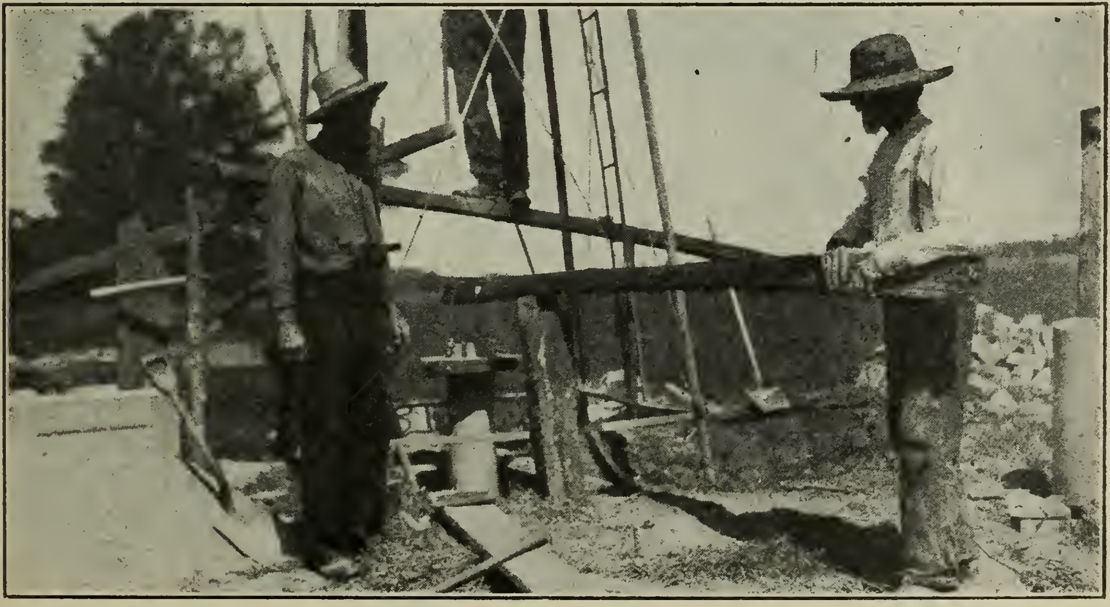


Fig. 5.—(*c*) Withdrawing open drive pipe.

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 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 may 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.

Drilled Wells.

Where the water-bearing stratum is overlaid by a layer of rock or impervious clay or hardpan the dug and driven wells are impracticable, and drilling is resorted to. This may commence right at the ground surface, or in the bottom of a dry well. That portion of the bore passing through soil is protected by watertight, wrought-iron casing, which is extended into the rock only far enough to prevent surface water entering. For this purpose it should be driven firmly into the rock. The drilled well provides the purest water of the three types, because of the depth of soil through which it has filtered and the distance it has flowed underground.

The pump cylinder in a drilled well, as in all others, must be within 25 feet of the surface of the water. See section on pumps, page 15.

Artesian Wells.

In drilling, sometimes a flowing well is struck. These are called Artesian wells, because of their being discovered in Artois, in France. The explanation of this phenomenon may be seen by referring to Fig. 1 where the head of water in the porous layer feeding the Artesian well stands much above the ground surface at the point where the well was sunk. Indeed, drilled wells in which the water rises from the second porous layer up near the surface as at B, Fig. 1, are frequently called Artesian, although they do not overflow.

Whatever the source, a pump of some kind is almost invariably required to deliver the water from the well to the point of use.

PUMPS—THEIR PARTS AND ACTION.

The parts of the ordinary pump are illustrated in Figs. 6 and 9, and are as follows:

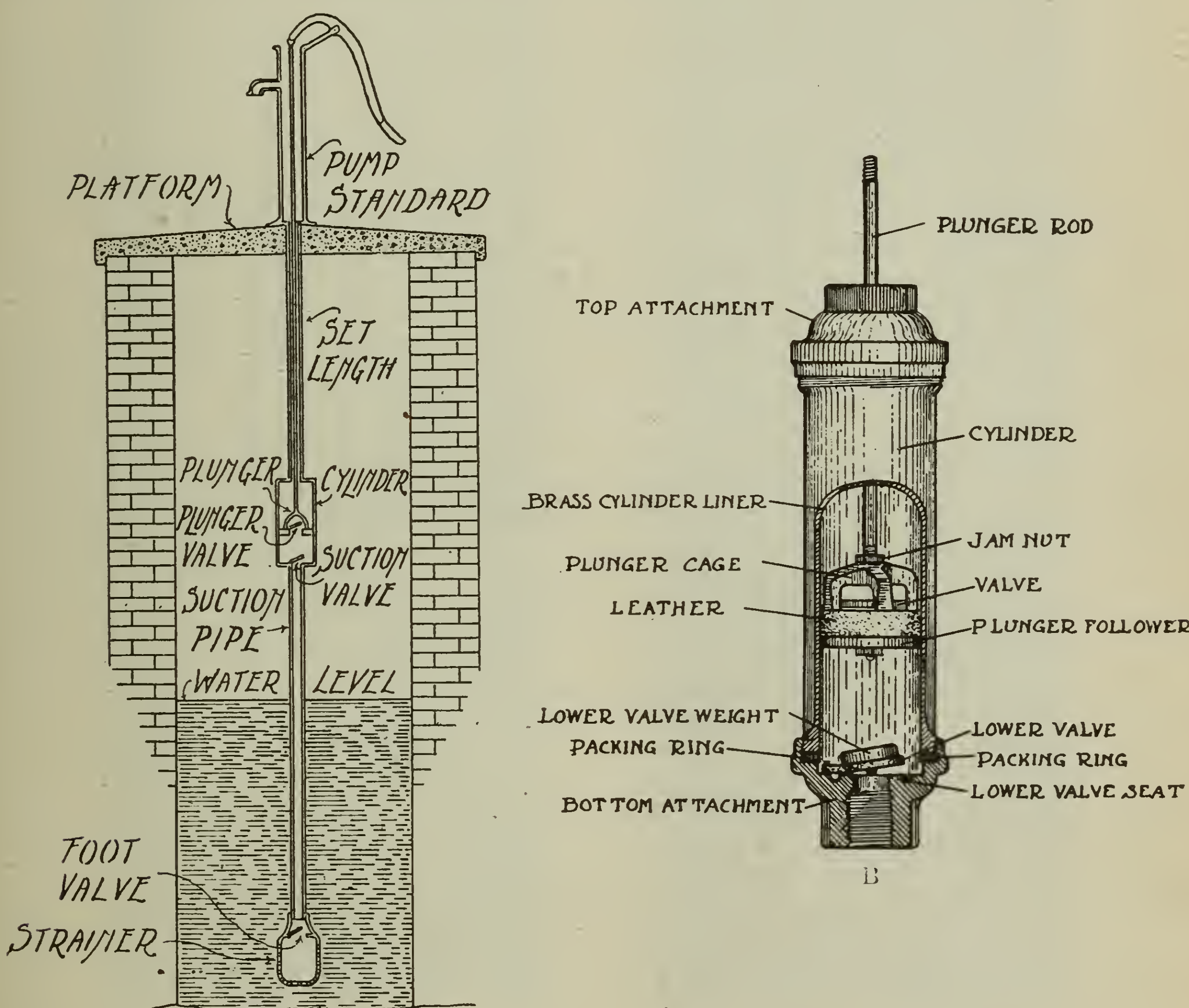
1. The handle.
2. The standard, barrel, or body of the pump.
3. The plunger, or "sucker," as it is almost universally called on the farm. The sucker contains a valve which opens upward. It also has one or more "leathers." These are turned up cup-shaped around the plunger. They hug the side of the cylinder, especially on the up stroke of the piston. Shallow well pumps have only one "leather," but those for deep wells have as high as three or four.

4. The cylinder, that portion of the pump in which the sucker moves. Sometimes, as in many cistern pumps, the cylinder is situated in the standard but in well pumps it is situated down in the well within 20 or 25 feet of the water surface.

5. The suction valve in the bottom of the cylinder. This valve also opens upward.

6. The suction pipe, which extends from the cylinder down into the water.

7. The "set length" pipe, between the standard and cylinder, and which may be varied in length to set the cylinder the proper distance above the water. To prevent freezing a small hole is drilled in the set length to allow the water to run back into the well when the pump is not in use.



A

Fig. 6.—(*a*) Suction pump, showing parts.
(*b*) Cylinder and sucker, showing parts.

8. Foot valve and strainer, sometimes attached to the bottom of the suction pipe.

Most farm pumps are of the "suction" variety, which are installed with the "sucker" or plunger above the water surface. When the pump is being started the air must first be pumped out and while this is being done the water is "sucked" up to the plunger. Let us see how this is brought about.

Air has weight—their are 75 pounds of air in a room ten feet square and ten feet high under ordinary conditions, a surprisingly large amount to most of us. The atmosphere extends about 200 miles high, but gradually decreases in density as the height increases. If we could extend a pipe one foot square to the top of the atmosphere and weigh the air inside it we should find the weight to be more than a ton. How do we know this when we can't try it out? Because we have a method, and a very simple one, of weighing the atmosphere.

Principle of the Barometer.

To do this we take a glass tube more than 30 inches long, and seal one end,

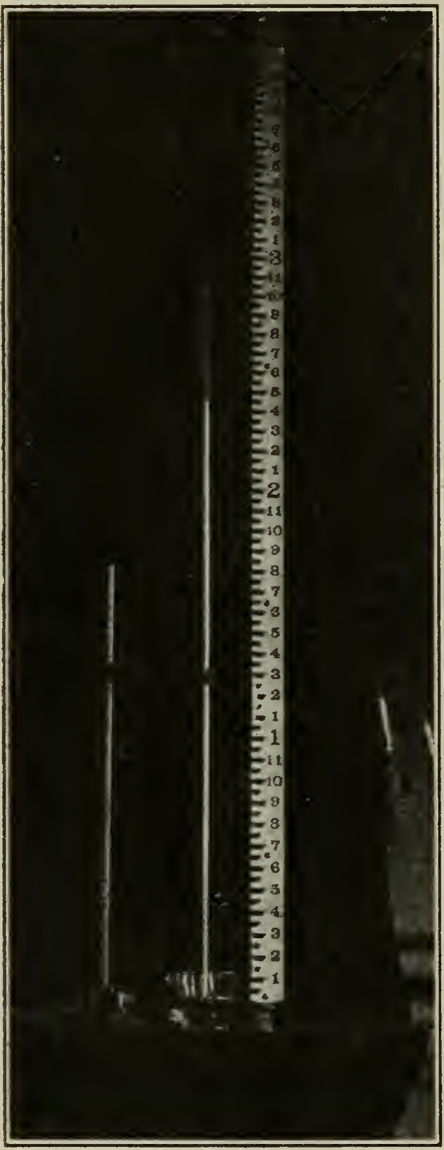


Fig. 7.

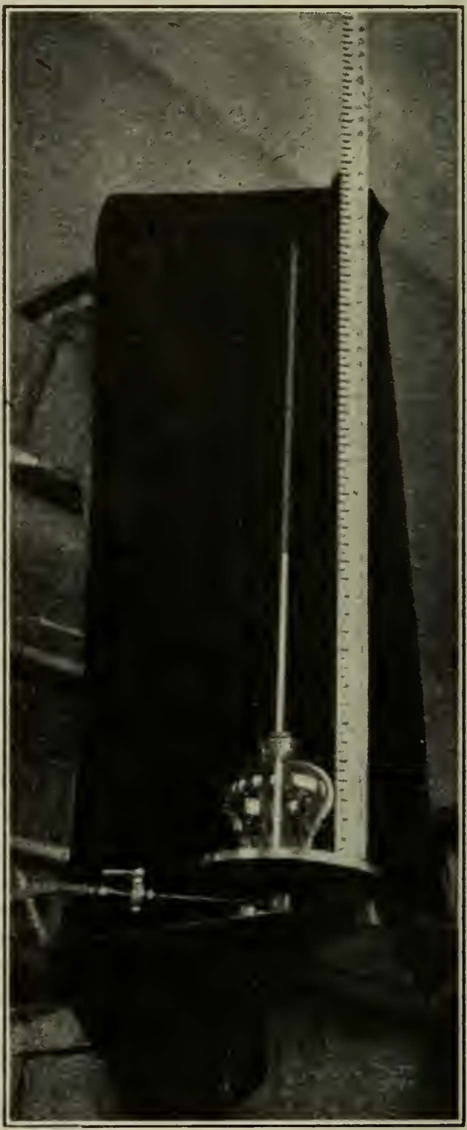


Fig. 8.

Fig. 7.—The barometer. Note the mercury stands 28½ inches high in the tube. Note the glass dish in which the tube stands.

Fig. 8.—The same barometer as in Fig. 7, but the glass dish is placed in an air-tight jar, and some of the air exhausted through the pipe on the left—and the mercury now stands only 16 inches high. If all the air were exhausted the mercury in the tube would drop down level with that in the glass dish.

and then fill it with mercury, keeping the open end up and being careful to boil the mercury afterwards to expel all the air mixed with it during the pouring. When the tube and mercury are cool enough to be handled a finger is placed tightly over the open end, the tube inverted, and the open end thrust into a vessel of mercury, and the finger then removed. The tube does not empty itself—

the mercury only drops down till its surface in the tube is about 30 inches above the surface of the mercury in the open vessel. See Fig. 7. What holds up the 30 inches of mercury? The air pressing on the surface in the vessel. This is easily proven, for if we apply an air pump as shown in Fig. 8, and exhaust the air, the mercury in the tube drops. Hence that 30 inches of mercury must weigh the same as a column of air that size and extending to the top of the atmosphere. If our tube were an inch square we would have 30 cubic inches of mercury pressing on one square inch. And 30 cubic inches of mercury weighs 14.7 pounds, hence the atmospheric pressure when the barometer stands at 30 inches is 14.7 pounds to the square inch—speaking in round numbers we say 15 pounds. Some days the atmosphere is heavier than standard, some days lighter. At sea-level the average is about 30 inches, consequently that is taken as standard. At the Ontario Agricultural College, which is 1,100 feet above sea level, the average barometer is a shade under 29 inches. In a general way, an increase of 1,000 feet in altitude reduces the barometer reading one inch. Altitude, therefore, has to be kept in mind when setting the pump cylinder.

Water as a Barometer Liquid.

Now we can use water instead of mercury to measure the atmospheric pressure, but since mercury is 13.6 times as heavy as water the water column in the glass tube would be 13.6 times as high as the mercury column. Now 13.6 times 30 inches=34 feet. Hence the column of water that can be supported by the atmosphere at standard pressure is 34 feet high. Suppose we had an iron pipe 68 feet high, dipping into water, closed at the top, open at the bottom, but with provision for attaching an air pump at the top. If we exhausted every particle of air from the pipe the water would only rise 34 feet high; the top half of the pipe would contain only water vapour.

The Barometer and the Pump.

This has a very important relation to the suction pump. If the "sucker" is more than 34 feet from the water in the well, the pump will never work, the water will never rise up to the sucker even if it were perfect enough to remove all the air from the pipe. But the pump cannot be made so perfect as this, first on account of the weight of the valves and, secondly, because the valves or the collar of the sucker may allow some air to slip past them. Because of these imperfections and the fact that the water barometer may fall several feet below the standard when the atmospheric pressure is low or the well several thousand feet above sea level, practical pump men find it necessary to place the sucker not over 25 feet above low water mark in the well, and as a special safeguard some adopt only 15 or 20 feet. Even better results are obtained by putting the cylinder right in the water. This is always done in "deep" well pumps.

Action of the "Suction" Pump.

When installed with the cylinder above water the pump may be said to act by "suction" as distinguished from the action when installed with the sucker under water, although it will be readily understood from the explanations regarding the barometer that the term suction is a misnomer—the rise of the water in the pump is due to inequality of air pressure on the surfaces. Fig. 9 shows several stages in the action of the simple pump, as follows:

(*a*) The pump before use, handle still, both valves closed.

(*b*) The handle, being raised, which lowers the plunger, the air between the valves opens the top one by resistance against compression, and the air escapes through the open valve. This stroke continues till the sucker reaches the bottom of the cylinder, practically all the air between the valves being expelled.

(*c*) The handle being forced down, which lifts the plunger. The plunger valve immediately closes because of the pressure of air above it. Lifting the plunger lessens the pressure on the top of the suction valve, and when this occurs the air in the suction pipe expands opening the suction valve and part of the air in the pipe flows out into the cylinder. This expansion lessens the air pressure on the water in the pipe. Outside the pipe, however, the pressure on the water is the full atmospheric pressure, and because of this inequality the water is driven upward in the pipe by the outside pressure until the water column and the reduced air together exert a pressure just equal to that of the atmosphere, which occurs at the end of the up-stroke of the plunger.

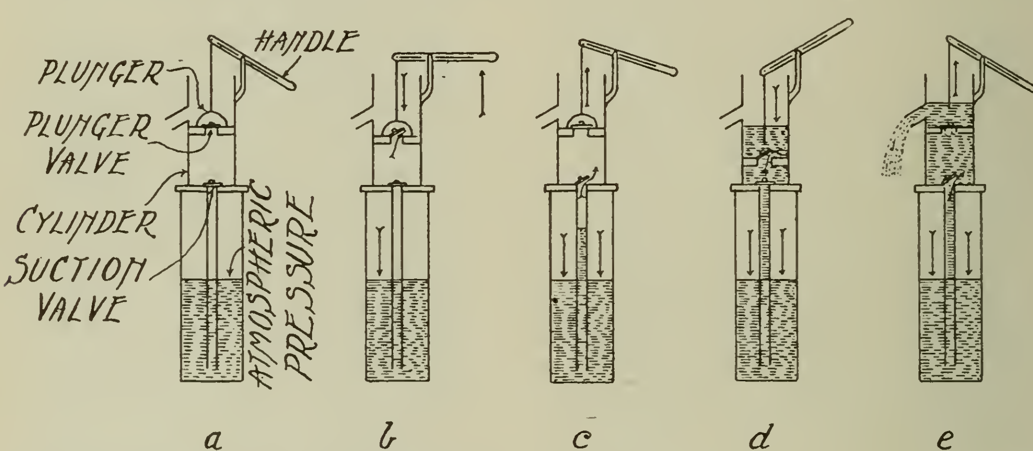


Fig. 9.—Stages in the action of the suction pump.
(*a*) The pump before use, both valves closed.
(*b*) First up-stroke—air in cylinder being forced out through valve in plunger.
(*c*) First up-stroke—air pressure in cylinder reduced. Atmospheric pressure on water in well drives water part way up the suction pipe.
(*d*) The water has reached cylinder, plunger moving down.
(*e*) Up-stroke—water begins to flow from spout.

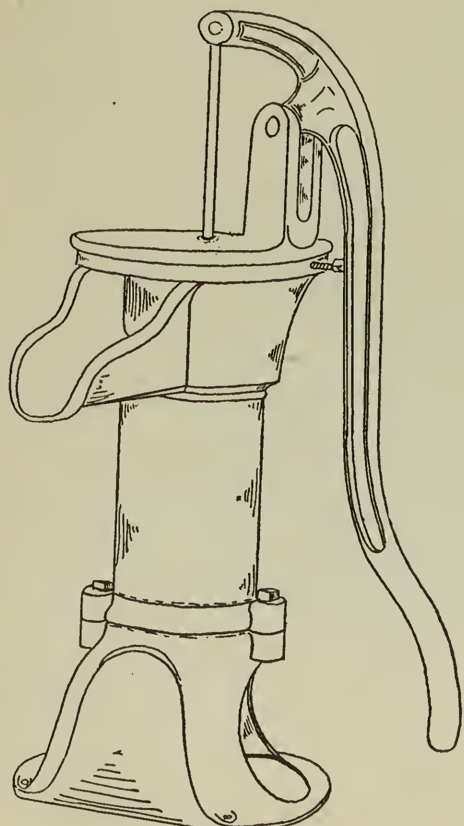
(*d*) On each upward stroke more air is expelled and the water rises higher until finally it reaches the plunger. With the water in the cylinder the valves act just the same as with air, only more pronounced, because the water is not elastic like the air.

Principle of the Lift Pump.

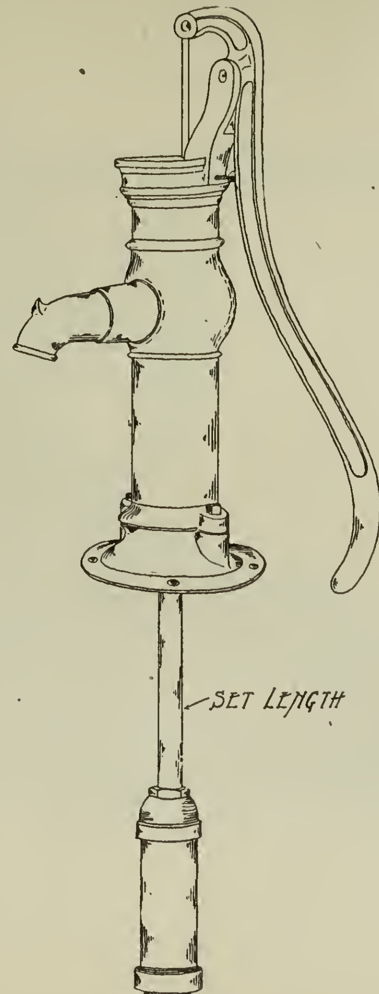
All pumps built for discharging the water only at the spout as shown in Fig. 6 are called "lift" pumps. In this type the pump head is not airtight, nor is the pump rod packed where it passes through the head. Pumps of this type when intended for cistern use, where compactness is very essential, frequently have the cylinder located in the body of the pump as shown at A in Fig. 10, although "set length" cistern pumps are also in use, as illustrated at B in the same figure.

Force Pumps.

Frequently, however, it is necessary to force the water higher than the spout, possibly to a tank situated high up in the house or barn, or it may be desired



10a.



10b.

Fig. 10.—(a) Cistern pump with cylinder in barrel.
(b) Set length cistern pump.

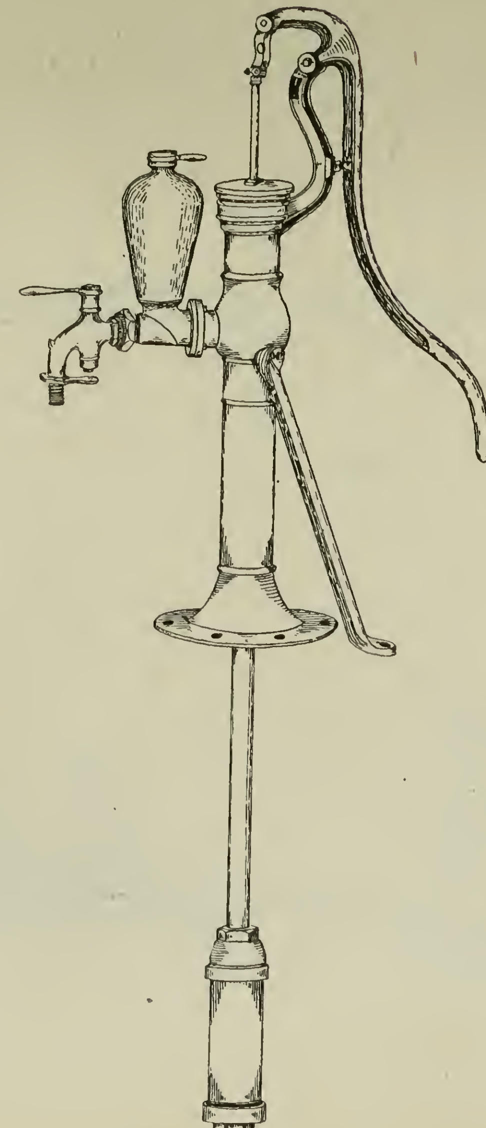


Fig. 11.

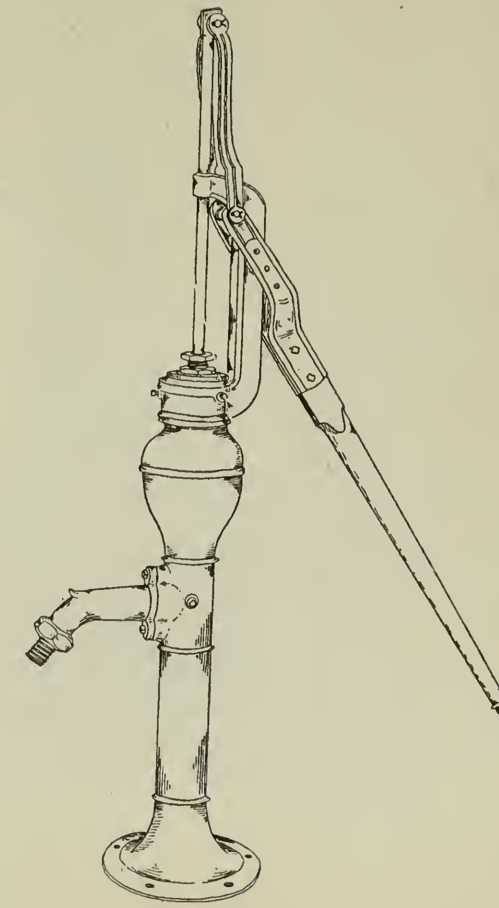
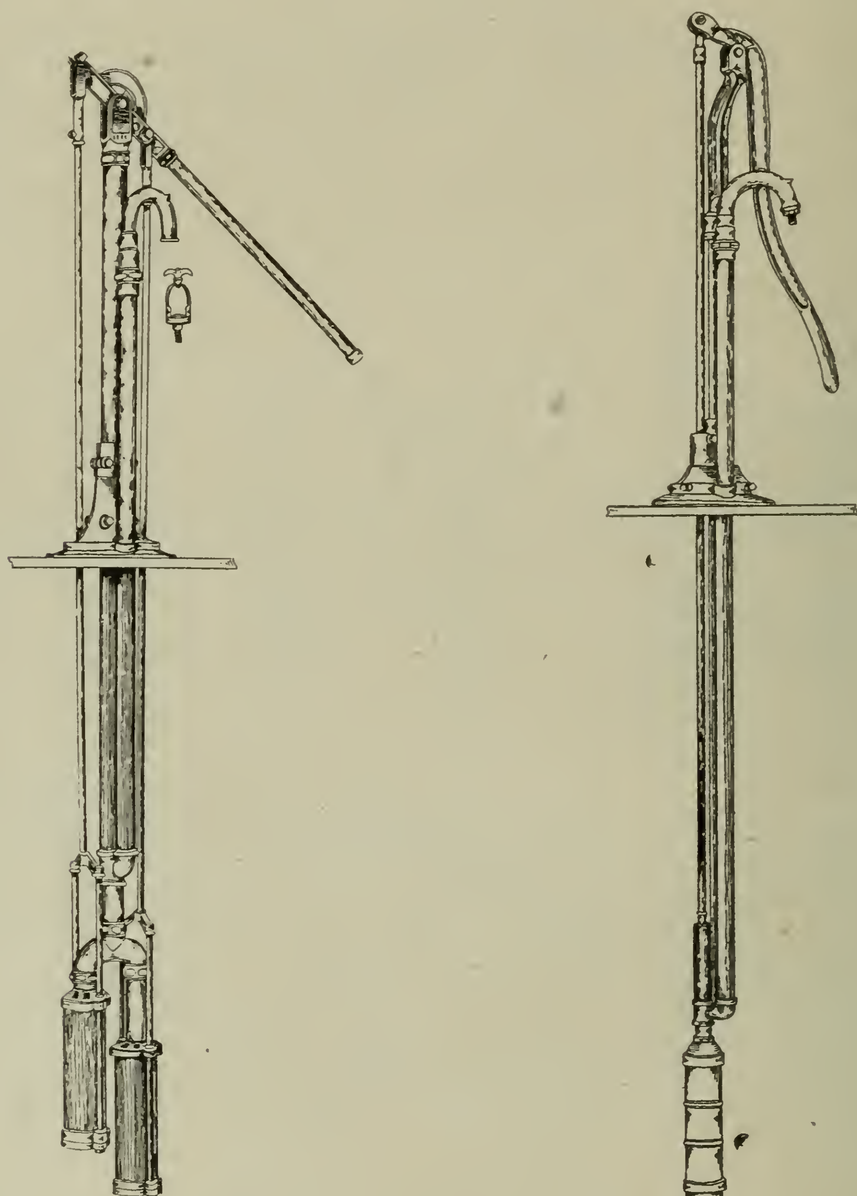


Fig. 12.

Fig. 11.—Force pump, with air-dome on spout.
Fig. 12.—Force pump, with air-dome in barrel.

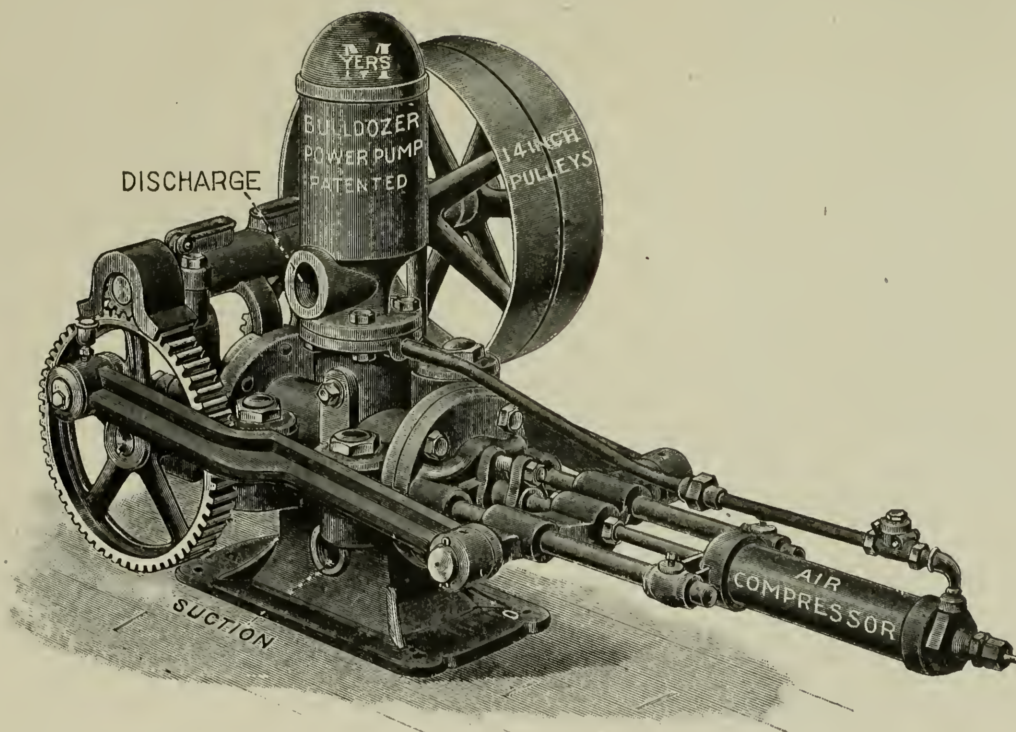
to obtain water under pressure. Then a force pump is used, such as illustrated in Fig. 11. In this the head must be airtight, including the rod where it passes through the head. And there must be a means of attaching a pipe or hose to the spout. The air-dome on the spout (see Fig. 11) is not absolutely necessary, but yet desirable, because it reduces the labor of pumping very materially. Suppose there were no air-dome then the water would have to go up the pipe or hose as fast as de-



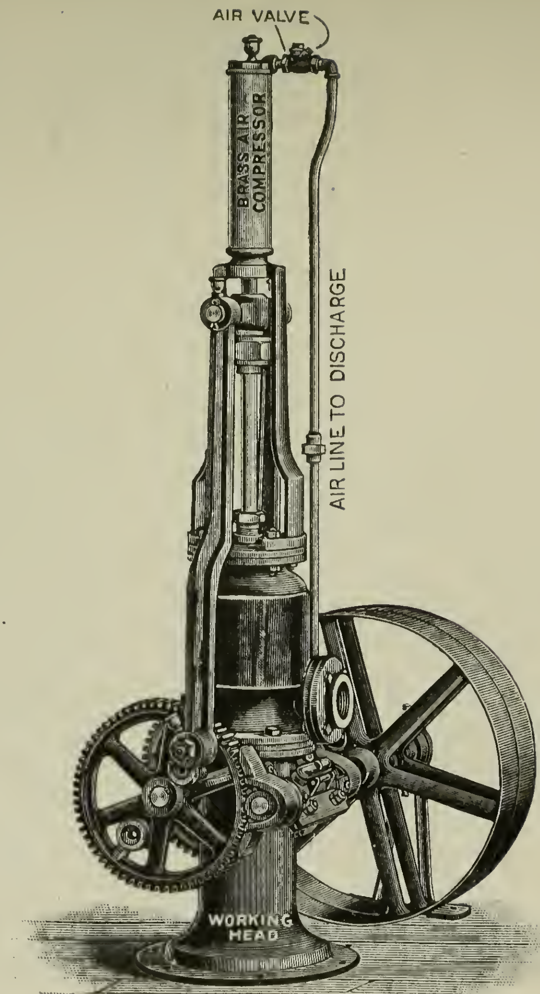
13*a*. 13*b*.

Fig. 13.—(*a*) Double acting force pump, with two cylinders side by side and two pump rods.
(*b*) Double acting force pump, with two cylinders, one above the other, the upper having about half the capacity of the lower.

livered from the cylinder, and while the sucker was on the down-stroke the water in the pipe would come to a standstill, and on every up-stroke it would be necessary to start this long line of water afresh. Every person who has driven a team knows the heaviest pull is in starting the load and getting up speed, and the same holds true here. With the air-dome, however, about half of the water delivered on the up-stroke is forced into the dome against air pressure, and this pressure keeps the water flowing from the nozzle during the down-stroke, thus giving a steady



14*a*.



14*b*.

Fig. 14.—(*a*) Double acting power force pump for shallow wells. It may be set some distance away from the well.

(*b*) Double acting power force pump for deep wells. Must be located at the well.

stream instead of an intermittent one. And on a fresh up-stroke the only water that has to be set in motion is the little bit delivered by that stroke. Nor is this the only difference. Without the dome, the water while flowing would have to move twice as fast in the pipes and this would make the friction *four* times as great, because the friction varies with the square of the velocity. Consequently, from the practical standpoint, the air-dome on the force pump plays a very valuable part in economizing labor. In some types the air-dome is merely an expansion of the pump barrel as shown in Fig. 12.

Where large quantities of water are required it is customary to install double-acting force pumps. These are of several types, two of which are shown in Fig. 13. Pump A uses two cylinders side by side, and two pump rods, attached to the handle, one on either side of the support. Pump B uses a small cylinder above a large one, the plunger in the top cylinder having no valve in it, the bottom plunger being of the ordinary type with a check valve in it, there also being a suction valve below it. There is no valve between the cylinders. On the up-stroke half the water in the bottom cylinder is forced into the top one and the other half is forced up the pump toward the tank. On the down-stroke the water in the upper cylinder is also forced up the pump.

Fig. 14a shows another type of double-acting force pump much used in connection with power pumping plants, where the water level is within 20 or 25 feet of the ground surface. There are two valves at each end of the cylinder, one a suction valve, connected with the suction pipe, and the other an outlet valve connected with the pipe leading to the elevated or compressed air tank. The plunger itself is solid. When a compressed air system is to be used the pump is supplied with an air compressor as shown in the figure. By turning the cap at the right of the compressor, the pump may be set to pump air along with the water or not, as desired.

When the well is a deep one and the pump must consequently be placed directly over it, a different form of pump must be used, as shown at B in Fig. 14.

Foot Valve and Strainer.

In many cases another valve is introduced, being what is known as a foot valve, at the bottom of the pump. It is frequently accompanied by a screen to prevent anything but water from being drawn into the pump. In case the suction valve may become somewhat defective the foot valve, if still good, would cause the pump to work in spite of the defective suction valve. Another function of the foot valve is to aid the suction valve in maintaining the pipe full of water at all times and the pump thus well primed.

Pump Troubles.

If you are not getting water, see if there is any in the well.

If the pump is not working properly there is a cause. Find it.

If it loses its priming (the water running down) the suction valve is defective, or some dirt or obstruction has lodged under it. Sand, gravel, or sometimes pipe-thread cuttings will cause this. Remove valve, and clean it off thoroughly.

If pump is discharging air bubbles with the water, there is a defect in the suction pipe, or it is not properly tightened in cylinder.

If the handle works up and down without apparent resistance, and delivers no water, it indicates that the plunger leather is worn and is not creating a vacuum in cylinder, or else suction valve is not working properly. Remove sucker and renew leather or release valve.

If pump works hard, or handle jerks up when pushed down, it is evident that something is preventing the water rising in suction pipe to cylinder. Perhaps the suction pipe is too long, or too small, or strainer (or drive point if used) is plugged up.

In a lift pump if water splashes out at top of pump (where rod works through) it indicates that cylinder is too large for capacity of head. If pump is taking air below cylinder it will also have a tendency to do this.

Capacity of Pumps.

To determine the capacity of a pump, square the diameter of the cylinder, in inches, multiply by the length of the stroke, in inches, multiply by the number of strokes per minute, and divide the product by 352. The answer will be the number of gallons per minute.

Work of Pumping Water.

The deeper the well or the higher the water has to be forced the more power is required to work the pump. On every up-stroke the plunger has to lift all the water in the pipe above it. In 100 feet of $1\frac{1}{2}$-inch pipe the weight of the water and the pump rod together would be about 150 pounds. If one had a herd of 40 cattle and each drank 10 gallons or 100 pounds a day, which for the year round might be a fair average, the work of raising that weight of water 100 feet would be 10,000 foot-pounds and for 40 head, 400,000 foot-pounds; and the work of lifting the pump rod would be nearly as much more. If a man can do one-sixth of a horse-power of work then it would take him about an hour and a quarter a day to pump the water for the cattle. It is not surprising therefore that in these times of scarcity of labor, windmills, gasoline engines and electric motors are being more rapidly adopted than ever before for pumping purposes.

Power Pumping.

For many years the windmill held sway as the most popular power method of pumping water, the two chief reasons for this being:

1. Operating cost is practically nil.
2. Little attention is required, this being limited to an occasional oiling and throwing the mill in gear from time to time.

The mill is nearly always placed directly over the well, usually on a steel tower. Fig. 32 illustrates a typical windmill installation. The tank which may be located either in the tower or above the stable holds a supply sufficient to tide over a few days of calm weather. The price of mills for pumping ranges from \$100 to \$200 depending on size of wheel and height of tower.

The mill may be made to operate a pump at a distance by the use of windmill quadrants, which are illustrated in Fig. 15, and the operation of which will be readily understood from the drawing.

But the gasoline engine is rapidly coming into favor for pumping purposes. Where the wells are shallow the pump may be placed near the engine in the barn, drive-shed, or engine room as the case may be. A favorite type of pump for use under such circumstances is shown in Fig. 14a. Where the well is deep and the pump, Fig. 14b, has therefore to be set directly over the well, the engine may either be placed at the well or in a convenient room at the buildings and the power transmitted to the pump. There are numerous methods of doing this, three of which are illustrated in Figs. 16, 17 and 18. No. 16 shows the pump being operated from a line shaft in the same way as the knives of a reaper or mower are operated by the pitman shaft. In Fig. 17, the old-fashioned rope belt driven by the grooved pulley on the line shaft runs the grooved pulley at the pump, operating the plunger of the pump as before. Still a third method is shown in Fig. 18. The pitman wheel on the line shaft moves the pitman shaft back and forth, and this in turn works the L-shaped handle of the pump. Quadrants may also be used, as with the windmill. The authors have seen all these

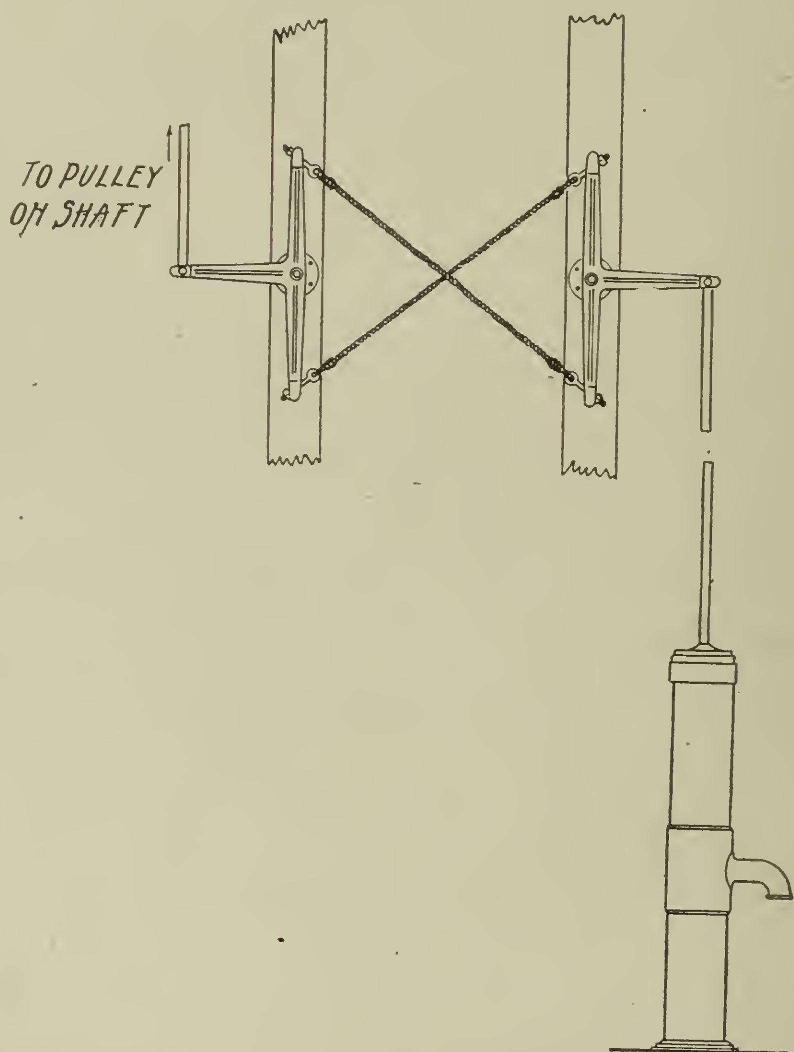


Fig. 15.—Windmill quadrants for operating a pump at a distance from the mill.

methods in satisfactory operation. and with these suggestions the reader should be able to adapt the principles to meet the circumstances of his own particular case. Ready-made pump jacks may be had from pump manufacturers.

Calculating Speed of Pulleys.

It is necessary to reduce the speed of the engine to the proper rate for pumping. In doing so one would be safe in assuming that the pump should run about as fast as when one is pumping by hand, say from 40 to 60 strokes per minute for shallow wells and 20 to 30 for deep wells. The calculating of pulley speeds would give little trouble if we would remember that all parts of the belt travel at

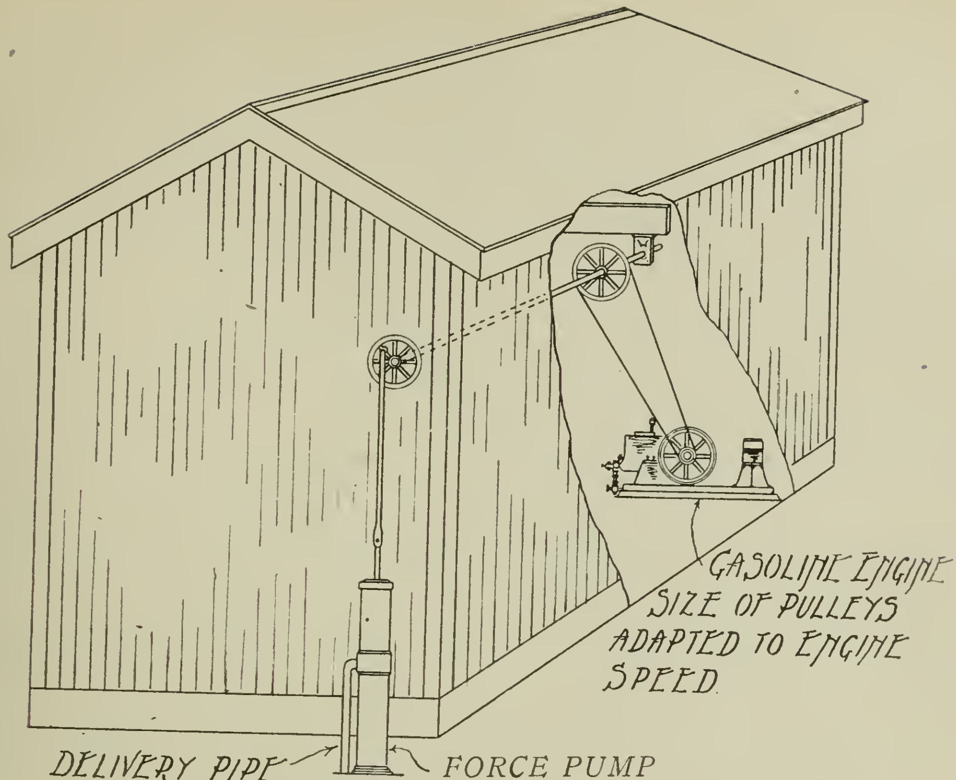


Fig. 16.—Pump operated by pulley on line shaft driven by gasoline engine.

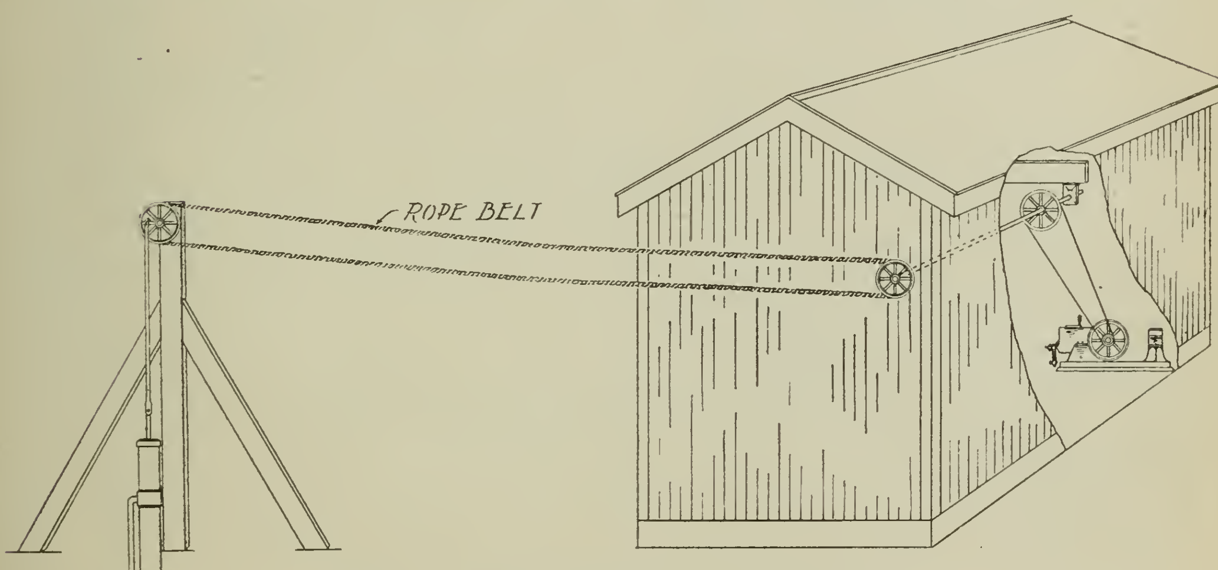


Fig. 17.—Pump operated by rope belt.

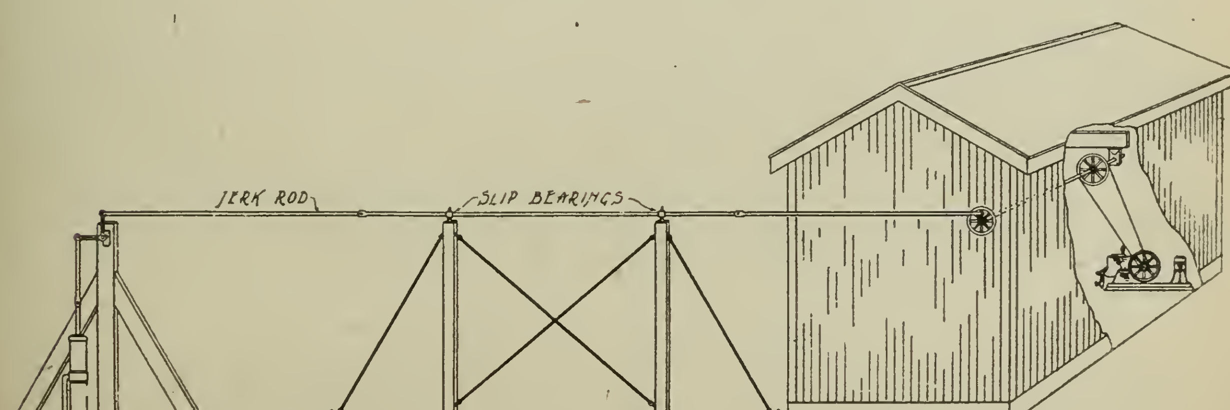


Fig. 18.—Pump operated by jerk rod.

the same speed. The length of belt that passes over the driver is equal to the circumference of the driver multiplied by the r.p.m. (revolutions per minute) of engine pulley. Therefore, belt travel = diameter of driver × 3 1/7 × speed of driver. Similarly the belt travel on the driven pulley = diameter of driven × 3 1/7 × speed of driven. But the belt travel is the same for the two pulleys. Hence we must have the following holding true:

Speed of driver × its diameter × 3 1/7 = speed of driven × its diameter × 3 1/7, and therefore

$$\text{Diameter of driven} = \frac{\text{speed of driver} \times \text{its diameter}}{\text{speed of driven.}}$$

This formula may also be reversed thus:

$$\text{Diameter of driver} = \frac{\text{speed of driven} \times \text{its diameter}}{\text{speed of driver.}}$$

Example:

An engine runs 400 r.p.m. Its pulley is 6 inches in diameter. What size of pulley should be used on the line shaft so as to run a pump at 60 strokes per minute?

$$\text{Diameter of pulley} = \frac{\text{speed of engine pulley} \times \text{diameter of engine pulley}}{\text{speed of pump.}}$$

$$= \frac{400 \times 6}{60}$$

$$= 40 \text{ inches.}$$

Cost of Engines.

For pumping purposes a small amount of power is all that is necessary. A 1½ horse-power engine may be had at from $60 to $100. The fuel requirements are not large—a pint an hour a horse-power. On page 21 we saw that the work to pump water for 40 head of cattle would average about ⅙ horse-power for 1¼ hours per day, so that the gasoline for pumping would be a small item.

Where electricity is available, pumping may be done by electric motors, and the same methods as adopted for the engine are applicable to the motor, except that since the speed of the motor is so great, usually 1,500 r.p.m. or more, one pair of pulleys may not reduce the speed sufficiently, in which case a jack-shaft is used between the motor and the line-shaft, one reduction being made from the motor to the jack-shaft and another from that to the line shaft.

Cost of Motors.

In Fig. 28, page 40, the reader will see a ⅙ horse-power motor installed for pumping water from a shallow well into a tank against 50 pounds pressure, which is equivalent to raising the water 100 feet high.

Motors are made in smaller sizes than engines. A ½ horse-power motor would do the pumping nicely on most farms, and it may be had at from $55 to $75 depending on type to suit conditions. Indeed, a ¼ horse-power would usually be of ample size. It can be had at from $40 to $50.

Rainwater and Cisterns.

Next to the well, perhaps the commonest source is the rainwater that falls upon the roof, and is conveyed by eave-troughing and conductor pipes to the cistern located either underground or in the cellar.

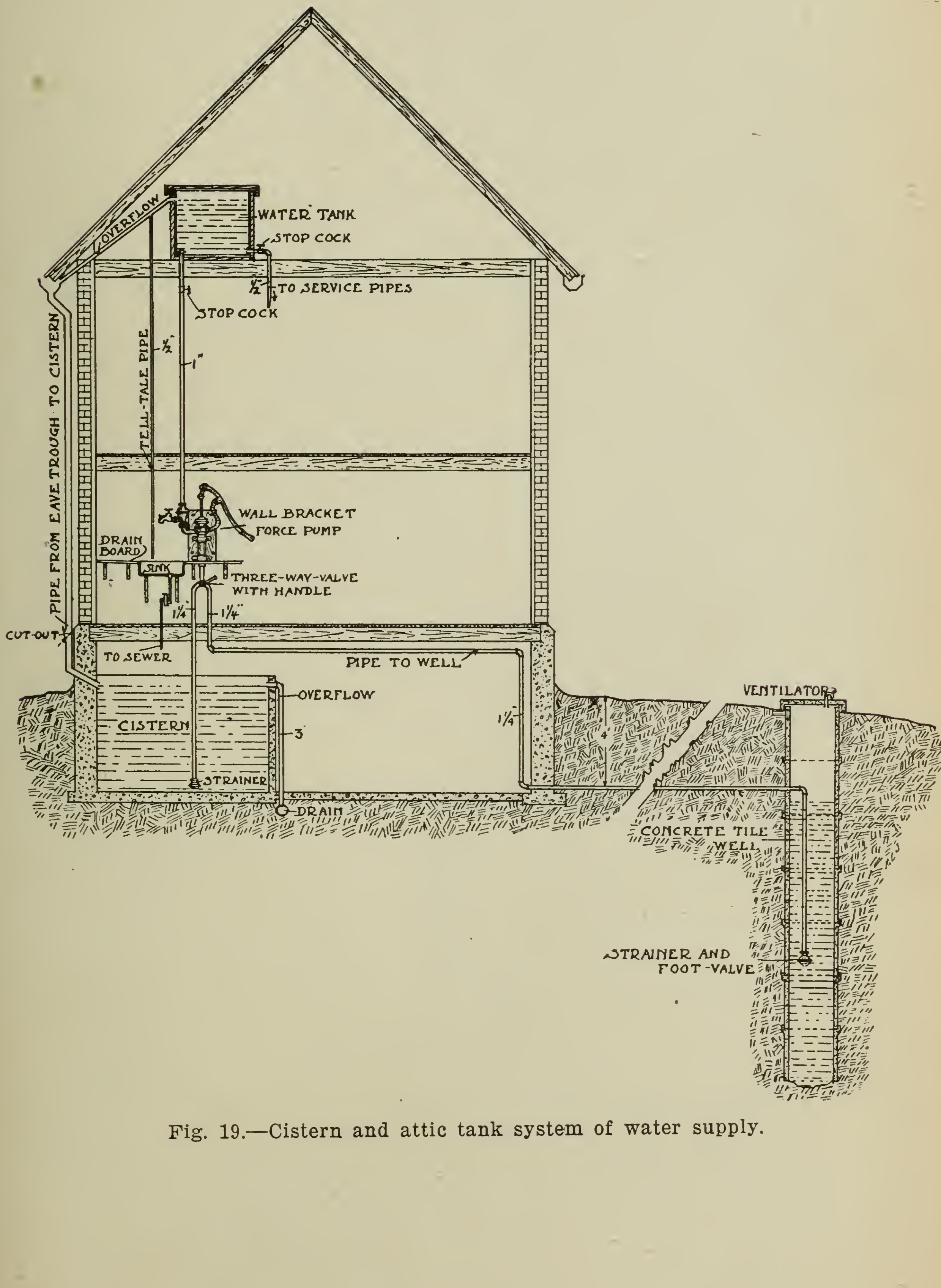


Fig. 19.—Cistern and attic tank system of water supply.

The value of a good cistern should be emphasized because the greatest demands for water in the home can be met by soft water which is supplied abundantly in this country by rains and thaws. In conjunction with an attic tank it can be made available to all parts of the house as detailed later. It is an easy matter to build a cistern and the cost is not great. The best material is concrete. The size varies with size of home or family and uses to which it is put, but it should be large enough to assure water all the year round, probably a tank about 7 ft. by 7 ft. by 5ft. would be ample in most cases. See Fig. 19 for further details.

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. 20 shows details of such a system.

Use of the Siphon.

When the source and the house are on opposite sides of a ridge, and the source higher than the house, as shown in Fig. 21, the water can be siphoned over the ridge to the house in a pipe laid under the frost-line, if the perpendicular distance marked AB in the sketch does not exceed 20 to 25 feet, and the pipe is once filled with water. The pipe line should be made airtight and frost-proof, and it should be laid over the elevation with as gradual a bend as possible. The pet-cock at the highest point is installed for the purpose of pumping out any accumulation of air that may occur there from time to time and stop the flow. The pipe is filled with water in the beginning by means of a pump attached to

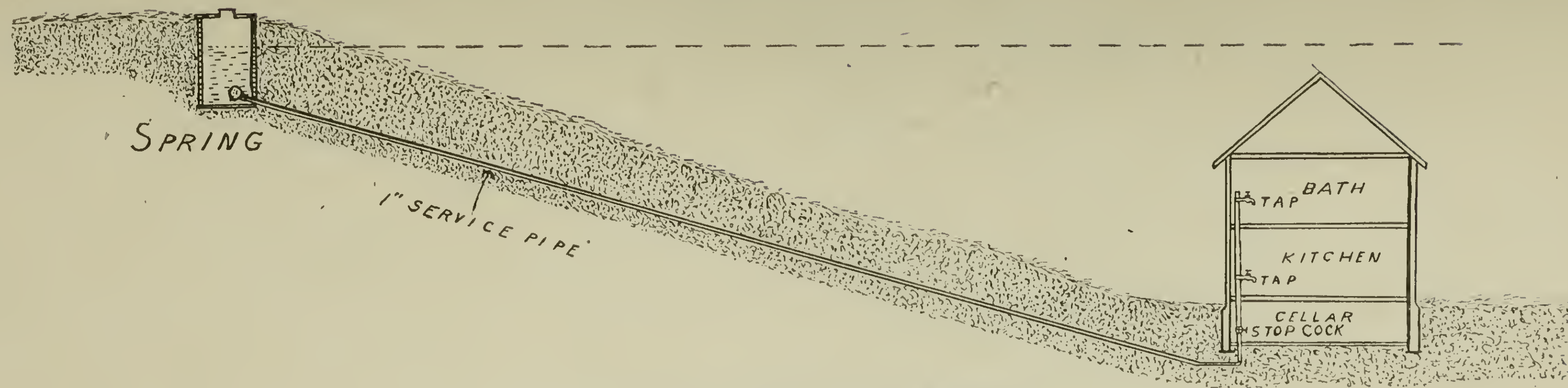


Fig. 20.—Gravity water system.

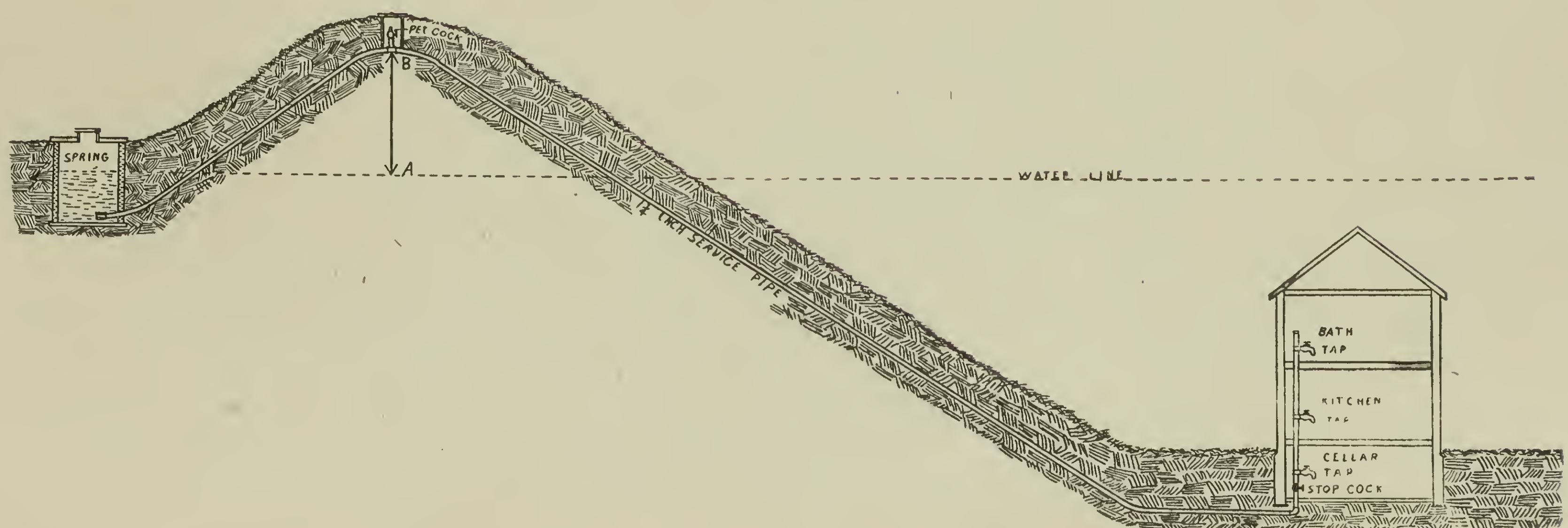


Fig. 21.—Siphon gravity water system.

the pipe in the house and once this is done the water will flow at the taps whenever they are opened. Occasionally this system is found in use. It also may give trouble by becoming airbound at the highest point, so some means as suggested above should be provided in order to easily remove the air and restore the normal flow.

Where the point of use lies at a higher elevation than the spring, stream or lake, then the pump may be used, in one or other of the forms already described, and operated either by hand, windmill, gasoline engine or electric motor.

THE HYDRAULIC RAM FOR ECONOMICAL SERVICE.

In many cases, however, it is possible to install an hydraulic ram, a variety of pump in which the energy of the water falling from the source to the ram is used to pump a portion of the water from the ram to the buildings situated at a much greater height. Fig. 22 (*a*) shows a sectional diagram of the hydraulic ram from which we may study its principle. S is the source of supply, being a spring, pond, lake or river, D the drive pipe, W the waste valve which opens downward, A the air chamber, C the check valve between the air chamber and the drive pipe which opens upward, and P the supply pipe by which the water is carried from the ram to the buildings.

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 closes, and very suddenly, too. If the drive pipe D is 1½ inches in diameter and 50 feet long, which is a length frequently used, the weight of water in the pipe is 38 pounds, and this is moving rapidly down the pipe. When the waste valve closes suddenly the 38 pounds of water strikes a blow on the inside of the pipe, including the valve C. Think of the blow a 38-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 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 38-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

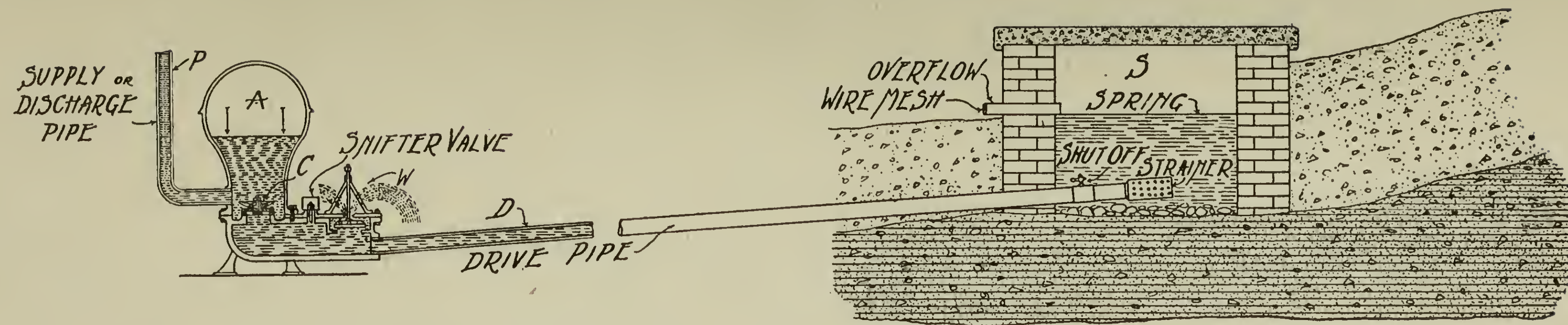


Fig. 22.—(a) Sectional diagram of hydraulic ram installation.

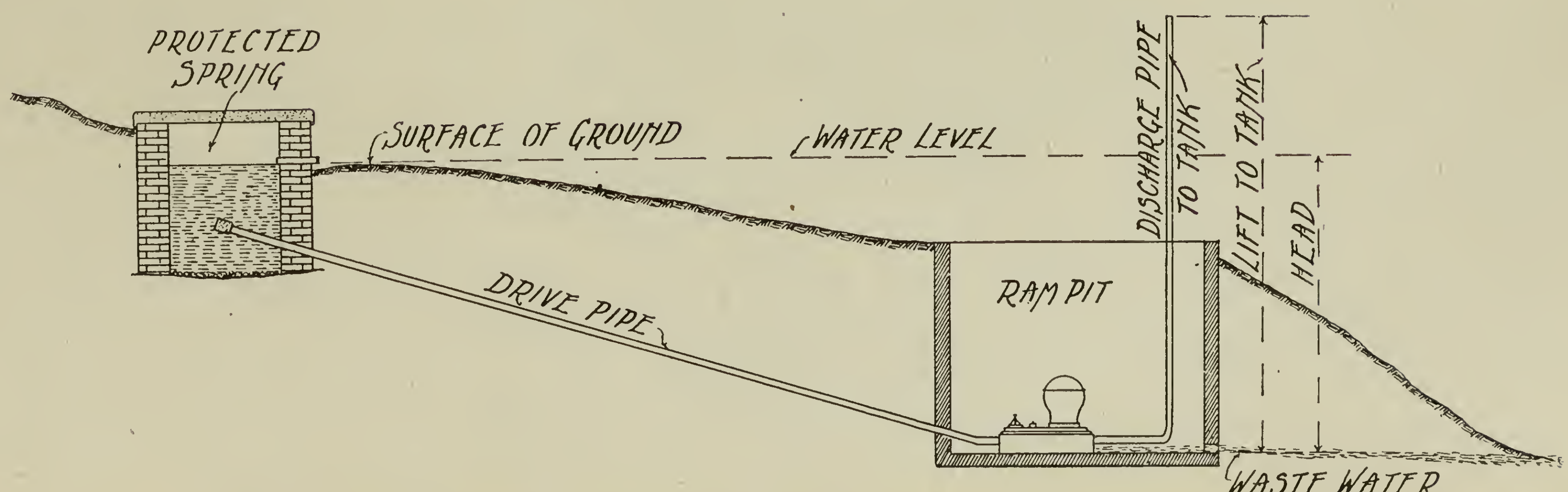


Fig. 23.—The hydraulic ram installation under ordinary conditions, ram close to spring.

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.

Fig. 22 (*b*) gives a sectional view of a ram, by which it will be seen that the

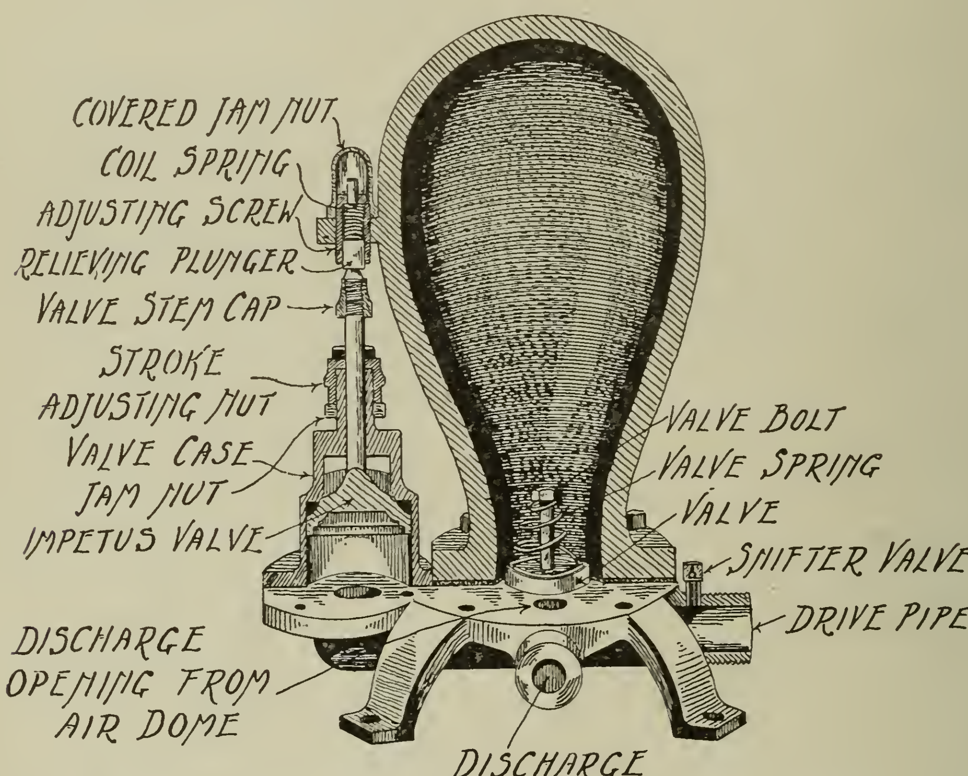


Fig. 22.—(*b*) Section of hydraulic ram, showing parts.

waste valve may be placed on the opposite side of the air-dome, in which case the drive pipe passes directly under the ram. As an additional help to open the valve W at the right time some rams are fitted with a relieving plunger operated by a spring. It is so set that the stem of W hits the plunger when at the top of its stroke.

What the Ram Will Deliver.

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 65 to 90 per cent., i.e., it uses 65 to 90 per cent. of the energy of the falling water. Suppose the spring supplies 10 gallons per minute and the fall from the spring to the ram is 5 feet. Multiply these together and then take 65 per cent. of the product, and we have the energy available for driving water to the buildings.

$$\text{Energy in this case} = \frac{65}{100} \times 10 \times 5 \text{ foot-gallons.}$$
$$= 32.5 \text{ foot-gallons.}$$

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

Number of gallons delivered per minute $= \frac{32.5}{32.5} = 1$ gallon which is 1/10 of the water supplied by the supposed spring.

Therefore number of gallons per day=60 × 24=1,440 gallons=about 29 barrels. Consequently with 5 feet of head and 32.5 feet of lift the ram will deliver at the buildings 1/10 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.

Generally speaking it is found that for each 10 feet of lift there should be 1 foot of head, but there is a limit—it is seldom advisable to install rams where the head is less than say two feet, although they have been known to work with as little as 18 inches. The length of drive pipe should not be less than three-quarters the lift to the buildings, nor less than five times the fall from the spring to the ram. It may, however, be longer, but seldom exceeds 50 feet, and 75 feet might be taken as an extreme length for sizes of ram suitable for farm conditions. If too long a drive pipe be used, the extra friction in it prevents the water from striking as heavily or as frequently as with a drive pipe just the right length.

Figs. 23, 24, 25 and 26 show how to install the ram under varying conditions. Fig. 23 illustrates the ordinary case where the conditions are such as to allow of building a ram pit within 35 to 50 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. 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 35 to 50 feet from the ram, as shown in Fig. 24. 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, in it friction is so great 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. 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.

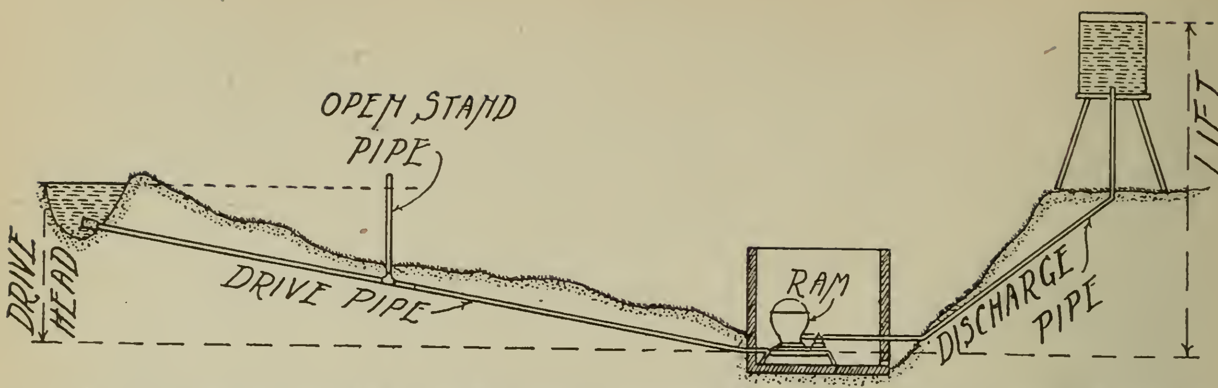


Fig. 24.—When the ram is at considerable distance from the spring, an open stand pipe or reservoir must be provided within 35 to 50 ft. from the ram.

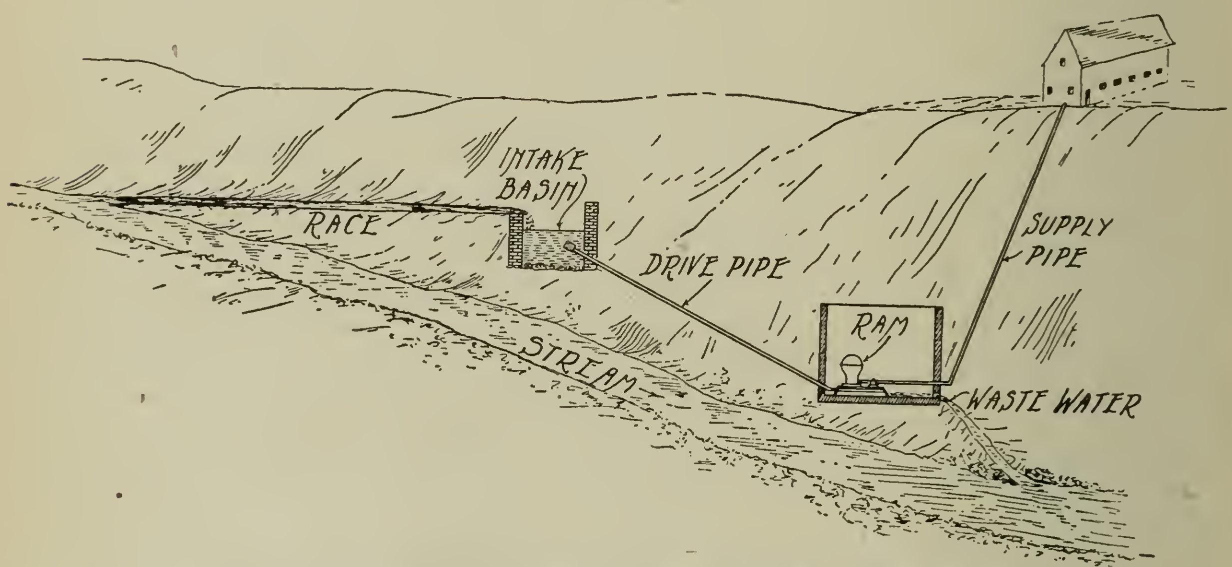


Fig. 25.—Obtaining head for ram along a river bank.

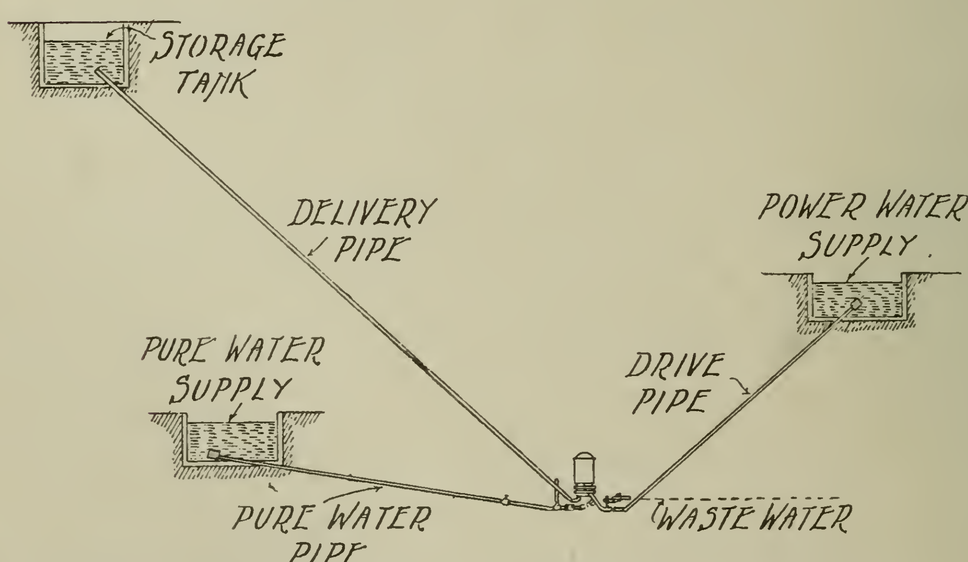


Fig. 26.—Double acting ram using impure water supply to drive pure water to the buildings.

This is illustrated in Fig. 25. 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 nearly all the spring water at the buildings. Fig. 26 shows this installation.

When to Use Ram.

The steps to be taken in deciding whether a ram can be used are as follows:

1. Measure the flow of the spring. It requires 2 to 3 gallons per minute to operate the smallest size of ram. To measure the spring, construct a small dam with an opening in it and catch the water in a pail or tub noting the time it takes to fill it. Then measure the water in gallons.
2. See if there is drainage for the waste water.
3. Determine the lift between the ram and the buildings.
4. Determine the head that may be procured from the spring to the ram-pit and see if this is great enough as compared with the lift—one foot of head to ten of lift.
5. Determine the amount of water required per day at the buildings, using as a basis the quantities mentioned on page 34.
6. Using the method explained on page 31, calculate the amount of water the ram will deliver. If this is as large as the quantity required the ram may be installed.

Appendix 1 contains a form which if filled out and submitted to any maker of rams will enable him to advise whether a ram is practicable, and if so, what size.

Cost of Installing Ram.

In February, 1917, we obtained prices on rams, piping, etc., and made an estimate of the cost of installing rams of different sizes to supply water to buildings situated 100 feet from the ram, and also the additional cost for each 100 feet additional distance between ram and barn. This estimate is presented in Table I. The prices are somewhat in excess of those obtaining before the war, but on the other hand are less than at the present time (May, 1918).

Table I, Showing the Approximate Cost, February, 1917, of Installing Hydraulic Rams.

Size of Ram.	Cost of Ram.	Drive Pipe.		Price of 35 feet	Supply Pipe.		Digging 135 ft. trench and laying pipe, say	Filling trench, say	Ram pit, say	Intake, say	Total for delivery 100 ft. from ram.	Cost of each additional 100 feet.
		Length and size.	Rate per 100 feet black.		Length and size.	Rate per 100 feet black.						
	$	ft. in.	$	$	ft. in.	$	$	$	$	$	$	$ in.
No. 2....	9	35 x ¾	6.20	2.17	100 x ½	5.05	7.90	1.00	5.00	5.00	35.12	12.05—½
No. 3....	11	35 x 1	9.16	3.21	100 x ½	5.05	7.90	1.00	5.00	5.00	38.16	12.05—½
No. 4....	14	35 x 1½	14.83	5.29	100 x ¾	6.20	7.90	1.00	5.00	5.00	44.39	
No. 5....	22	35 x 2	19.94	6.98	100 x 1	9.16	7.90	1.00	5.00	5.00	57.04	
No. 6....	40	35 x 2½	31.54	11.04	100 x 1¼	12.40	7.90	1.00	5.00	5.00	82.34	

Chief Features of a Good Water System.

But modern systems of farm water supply do not end with a suitable pump or other means for delivering the water at the buildings. They aim at providing the same conveniences as are enjoyed in city homes, viz., water on tap wherever required, whether on the lawn, in the kitchen or at the bath-tub. To do this, three elements are necessary in the system, first, a storage tank of some type or other, secondly, a method of providing pressure either by gravity or compressed air, and, thirdly, a distribution system from the tank to the points of use. Several methods are in vogue, according to the varying needs under different circumstances, but whatever the method there are certain general features that apply in all cases:

(1) The system should have capacity enough to meet the maximum requirements every day of the year.

(2) It should be simple in construction, compact, durable, not liable to leak, easy to operate and keep in repair.

(3) It should keep the water in a pure, fresh and cool condition for delivery at the taps at all times.

(4) It should be capable of rendering assistance in washing vehicles, watering the lawn and garden, and in fire protection.

Quantities of Water Required per Day.

In determining the capacity of systems for homes equipped with all modern conveniences it is the rule to allow at least 25 gallons per person per day, but where there is neither bath nor water-closet 10 gallons is sufficient.

For stock, the following quantities are allowed: cow 10, horse 10, sheep 2, and pig 1 gallon per day.

A knowledge of these amounts is an aid not only in calculating intelligently the size of water storage tanks for house or barn, but also determining type and capacity of pump to use, and size of septic tank required to take care of the sewage from the home.

THE ATTIC TANK SYSTEM.

Perhaps the simplest of all is the attic tank system, the distinctive feature of which, as its name implies, is a storage tank in the attic of the house for supplying water by gravity. The tank may be filled by kitchen pump, power pump, hydraulic ram or siphon, or by the rain water from the roof. This system is best adapted for utilizing the soft water from the roof or cistern for washing or bathing but for drinking purposes the water would become rather warm in summertime. The tank may be made of wood lined with galvanized iron, of metal, or of two or three oak barrels joined at the bottom by iron piping. A tank about 3 feet square is large enough for the ordinary-sized home. Other details as cover, overflow pipe, etc., are shown in Fig. 19. This system is giving good service in many homes to-day. One disadvantage is that occasionally the tank may spring a leak, causing damage to the house or furniture. As the quantity of water stored is usually not large, the system is not applicable for washing vehicles, etc., nor for fighting fire, especially as it will not deliver water higher than the tank itself.

THE ELEVATED TANK IN THE YARD.

A system somewhat akin to the one just considered is that of having a large stave or metal tank erected on a high tower in the yard usually in connection with the windmill structure. Water is pumped into it by one or other of the methods already noted and flows by gravity through pipes laid to the house, barn, lawn and garden.

The system has many obvious disadvantages for general use, but it is well adapted for lawn and garden watering, as the water has a chance of being warmed in the sun before being applied to the plants. Except for this particular advantage, it is doubtful if anyone would consider installing this system to-day when superior ones can be secured, for example, the compression system next to be described.

THE COMPRESSION WATER SUPPLY SYSTEM.

In bare outline this system consists in storing water in a steel tank under high air pressure, which drives the water out of the taps whenever they are opened.

The introduction of this system has made it possible for rural homes to have practically as good a water service as those in towns and cities. Since its advent a few years ago it has been installed in a great many rural homes, also in many suburban and village homes and summer resort cottages. Its popularity is due to its many distinct advantages over other systems, chief of which are given herewith:

1. The stored supply of water is kept clean, pure, aerated and cool in an air-tight tank underground or in the cellar, and always under sufficient pressure to render it available at all parts of the house and barns for ordinary service, and, if necessary, under extra pressure for fire protection, watering lawns and garden, and washing vehicles.
2. It is simple and compact in construction, durable, efficient, and easy to operate, the electric-driven outfit being entirely automatic.
3. Unlike the elevated tank system it is not a source of danger to life and property and the stored water is not subject to freezing in the winter and heating in the summer.

Farmers who have installed this system in their homes freely testify to the importance of these advantages. Indeed only those who have enjoyed the privileges of a good water system, like this one, can fully appreciate its value.

Construction of System.

As illustrated in Fig. 27, the system is composed of the following parts: One airtight metal storage tank, one force-pump with air compressor attachment, one pressure gauge, one water gauge, iron piping for connecting well to pump, pump to tank, and tank to faucets, and miscellaneous fittings such as check valves, unions, valves, etc. When the pump is power-driven there is also an engine or motor and their automatic controls.

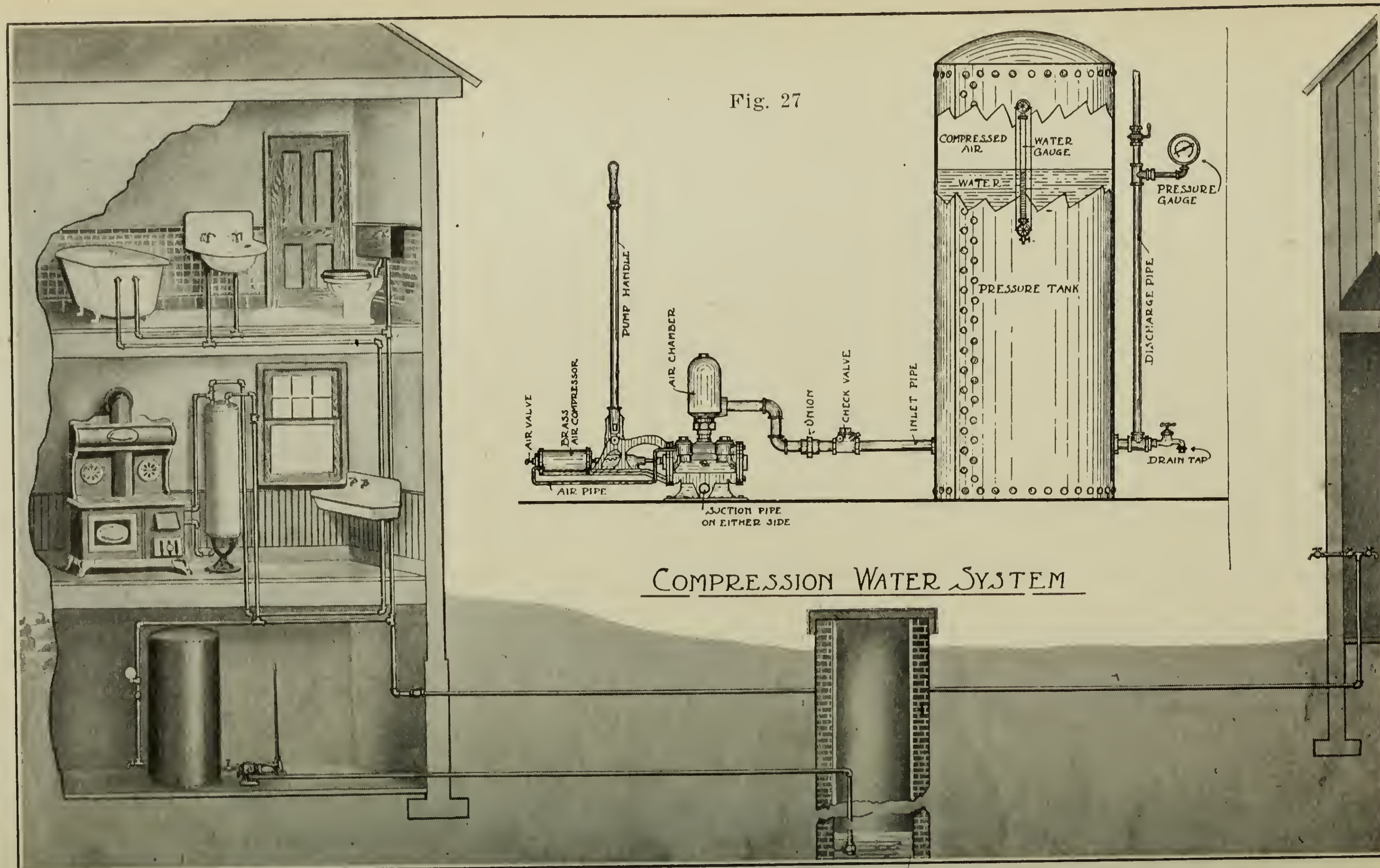


Fig. 30.—Water convenience for house and barn.

Fig. 27.—The compression water system, showing details of parts.

Storage Tank.

The storage tank is a cylindrical metal one having a guaranteed factory test of 125 pounds, and a working test of 75 pounds per square inch. The size depends upon the storage capacity required, and the power used for pumping, but for the average-sized home it is usually 30 in. by 6 ft. with hand, gasoline engine and windmill power, and 24 in. by 6 ft. with electric motor power; and when the same plant serves both house and barn 36 in. by 10 ft. is the common size. The accompanying table No. II may be found useful for reference on this type of tank.

Table II. Compression Storage Tanks. Common Sizes.

Diameter in inches.	Length, feet.	Capacities.			Approximate weight in pounds.
		Barrels of 50 gals.	Gallons (Imperial), full capacity	Gallons, working capacity, $\frac{2}{3}$ of full capacity.	
24	6	2.36	118	62	350
30	6	3.70	185	123	530
30	8	4.96	248	165	650
30	10	6.14	307	204	770
36	6	5.30	265	176	750
36	8	7.08	354	236	900
36	10	8.84	442	294	1050

For both hard and soft water two tanks are required, but each smaller than for the single installation, probably 24 in. by 6 ft.

The function of the tank is twofold, namely, the storage of water, and the retention of compressed air, which forces out the water when the faucets are opened. Since the storage tank contains both water and compressed air, the system is also known by the name "hydro-pneumatic water supply system."

The Pump.

The type and capacity of pump depends upon the kind of power used, class of well, whether shallow or deep, size of the installation, suction distance and so on, but it must always be a force-pump, being required to pump water against pressure. The reader is referred to the treatment of pumps in another part of this bulletin, for further information, and requested to note Figs. 11 to 14 as they show the common types of pumps used in connection with the compression water system.

The Air Compressor.

In the treatment of the hydraulic ram it was pointed out that air is soluble in water, and consequently unless fresh air was admitted to the dome the supply would become exhausted. The same is true here. To overcome this difficulty we require an air compressor by which fresh air can be forced into the tank from time to time. This is shown in Figs. 14 and 27. It consists of a small brass cylinder tapped at one end for a suction and a discharge valve, and containing a solid piston.

The piston is joined directly or indirectly, as the case may be, to the piston rod of the water pump, so that both pistons move simultaneously. A small iron pipe connects the compressor to the discharge side of the water pump, through which the air is forced to the pump, and thence with the water into the tank. When air is required a screw cap or tiny lever is turned one way to make the suction valve operative, and when air is not required this adjustment is reversed. Some authorities claim that the air pump should be used once or twice a week, but this is a matter for the attendant to find out by experience for his own particular case.

The Pressure Gauge.

This is the instrument resembling a small clock, that is seen in Fig. 27, attached to the discharge pipe at a point close to the side of the tank. This is the preferred location for it, being easily seen and convenient, but it may be placed anywhere in the system for either air or water will operate it. Its purpose is to indicate the pressure in pounds per square inch of the compressed air in the tank, in order that the attendant may know when to pump water into the tank, and when to stop, as he will know by experience what range of pressure gives the best satisfaction. This range will usually vary from 30 to 45 pounds.

The Water Gauge.

This is the glass tube on the front of the tank for indicating the amount of water and air, and as the water should be kept about two-thirds way up the tank this gauge is located near the top. Every height of the water records a definite pressure on the gauge as seen in pressure table on page 39, and if the height of the water is found to be above what it should be for the recorded pressure, the tank needs more air.

Piping.

All the piping should be A1 galvanized iron. The size of the discharge pipe is ¾ in., the suction and delivery 1¼ in. to 2 in., depending on the size of the installation, and the distance the water has to be drawn or forced. The service pipes throughout the house are ½ in. inside diameter.

Check Valves.

As shown in the illustration a check valve is located in the delivery pipe connecting the pump and the tank. Its function is to prevent the return of the water and air once they are pumped into the tank, and the pumping ceases. It should be installed so that the flapper or valve will open in the same direction as the water moves. It is advisable to put a check valve on the end of the suction pipe in the well whenever the suction distance is great, for the purpose of keeping the suction pipe full of water and the pump always primed. Combined with this check valve there should be a metal strainer to keep out things that might choke or destroy the pump valves. "Foot-valve and strainer" is the common name for this combination.

Drain Cock.

At the bottom of the tank is a drain cock. Its purpose is to drain the tank when necessary, for example, in cleaning, repairing or moving it.

Stop and Waste Cock.

In the discharge pipe above the pressure gauge is a stop and waste cock. Its purpose is to shut off the flow from the tank in case of repairs or alterations in the service pipe. It also drains the pipes.

Automatic Controls.

Speaking generally, the power-operated installations are equipped with automatic control switches for turning the power on or off at predetermined set pressures; for example, if the control be adjusted for a minimum pressure of 30 pounds and a maximum of 45 pounds the pumping will start and stop respectively whenever these pressures exist in the tank. This, of course, does not apply in full to the gas-operated plant, as the engine has to be cranked for starting. It is claimed that these controls are reliable and safe, and their advantages are obvious, but the attendant must take heed lest, just because it is automatic in this regard, he fail to give the plant the necessary care otherwise.

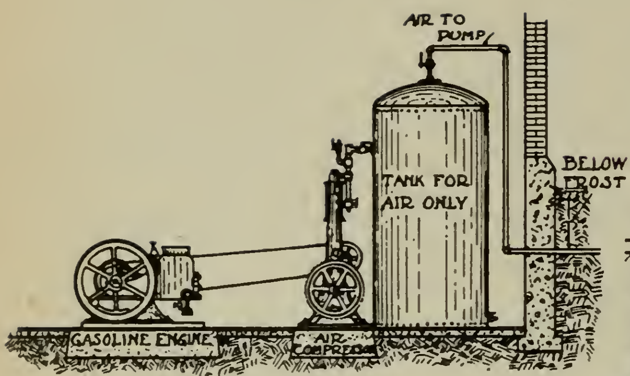
Kinds of Power Used for Pumping.

As already intimated, the power used may be hand, gas engine, electric motor or windmill. Probably the majority of the systems installed to date are operated by hand, but the power-driven are rapidly increasing, and are very much more satisfactory. One, or one and a half horse-power gasoline engine is adequate when used only for pumping, but in many cases it would be advisable to have a larger engine so that other work might be done as well. Since the electric-driven units are absolutely automatic they need not be so large and, consequently, less power is required, about 1/4 to 1/6 horse-power motor being large enough for small outfits for short suction distances. See Fig. 28.

Reference has already been made to the pressure gauge and its use. Now we shall see what the pressure is for different heights of water in the tank, and how high the various pressures will lift water in the pipes; first, when no air has been pumped into the tank previous to the water; secondly, when enough air has been pumped in first to make the gauge read, say, 10 pounds. The facts are given in the tabulated form herewith.

Table III. Pressure in Pneumatic Tanks and Height Water Will Be Forced By It.

Amount of water in tank.	Gauge Pressure.		Actual height in feet water would be forced in pipes.	
	Nothing to start with.	10 lbs. to start with.	Gauge at 0 to start with.	Gauge at 10 to start with.
None.	0	10	0	20
1/4 Full	5	18 1/3	10	36 2/3
1/3 "	7 1/2	22 1/2	15	45
1/2 "	15	35	30	70
2/3 "	30	60	60	120
3/4 "	45	85	90	170



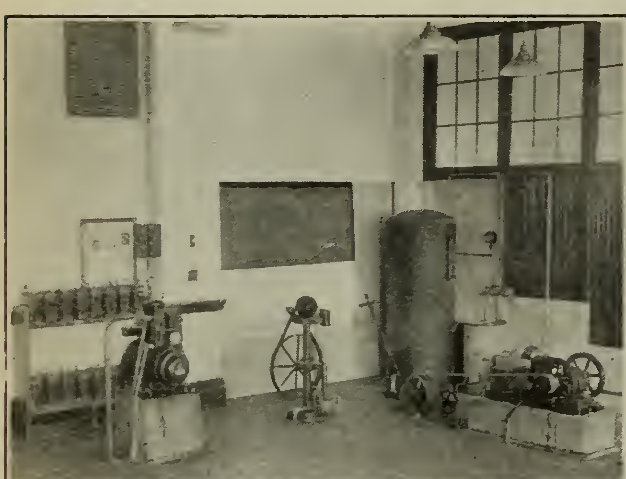


Fig. 28.—Demonstration pneumatic water system installed in Department of Physics, O.A.C. On the right is a 1½ h.p. gasoline engine. In front of the tank a double acting force pump of the same kind as shown in Fig. 14 (*a*). Note the pump handle. Just to the left of the tank is a ⅙ h.p. motor and pump of same type as shown in Fig. 14 (*b*). This motor is operated from the storage battery of the electric light plant on the left of the picture. The tank may be filled by hand, gasoline engine or electric motor.

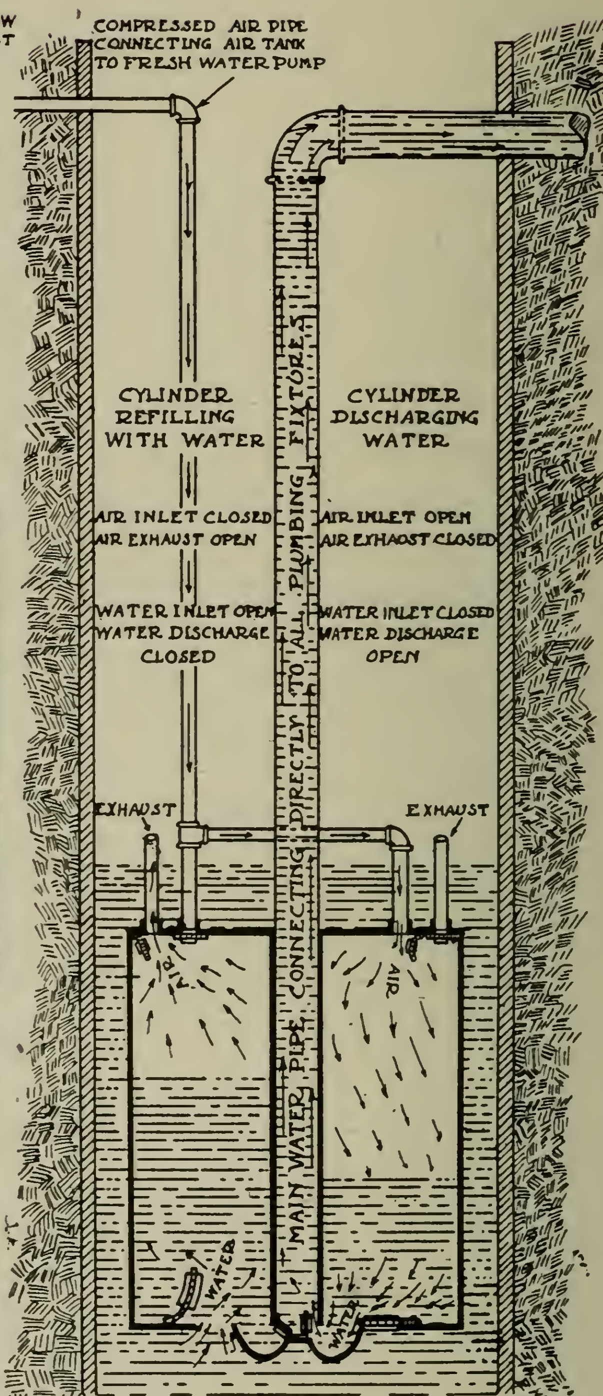


Fig. 29.—Fresh water system.

The heights recorded in columns 4 and 5 of the above table were calculated on the basis that when a tap is opened one pound pressure will lift water two feet in ordinary water pipes, friction included, but for stationary water under standard barometer, one pound pressure will support a column two feet four inches high.

In comparing the figures in column 3 with the corresponding ones in column 2 we note the decided gain in pressure by pumping some air into the tank first, a great advantage no doubt, in respect to fire protection, and in view of the fact that the tank could be entirely emptied at the highest tap in the house if necessary, but a disadvantage from the standpoint of pumping, especially by hand, as more power is required to pump against the higher pressure.

Additional Care of System.

1. Always keep the tank ½ to ⅔ full of water.
2. Pump a little air into the tank once or twice a week.
3. Keep pump, gasoline engine or electric motor well oiled, and otherwise in good working order.
4. Pump valves and valve seats will need cleaning and renewing occasionally. It doesn't pay to allow them to be old and badly worn.

Hints to Prospective Purchasers.

Names and addresses of companies handling this system may be secured from their advertisements in farm magazines and papers, from local plumbers and hardware dealers. It is a good plan to write the various firms for their catalogues describing the system, and make a careful study of the various types before purchasing. The companies will answer questions and give estimates of costs without any charge or obligation to buy.

Appendix 2 contains a form that will be convenient for sending information that will enable them to give you the estimates without delay.

General Statement of Costs.

The costs can be given only in a very general way as they vary considerably with size and type of installation, conditions under which the system is installed and so on.

1. Hand operated plants, $90 to $130. Size of tank 30 in. by 6 ft.
2. Gasoline engine operated, about $200. Size of tank 30 in. by 6 ft.
3. Electric motor driven unit, about $200. Size of tank, 24 in. by 6 ft.

All these estimates include tank, pump with air compressor, engine or motor for power, pressure and water gauges, connecting pipes, valves, unions, etc., but they do not include the service pipe throughout the house or barns, or from the pump to the well.

Pointers Regarding Installation of System.

1. The tank should be put in a frost-proof place, the cellar being the most common and best location, although it is sometimes placed underground. It may be set vertically or horizontally, depending on the height of the room.

2. The pump may be located inside the buildings and close to the tank if the well is shallow; that is, if the water is never more than 20 to 25 feet lower than the level of the pump cylinder. This arrangement is highly desirable if it can be secured.

3. If the pump is inside and operated by power, use the belt driven method of transmission as it is quieter than the direct drive.

4. Unless the purchaser has had some experience with plumbers' tools, or is a good mechanic, he had better get a plumber to install the system.

5. Insist on the plumber making a thorough test of the system before he leaves the job. This consists of pumping up the tank with air and water to about 50 pounds pressure and waiting to see if the pressure holds well or not, and if there are any leaks in pipe, connections, etc.

6. See that the check valve between the pump and the tank is put in as recommended in a previous paragraph.

7. Before starting the pump, open the suction valve or valves and pour in water enough to prime it well, and then screw the valve cap on again very tightly.

FRESH WATER SYSTEM.

There is another type of pneumatic system of water supply, a new one only just beginning to be introduced, known as the Fresh Water System, because no storage tank is used, the water being pumped direct from the well by compressed air whenever a tap is opened. It is illustrated in Fig. 29. Close to the engine or motor is situated an air pump by which air is forced into the air storage tank. The water pump, which is of special design, is located in the water in the well. The air tank and the pump are connected by a compressed air pipe and from the pump water-pipes lead to all points of use as in the system already described and which it resembles except in the respect already mentioned. When a tap is opened the water pump is operated automatically by the compressed air, which after being used by the pump is allowed to escape through the exhaust pipes just like the exhaust from a gasoline engine. The same automatic controls as used in the former system can be used here to keep the air pressure up to the desired limit.

HOUSEHOLD WATER EQUIPMENT.

The plumbing fixtures for the ordinary house consist of a kitchen sink, laundry sink or laundry tubs, and a basin, bath tub and water-closet for the bathroom. Good types of these, also their connection with the water service pipes and with the waste pipes, are illustrated in Fig. 30, page 36, and Fig. 35, page 58.

These fixtures may be secured in many different designs and qualities and at as many different prices. Your local plumber, or any dealer in them, should be qualified to give you all such information about them.

The Kitchen Sink.

The kitchen sink is made of plain galvanized or enameled cast iron, slate or porcelain, but the enameled cast iron is preferable for ordinary use. They are made in three sizes, 18 in. by 36 in., 20 in. by 36 in., and 20 in. by 42 in., the first size mentioned being most common, and it is quite satisfactory for most cases. The sink should be set with its top about 33 in. above the floor to avoid undue stooping for those using it. It should be provided with a back, and also a drip or drain board, and a flexible wire, wooden or rubber mat that fits nicely in the bottom to protect the surface from scratches and as a preventive to breaking dishes against the bottom. The drain pipe leading out of the sink is 1½ inches in diameter, but for the farm kitchen sink the horizontal portion should be 2 inches, as there are such large amounts of waste water passing out of it. The trap below the sink is a very valuable part, as it prevents return of odors into the kitchen, and it should be opened at the bottom occasionally and cleaned out.

Laundry Tubs.

Laundry tubs usually consist of two tubs side by side, either separate or in one large tub with a partition at the centre. They are made of metal, porcelain or artificial stone, the last giving very good satisfaction if not allowed to freeze. They are a great convenience in washing. The clothes wringer can be attached to the partition wall, the clothes being washed in one tub and passed through the wringer into rinsing water in the other.

Bath Tubs.

The higher grades of bath tubs are made of porcelain or enamelled cast iron with a wide roll rim, those of lower grade of enamelled cast iron, or steel body with copper lining known as "steel clad" tubs, or steel body enamel painted. Of the cheaper grades the steel-clad gives the best service. The 5 ft. and 5 ft. 6 in. sizes are the common ones. It should be installed far enough from the walls to allow a person to clean around it easily.

Wash Basin.

Basins are made of enamelled cast iron and a good type is shown in Fig. 30, page 36. They are designed either for attaching to the wall or a corner of the room.

Water-Closet.

The water-closet consists of the bowl, the seat and the flushing tank containing a ball-cock device for regulating height of water in the tank. The bowl is enamelled cast iron and it is important that the enamel be good. The part that gives the most trouble is the ball-cock valve in the tank. To be satisfactory it should be noiseless, quick closing, easy to repair, simple in construction, and made of high grade material free from impurities, so that the valve seat will not be destroyed readily by chemical action of water on it.

Installation of the Fixtures.

1. Secure a capable plumber to do the work, and have him test the installations thoroughly for defects or leaks before you accept the work.

2. Discuss with him the question of best layout for the various fixtures, for instance, where should the kitchen sink, used so much, be installed in order to be most convenient.

3. So far as practicable, the fixtures and water pipes should be kept away from outside walls, doors and windows in order to protect them against frost. This is very important.

4. The water pipe should be made of the best galvanized iron and it should be ½-inch inside diameter.

5. The waste pipes from sinks, basins and bath tub should be 1½-inch diameter and each of these pipes must be provided with a trap or water seal.

6. The hot water boiler may be located in the cellar close to the furnace, in the kitchen, or in the bathroom, some preferring one place and some another, according to personal taste and the layout of the house.

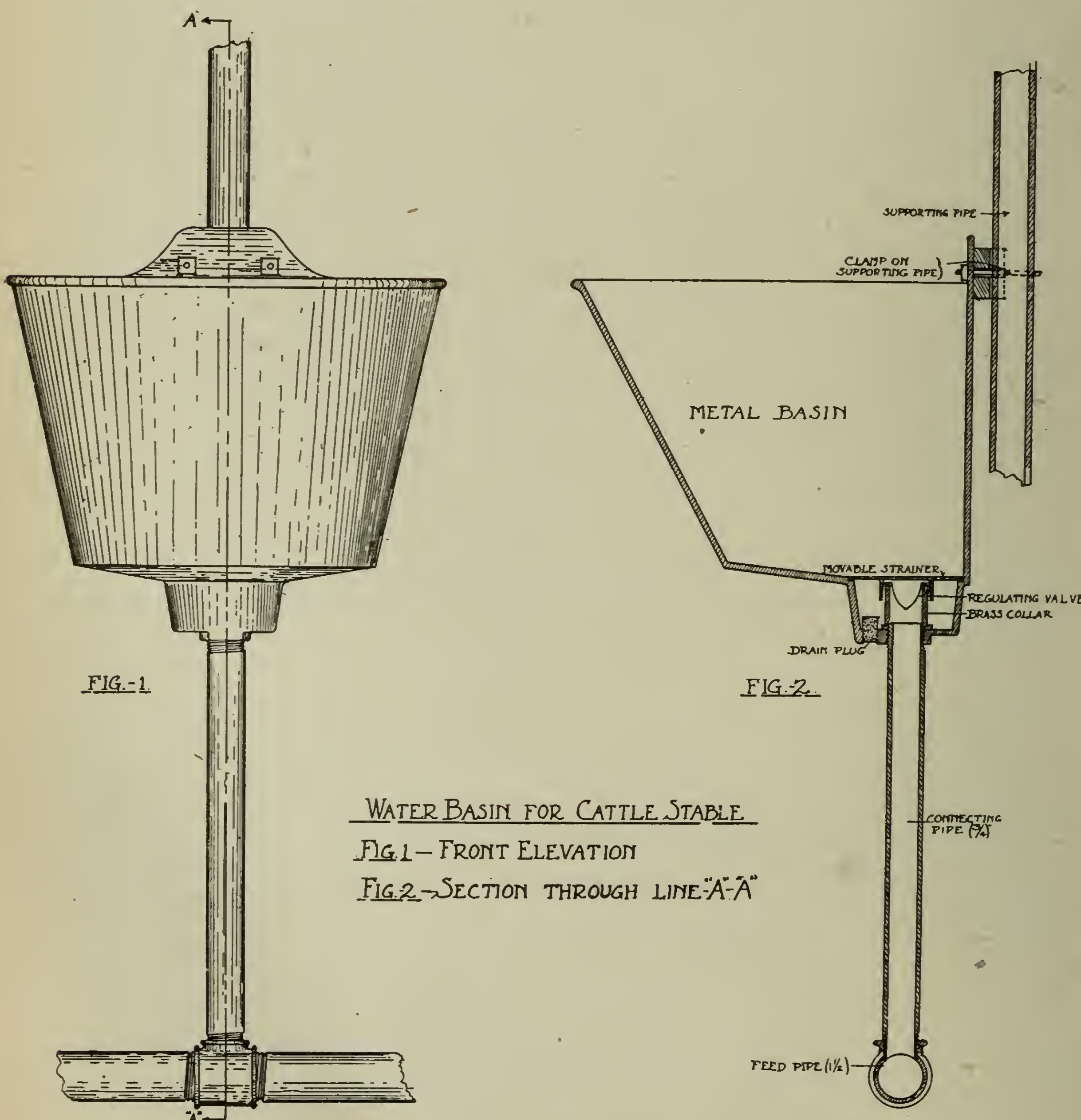


Fig. 31.—Water basin for stable.

WATER SYSTEMS FOR THE STABLE.

The best water system for the stable consists of a storage tank in the mow above the stable or suspended from the ceiling, and from which water gravitates to individual drinking basins in front of the cattle or horses. The water is maintained at a constant height in these basins by a float in a regulating tank in the pipe line between the main tank and the basins. The water is prevented from passing from one basin to another by a conical metal valve resting in a seat in the bottom of the basins, the advantage of this being that a diseased animal cannot affect the others through the drinking water, as is the case where the animals drink from a common water trough in front of them.

The tank may be of wood, metal or concrete. The metal tanks are usually suspended from the ceiling of the stable, while the wood and concrete are in the haymow or loft. If a windmill is used for pumping, the tank should be large enough to hold three or four days' supply of water to tide over the days that the wind may not blow. A tank 8 ft. by 4 ft. by 3 ft. will hold enough of water for 20 head of cattle for three or four days. The tank may be filled by windmill, gasoline engine or hydraulic ram. Some run the rain-water into it from the roof of the barn, but there is some objection to this practice on account of the dirt in the water, which may befoul it or choke up the pipes; however, if the tank be cleaned out occasionally the objection cannot be serious. An overflow pipe about 4 in. in diameter is required to take care of overflow in case of big rains. Tanks should be tightly covered and well protected from frost.

A very neat system sometimes found in use combines the house and stable systems, by having the overflow from the house tank lead to the control tank in the stable. In this way the water in the house tank is fresher than when the separate house system is used. This is only feasible where power pumping is used.

The design of the drinking basin needs emphasizing. It should be as simple as possible with no parts to get out of order, and be easy to clean and repair. The accompanying drawing, Fig. 31, shows a very desirable type, with all details named.

For a general outline of this system and for further details the reader is referred to Fig. 32. It could be extended to serve the horses with water in basins, but another regulating tank would be required since their basins would be higher than those for the cattle. It will be noticed that all water pipes are kept away from the walls of the stable in order to protect them from frost. The main pipe feeding the basins should pass from one row of cows to the other along the floor, not rise up to the ceiling and then over, as there would be a tendency for the highest point in the bend to become air-bound.

This system is the most common one to-day, but with the advent of the compression system described previously, we already know of some farmers using it for the stable as well as for the house, the one installation serving both duties. In a few cases the water is supplied to the stables by gravity from a spring, or pumped from a spring by an hydraulic ram, in either case a storage tank not being necessary.

As to the actual installation of the water system for a stable, there is very little about it that a handy farmer cannot do himself if he knows how to go about it and has a few good tools. He can either make the tank or buy it, he

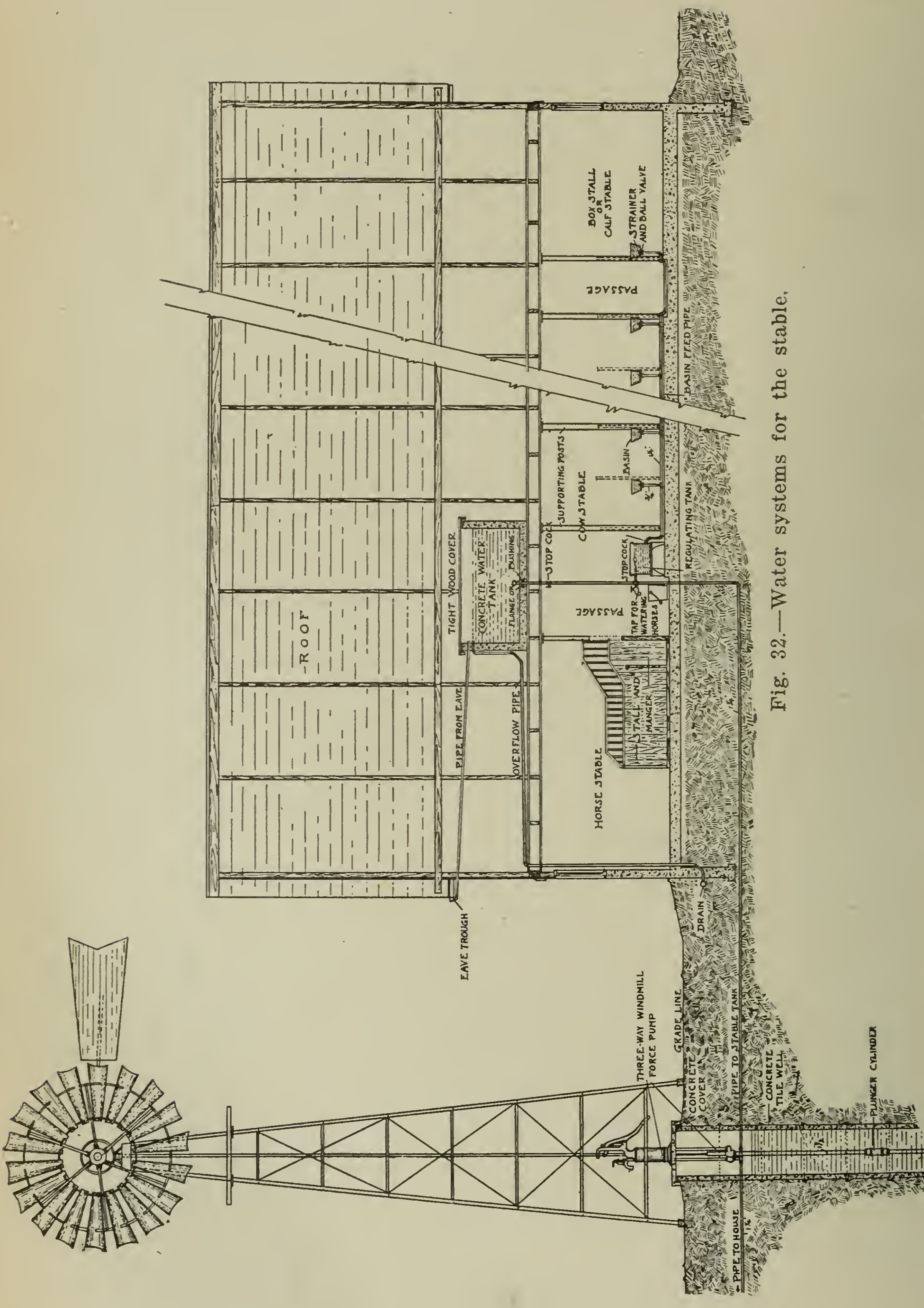


Fig. 32.—Water systems for the stable.

can buy all the pipe and fittings from a hardware dealer already cut and threaded, and the regulating tank and basins from firms dealing in stable equipment. With a couple of pipe wrenches and some white lead for the connections, and a boy to help him, he can install the system nicely.

Two types of regulating valves are used. These are shown in Fig. 33, A and B. The valve and lever in A may be bought for $1.00 to $2.00, depending on size. The float may be made by a tinsmith.

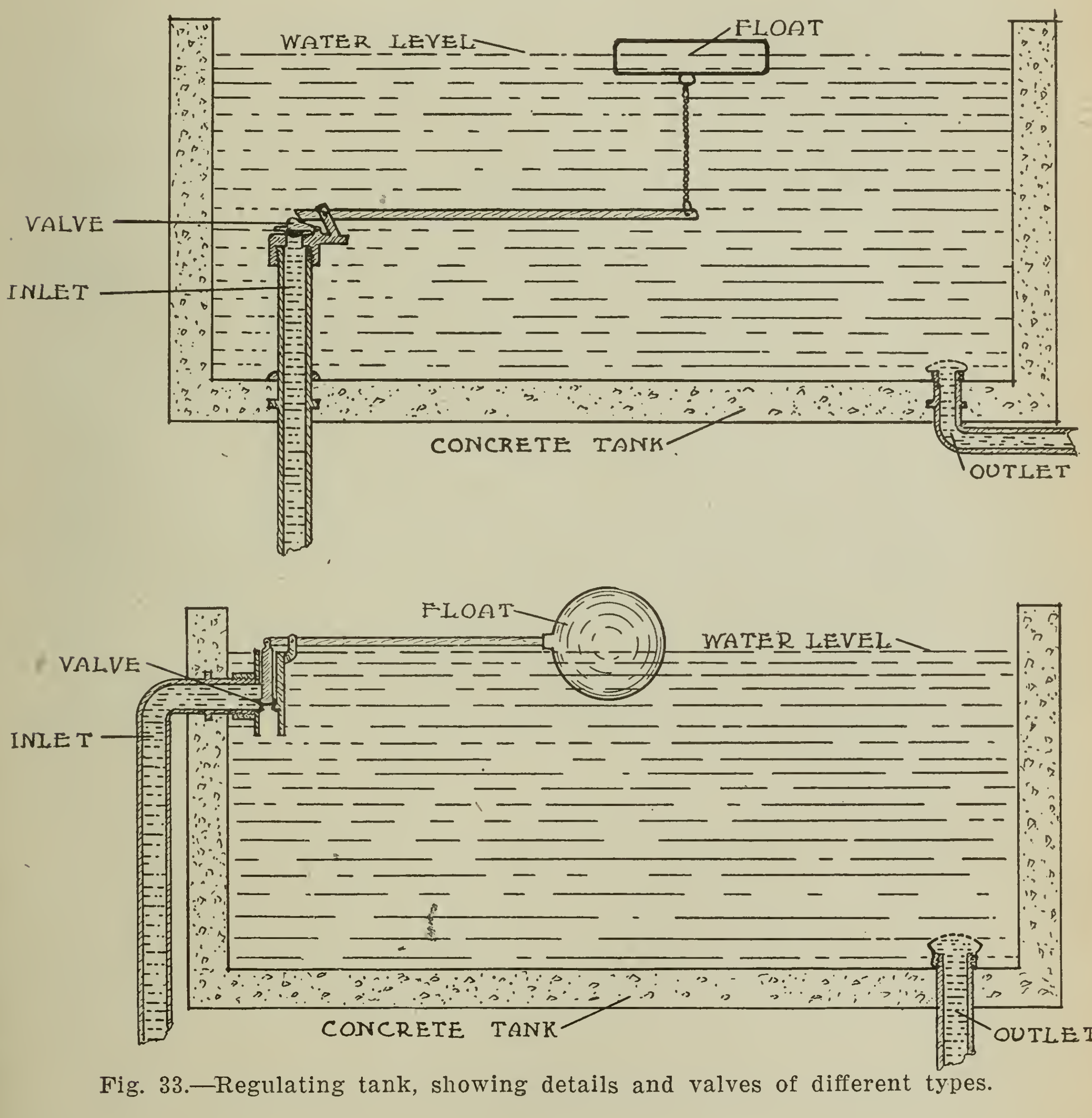


Fig. 33.—Regulating tank, showing details and valves of different types.

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 unicellular. In shape some are spherical, some are straight rods, and some are spiral. See Fig. 34, Nos. 1, 2, 3 and 4. Under favorable 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. 34, 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

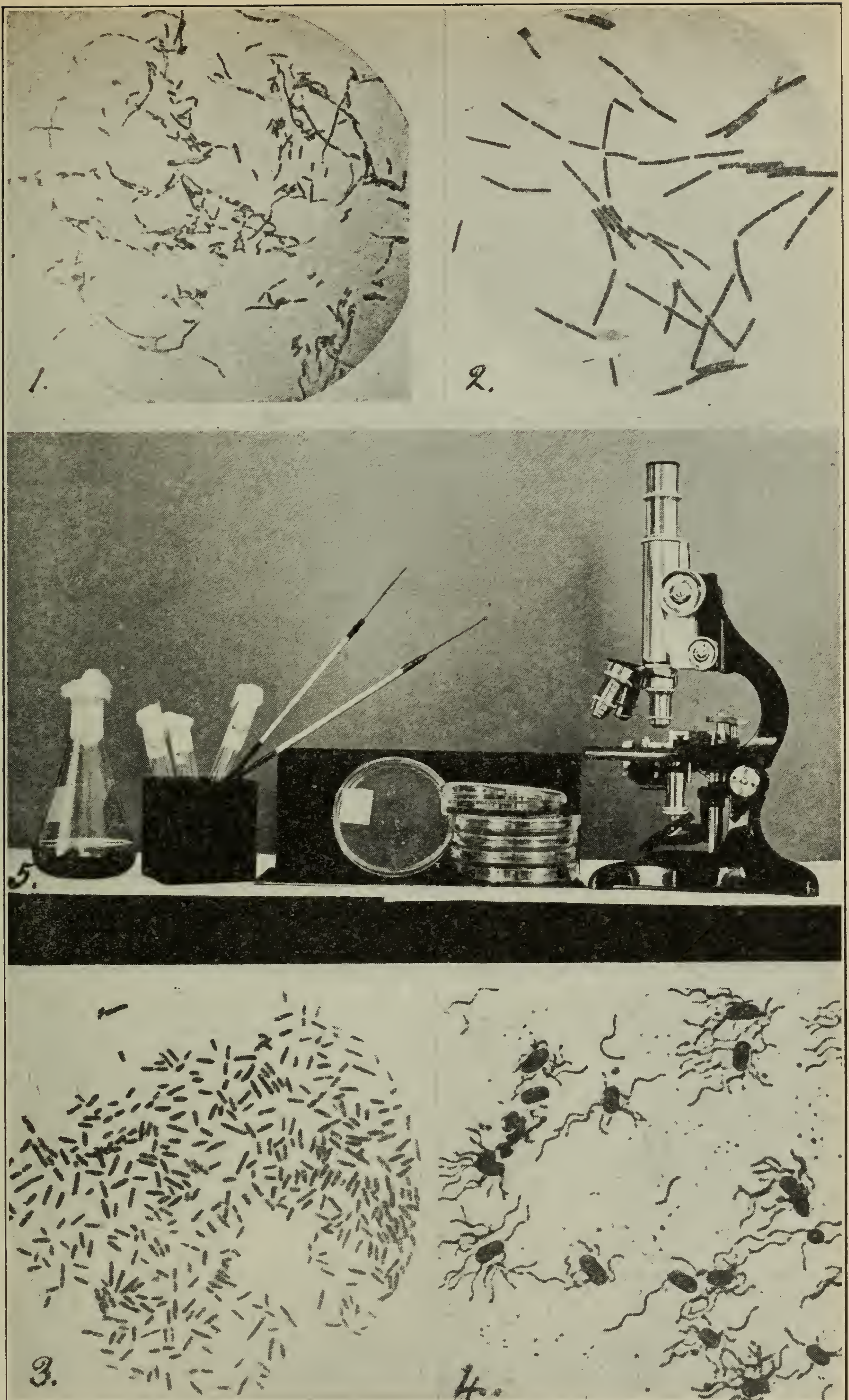


Fig. 34.

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.)

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. 34, 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. 34, 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 luke-warm 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 3 per cent. of chloride of lime or 1 per cent. of available chlorine.

Application. Mix one ounce of this stock solution to 5 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 3, and they should be followed in every detail. Also full information about the well should accompany the sample. For this purpose fill out the form in Appendix 5.

Chemistry of the Farm Water Supply

H. L. Fulmer.

Water, as we see and use it every day of our lives, is a very simple looking substance and most people through daily association with it undoubtedly come to look upon it, or consider it to be, as simple and as harmless as it appears.

In reality, however, water that we find in our wells, springs, streams, rivers, lakes and oceans is a rather complex liquid being often composed of many things mixed together. Some of the things present frequently are of a nature, or have in possession some property which they impart to the water as a whole, that makes the latter absolutely unfit for many of the domestic or household uses to which it is put. In many instances, in fact, serious accident, impaired health and strength and even death, have been directly caused by, or traceable to, the use of water of an undesirable or non-potable quality.

Some of the impurities nevertheless which are to be found in natural waters do not by any means render it non-potable; in fact, some are often desirable in that they make the water more palatable for drinking, or, as is the case with our so-called mineral waters, impart to it some decided medicinal value. Others again simply give it some objectionable taste or odor or property but do not render it unfit for the majority of farm uses, or make it unhealthful.

How Water Becomes Impure.

Pure natural water is an unknown thing except that which falls as rain toward the end of a very heavy shower. It is even doubtful if this latter is always absolutely chemically pure. The moment water comes into contact with the atmosphere near the surface of the earth, but more particularly with the soil and rocks, it begins to absorb the various impurities which it is afterwards found to contain. Because of its great and universal absorbent and solvent power it dissolves a certain proportion of some or all of the constituents of the soil and rocks and these dissolved portions are carried along in solution in the water wherever it goes unless, by some means or other, it is made to part with them. These dissolved substances frequently make water which we get in our wells or elsewhere, unfit for domestic use.

But even more dangerous and more objectionable are those impurities which find their way into our water supplies after they are located, such as dead and decomposed animals and plants, seepage from barnyards and out-houses, refuse from factories, sewage from towns and cities, and many things from other sources. All these latter can, and should be prevented from gaining entrance, in most cases, by proper safeguards. If not prevented, when possible, their presence can only be regarded as a straight case of adulteration.

Objectionable Impurities.

Objectionable impurities, or those constituents whose presence is undesirable for various reasons 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 these bodies the power, when taken into the alimentary tract of animals and men, to produce grave digestive and other disorders; but what is probably more important, their presence in water is a sure 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 discolors it and gives it a forbidding appearance; or imparts to it a bad odor 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 color or odor or taste of the water—sometimes the clearest and brightest water, one that is palatable and sparkling, 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 simple 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 pure 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 odor 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 color; 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.

3. Pour a little solution of silver nitrate 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 that is not cleared upon the addition of a little nitric acid, 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 cause. Most organically impure waters are so because of some preventable factor, and if this be located and removed 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 a water is not too badly infected with organic matter it can often be purified in small quantities, sufficiently to make it potable. 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 odors 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 colored this treatment will not clear it up, if the color 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 every day with fresh sand, gravel and charcoal, or with some of these that have been previously used and then afterwards thoroughly aerated and cleansed by spreading out in the sun or by baking in an oven.

Another method of purification is by the use of disinfectants. The most satisfactory disinfectant to use 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 50 of this bulletin and need not be repeated here. This treatment gives the water an odor of chlorine at first, but this finally passes off on standing or can be removed quickly by boiling for a few minutes. It also destroys the coloring 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.

The best plan, in cases of organic impurity, however, 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.

Inorganic Impurities.

(*b*) Inorganic impurities, or those derived from the mineral constituents of the soil and rocks, are seldom dangerous unless present in large quantity. Sometimes poisonous mnerals 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 consumption by man or beast.

The chief objections to inorganic impurities are that the water is made "hard" by them and often quite unfit for cleansing, cooking some kinds of vegetables, laundry work, or boiler use; also useless 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 a teakettle or boiler, or the flues of a steam engine. Also if the water is very hard, it is found that some kinds of vegetables, 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, can often 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 when boiled for a short time, or which produces a sediment in the bottom, or on the sides, of a vessel after boiling for a short period.

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 method for removing permanent hardness. The only way to remove 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 a rather complex chemical analysis. However, boiling for a short time, after the addition of a small spoonful of either of these to two gallons of the water, will probably be about the average amount to use to remove 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 this case, the hardness is about equally divided between the two classes, sometimes one predominating, sometimes the other. In this case a combination of the boiling and chemical treatment will completely soften the water.

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 that can employ a chemist to oversee the work or to constantly advise them. The farmer needing much soft water should aim at providing means for catching rain water and storing it in sufficient amount to supply his need.

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 and shipping samples of water to this laboratory will be found in Appendix 4. Also information sheet re well, Appendix 5, to be filled out and sent with the sample.

Farm Sewage Disposal

W. H. Day and R. R. Graham.

Sewage disposal systems for the farm may be divided into two general classes; one adapted to homes equipped with water systems and plumbing fixtures, the other to homes without these modern conveniences. In the former we have two types, the septic tank system and the cesspool; in the latter, the ordinary outside closet and the chemical closet.

THE SEPTIC TANK SYSTEM.

The elements of the septic tank system may be seen from Fig. 35. They are as follows:

1. The collecting system, composed of the water-closet, bath and wash basins, and soil pipes.
2. The tank, from which the system derives its name, and having two compartments, the first called the receiving or settling chamber and the second the discharge or flushing chamber.
3. The absorption bed, being a system of tile connected with a main drain from the tank, and into which the sewage from the discharge chamber is carried by the main tile.

The details of the tank may be seen from Fig. 36 (*a*) and (*b*).

This is nature's own way of disposing of sewage, and if the proper conditions are provided, the results are very complete and satisfactory. The process is as follows: From the collecting system the sewage is flushed into the dark water-tight settling chamber where it is partly decomposed by a certain class of bacteria. This chamber remains full at all times, and overflows into the discharge chamber whenever fresh sewage is received. The sewage which passes over is not fully decomposed and it carries with it some solids in fine particles held in suspension by the liquid. Further decomposition occurs in the discharge chamber, which is fitted with a valve or siphon so adjusted that when the liquid reaches a certain height the contents of the chamber are discharged automatically into the system of tile called the absorption bed. This may occur perhaps once or twice a day, or maybe not oftener than once in two or three days, according to circumstances. The liquid then seeps through the joints of the tile into the soil where the decomposition of the sewage is rendered complete by other classes of bacteria. For the full treatment of the bacteriological conditions the reader is referred to page 70. Too much agitation of the contents of the settling chamber would interfere with the action of the bacteria, so the inlet pipe is turned down into the liquid about a foot in order that the sewage may enter as quietly as possible. The overflow pipe in the partition wall also turns down into the contents of the receiving chamber so that solid particles cannot pass over before being acted upon by the bacteria. It should be emphasized that the intermittent discharge, contrary to the opinion of those who have not given the matter careful study, plays a very important part in the operation. The interval between the flushings allows time for the air to enter the soil, thereby enabling the bacteria to complete the work of purification and the pure water has time to soak away thus preventing the soil from becoming water-logged with unpurified sewage, as often happens with con-

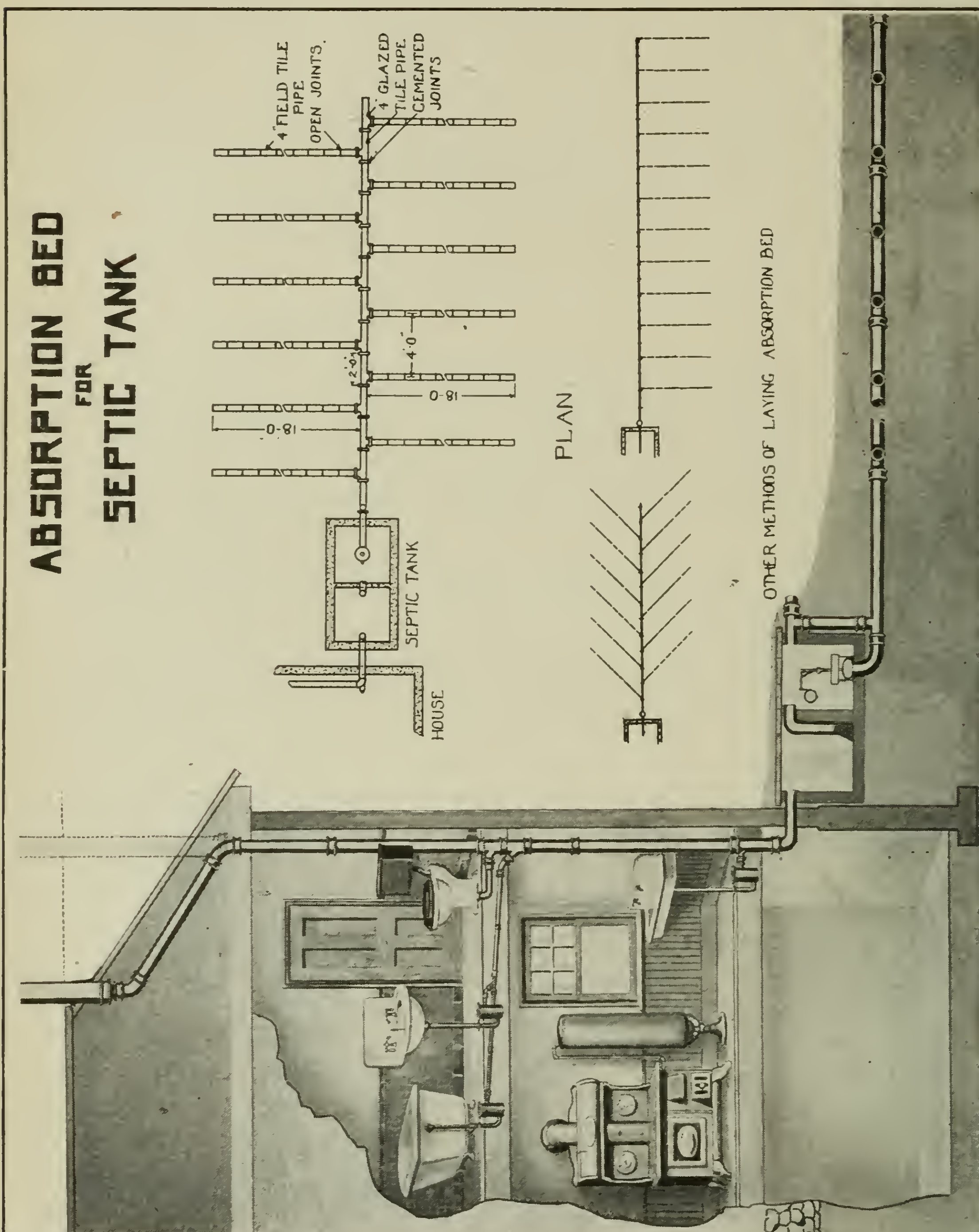


Fig. 35.—Septic tank system of sewage disposal showing
(*a*) Collecting system.
(*b*) The tank with Quinn valve.
(*c*) The absorption bed.

tinuous discharge. The siphon illustrated in the drawings and photographs is a very reliable and durable type, and is therefore highly recommended for septic tanks. There are also on the market reliable valves that work by a float, and trip automatically at the proper depth of liquid.

Action of the Siphon.

The reader will perhaps be interested in an explanation of the action of the siphon. Look at Fig. 36 (*a*). Note that there is air in the "bell" of the siphon and also in the long arm of the U. As the water slowly rises in the tank more of the air in the bell is forced down into the long arm, driving the water in the U before it. By and by the air reaches the bend in the U, and when the water rises a little higher in the tank a bubble of the air will be forced around the

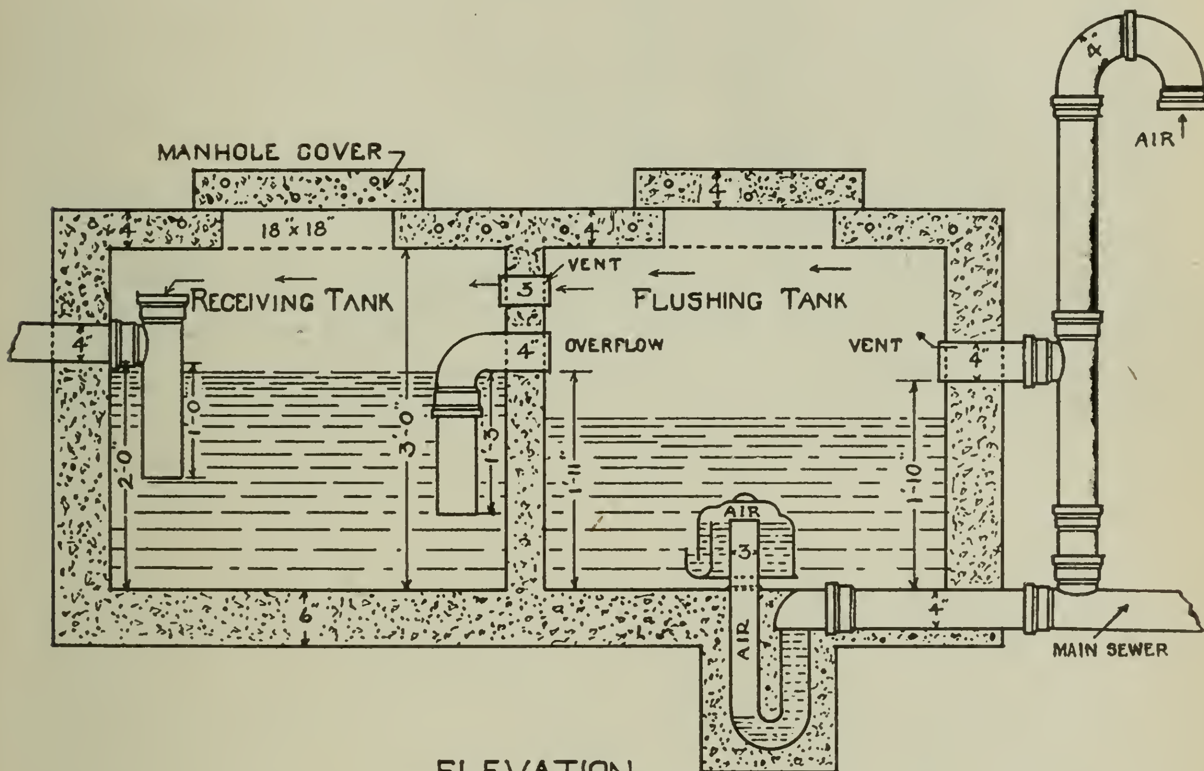


Fig. 36.—(*a*) Section of septic tank with Miller siphon valve, showing details of construction.

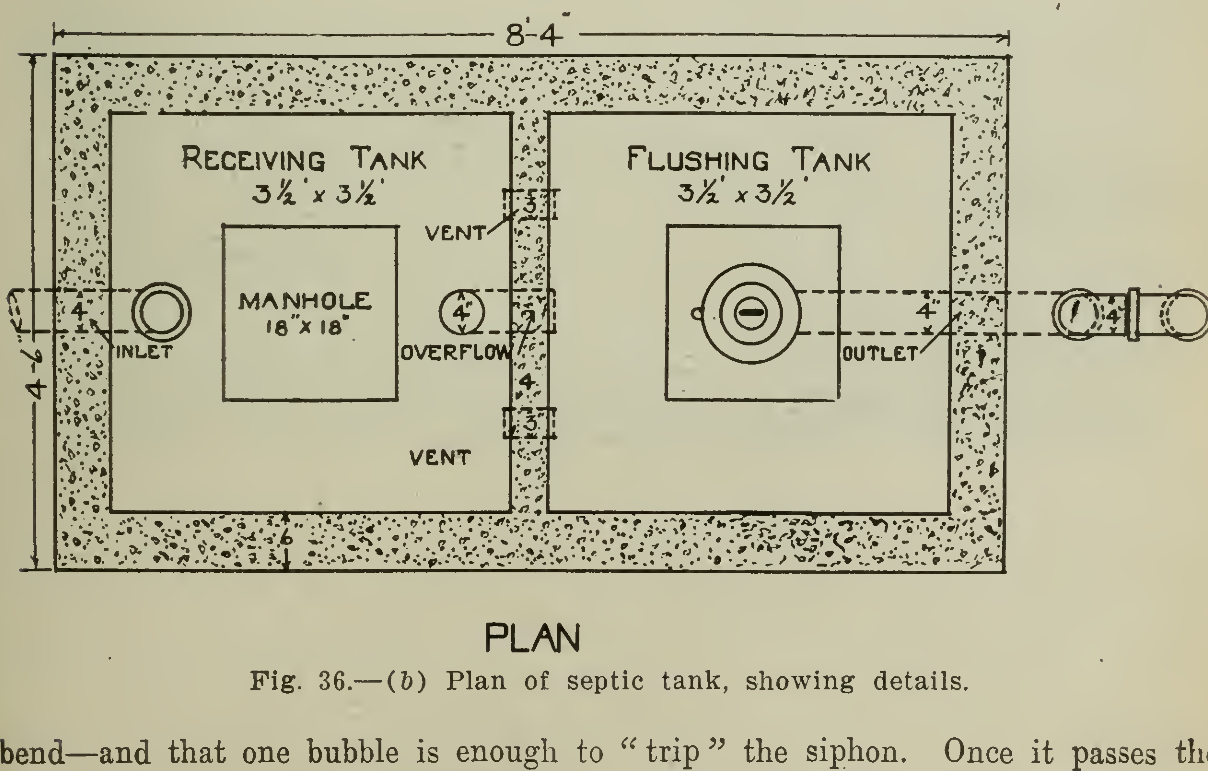


Fig. 36.—(*b*) Plan of septic tank, showing details.

bend—and that one bubble is enough to "trip" the siphon. Once it passes the bend it begins to rise in the short arm. As it does so it begins to expand because the pressure is less, and as it expands it forces some of the water in the short

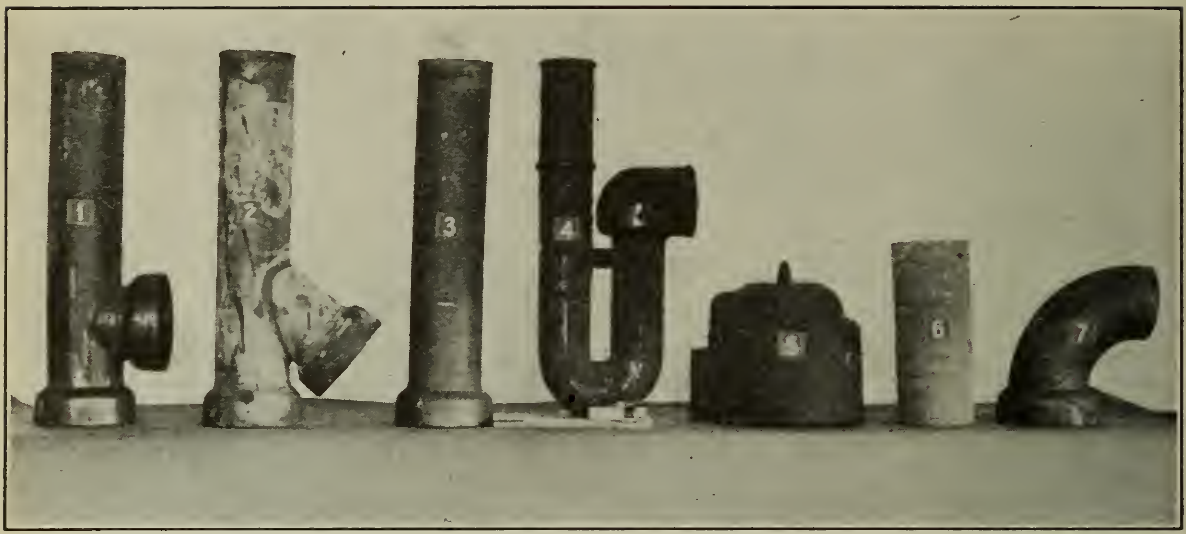


Fig. 37.—(*a*) Types of sewer tile fittings for septic tank installation, and parts of the Miller siphon.

Key to parts:

1. 4-inch T sewer pipe.
2. 4-inch Y sewer pipe.
3. 4-inch plain sewer pipe.
   (Each of these is 2 feet long.)
4. U-shaped or lower portion of siphon.
5. Bell or upper portion of siphon.
6. 4-inch land tile (1 foot long).
7. 4-inch quarter bend sewer pipe.

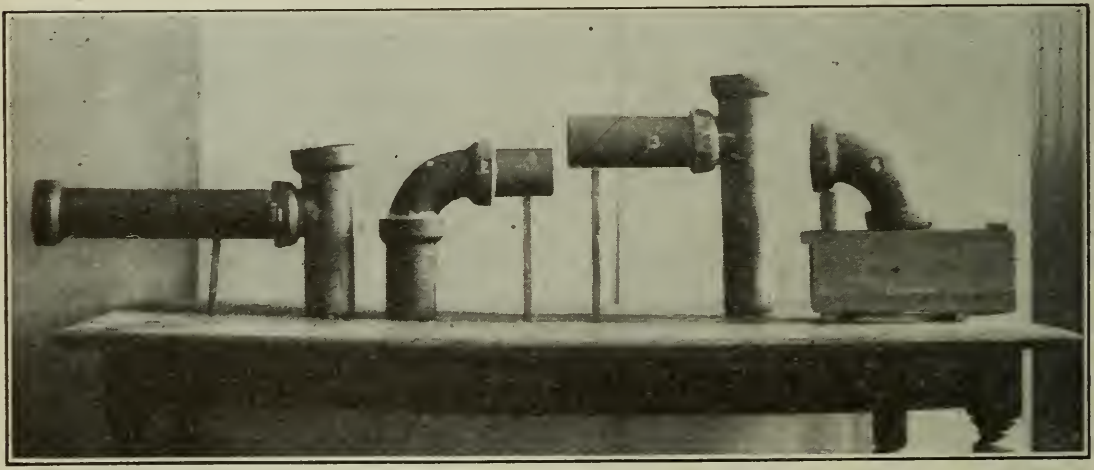


Fig. 37.—(*b*) Prepared sewer tile fittings for septic tank.

Key to parts:

1. Inlet and vent pipe for receiving chamber.
2. Overflow pipe for receiving chamber.
3. Vent pipe for discharging chamber.
4. Bend made of two quarter bends for installing on top of the vent pipe that projects above the ground.

Note.—See Fig. 38 for installation of these fittings.

arm out into the main drain. The air being lighter than the water it displaces both because of its nature and its expansion, this immediately reduces the pressure in that arm, thereby disturbing the balance and allowing larger bubbles of air to escape rapidly round the bend and force more water out of the short arm. Almost instantly the water in the dome reaches the top of the long arm and begins to flow rapidly down it and up the short arm and out into the tile. This continues until the water in the tank reaches the bottom of the bell. And when the tank is empty both arms of the U remain full of water up to the level of the main tile. The purpose of the air passage around the left side of the bell is to admit sufficient air to drive the water out of the U at the next discharge. Before this air passage was provided it was found that after a time the siphon would reach a state where instead of tripping it would just allow water to dribble through as fast as it entered the second tank, thereby producing a constant slow discharge into the tile instead of an intermittent one. The introduction of the air passage overcame the difficulty—it completely "breaks" the siphon every time. Understanding the action of the siphon the reader will appreciate the direction given later that the U of the siphon must be filled with water before the bell is put on. This is called "priming the siphon."

Capacity and Construction of the Tank.

In computing the size of tank, allow about 3 cubic feet in each compartment for each person in the family. Any variation in size should be made by altering the length or width. The depth should always be in the neighborhood of three feet, although in some cases the receiving chamber is made about 18 inches deeper than the discharge chamber. This device is especially valuable where space is limited, as by it the capacity of the receiving chamber can be made as great as desirable. The best material for the tank is concrete of rich strength, and the pipes or fittings may be either iron or vitrified sewer pipe. The accompanying drawing, Fig. 36, and photograph Fig. 37 (*a*) and (*b*) give all the required measurements and details of construction.

Some points, however, should be emphasized, namely: First, that the tile used in making the fittings shown in Fig. 37 (*b*) should be cemented together a few days before the tank is built, so that they will be ready for setting up with the forms; second, only single forms are required; third, that the fittings and siphon should be placed in the forms according to the measurements given in Fig. 36 and these measurements should be carefully verified before the concrete work is begun; fourth, the forms should be made tight, true to shape, and braced securely in position; fifth, the concrete should be made in the proportions of 1 part cement to 6 parts of clean, sharp gravel, thoroughly mixed while dry and again after wetting. Use mixture medium wet and tamp it slightly in the forms; sixth, build the floor and walls at the same time in order to get a good bond between them; seventh, plaster inside of tanks with neat cement mortar in order to make them watertight, smooth and well-finished before the top is built on; eighth, reinforce the top and the manhole covers with old pieces of iron or heavy wire; ninth, keep the concrete work moist and protected from the sun for a few days so that it will cure well before being put into use; tenth, be sure to prime the siphon.

Installing the Absorption Bed.

The details of the absorption bed are shown in Fig. 35, upper right hand corner. The purpose of Fig. 38 is to emphasize the fact that the absorption bed must be on a lower level than the tank, so that it will be possible to keep the lines of tile near the top of the ground, while the tank is below the ground entirely or nearly so. If a sufficient slope from the house does not exist, the tank may be kept partly or wholly above ground level, and banked and covered with earth, and if necessary specially protected in the winter by strawy manure. When the absorption bed has to be installed on a steep slope or on terraced ground it is necessary to adopt some such system as is shown in Fig. 39 in order to secure a uniform distribution of the liquid in the tile. Fig. 35 shows the various layouts of the absorption bed, and most of the important details, but some others should be mentioned, chiefly, first, that if the soil be very heavy or wet it should first be underdrained; second, 4-inch tile is preferable to 3-inch for the laterals, and about 35 4-inch or 50 3-inch tile should be used per person of the home; third, that all the tile

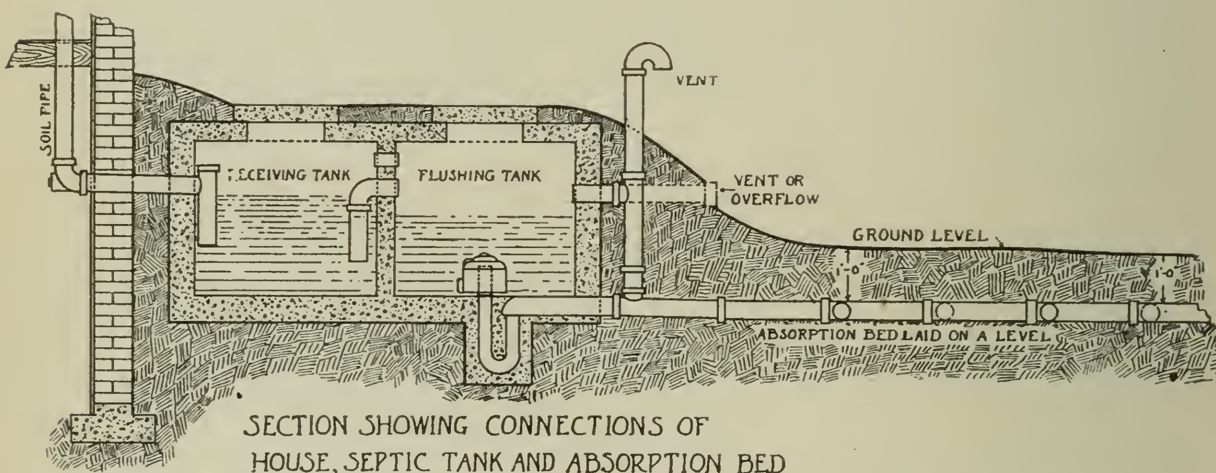


Fig. 38.—The absorption bed in relation to the tank.

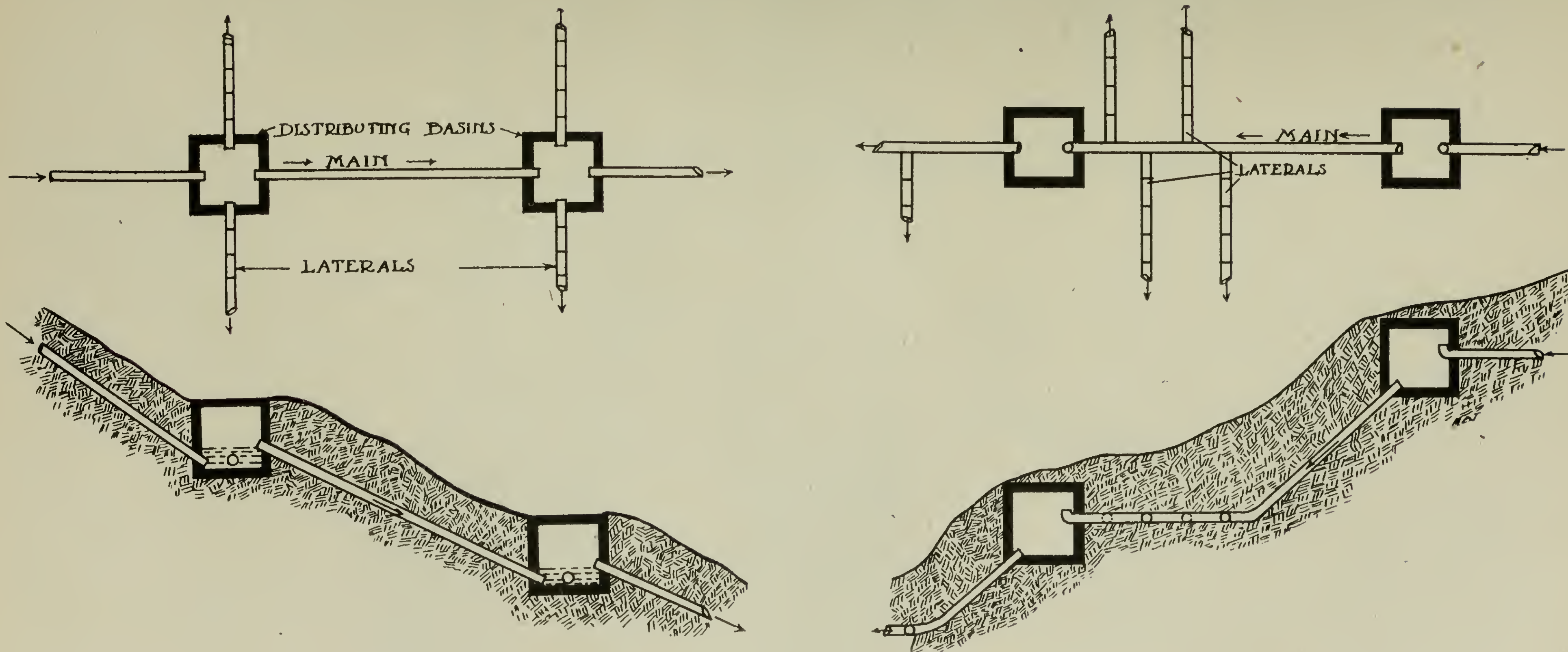
should be laid as level as possible, main included from point where laterals begin to branch off, and they should not be laid deeper than 12 or 15 inches; fourth, the laterals may be placed 4 to 6 feet apart depending on whether the soil is heavy or light: fifth, if possible the tile should be kept away from trees, shrubs or bushes, as the roots may in time choke them; sixth, the lines of tile should not exceed 30 feet in length; seventh, the absorption bed may be located close to the tank or any distance away, depending on circumstances.

Bill of Material and Costs.

The following estimate will serve to give the reader a general idea of the amount of material, the labor and the cost of the septic tank installation described and illustrated herein:

4	bbls. Portland cement at $2.25 per bbl.	=	$9.40
4	loads of gravel at $1.50 per load	=	6.00
8	plain 4-inch vitrified sewer pipe at 30c. each	=	2.40
15	"T" 4-inch vitrified sewer pipe at 65c. each	=	9.75
3	4-inch vitrified quarter bends at 65c. each	=	1.95
216	4-inch field tile at 5c. each	=	10.80
1	3-inch siphon	=	12.00
			$52.30

It would require the labor of two men for probably four days to complete the work, and as all the work can be done by the farmer and his assistant no estimate will be submitted to cover the labor.



A B

Fig. 39.—Plan and section of the absorption bed installed on terraced land.

(*a*) Where there is room for only one line of tile on each level.
(*b*) Where two or more lines may be laid on a level.

In regard to the bill of material, the estimate of the gravel and the field tile may be too high for many cases as the gravel may be available on the farm or in the immediate vicinity of the builder at a cheaper rate than quoted above, and the tile may have been bought in large quantities for drainage purposes. Also the item of 15 "T" 4-inch vitrified pipe might be reduced to 9 in number by making the laterals twice as long as shown in Fig. 38 which would reduce the cost by about $4. When these probable reductions are taken into consideration the actual cash outlay would not much exceed $40.

Care of Tank.

The septic tank should be carefully inspected twice a year to make sure that everything is working properly, once just before winter sets in, and again in the spring. And once in two or three years the accumulation of sludge at the bottom of the receiving tank should be removed. The covers should always be replaced tightly, and covered up with soil or turf.

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 is a hole in the ground 8 to 10 feet deep and 4 to 6 feet in diameter, lined up with field stone and safely covered with timbers, plank and earth. Into this pit the sewage is discharged through the inlet pipe and partly decomposes, and in the liquid form slowly seeps 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 3 or 4-inch pipe between them and turning down a foot or so into the contents of the pit. This is the second form of the cesspool.

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 to 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 wells 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 nearby 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.

WASH WATER AND KITCHEN SLOPS.

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 injurious 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. 40. The upper type is best adapted to heavy soils, and it will be necessary in this case to install a small absorption bed of 30 or 40, 3-inch or 4-inch drain tile on the

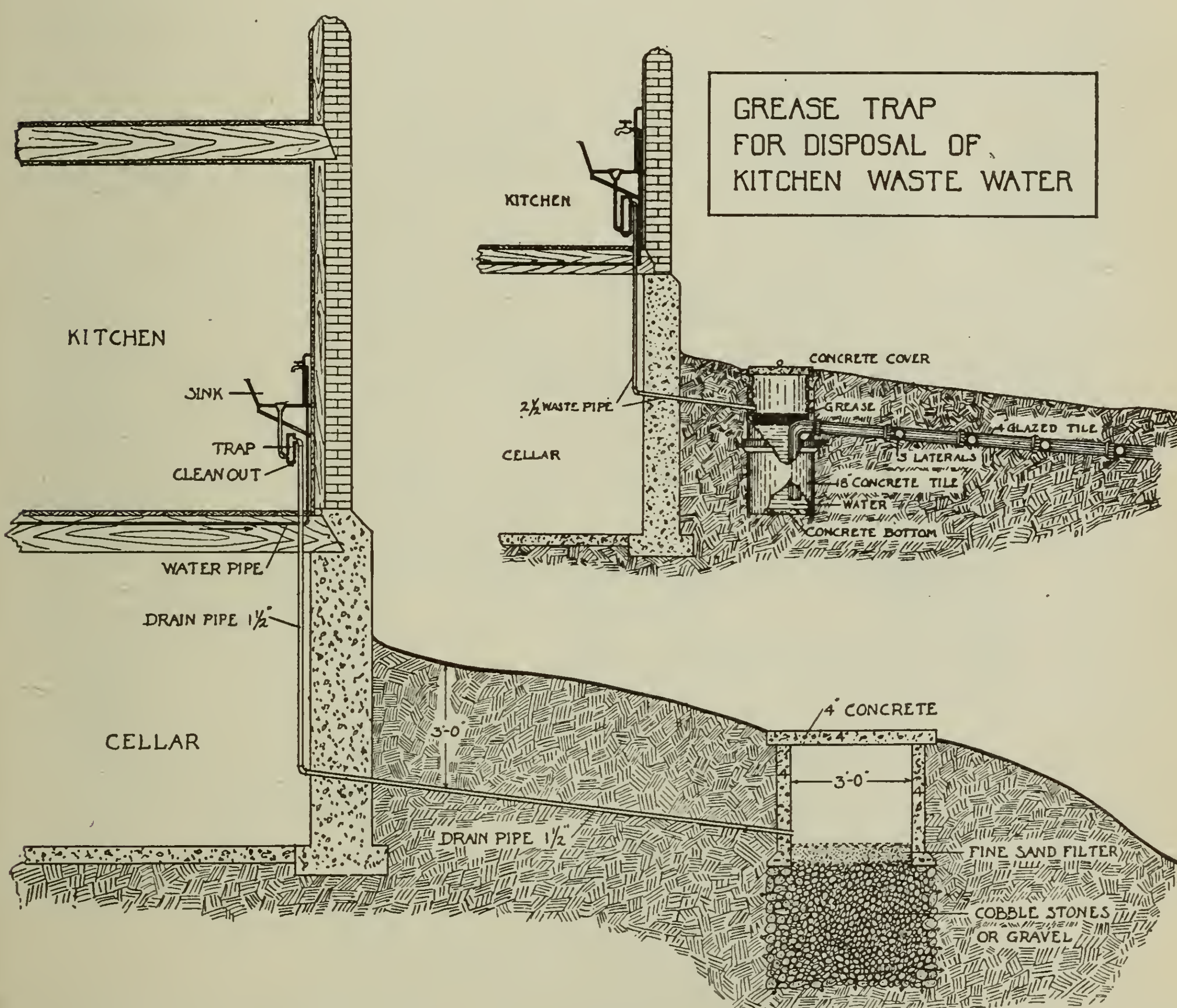


Fig. 40.—Two types of grease trap for disposal of kitchen waste water.

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 15 or 20 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.

CHEMICAL CLOSETS.

The chemical closet in its simplest form has a small wooden or metal chamber enclosing a pail-like receptacle, the top of the chamber constituting the seat. The firms that manufacture the closets supply their own chemicals. The chemical substance added to a little water is put into the receptacle as it is required, and this solution changes the raw sewage into a harmless and inoffensive product called sludge. The receptacle is removed and the product emptied out upon the ash-heap whenever it becomes full or the chemical is exhausted. See type B. Fig. 41. Another type that has recently come upon the market is illustrated in A. Fig. 41. Its principle is similar to the other, but it is more elaborate, and may be extended to capacities large enough to serve

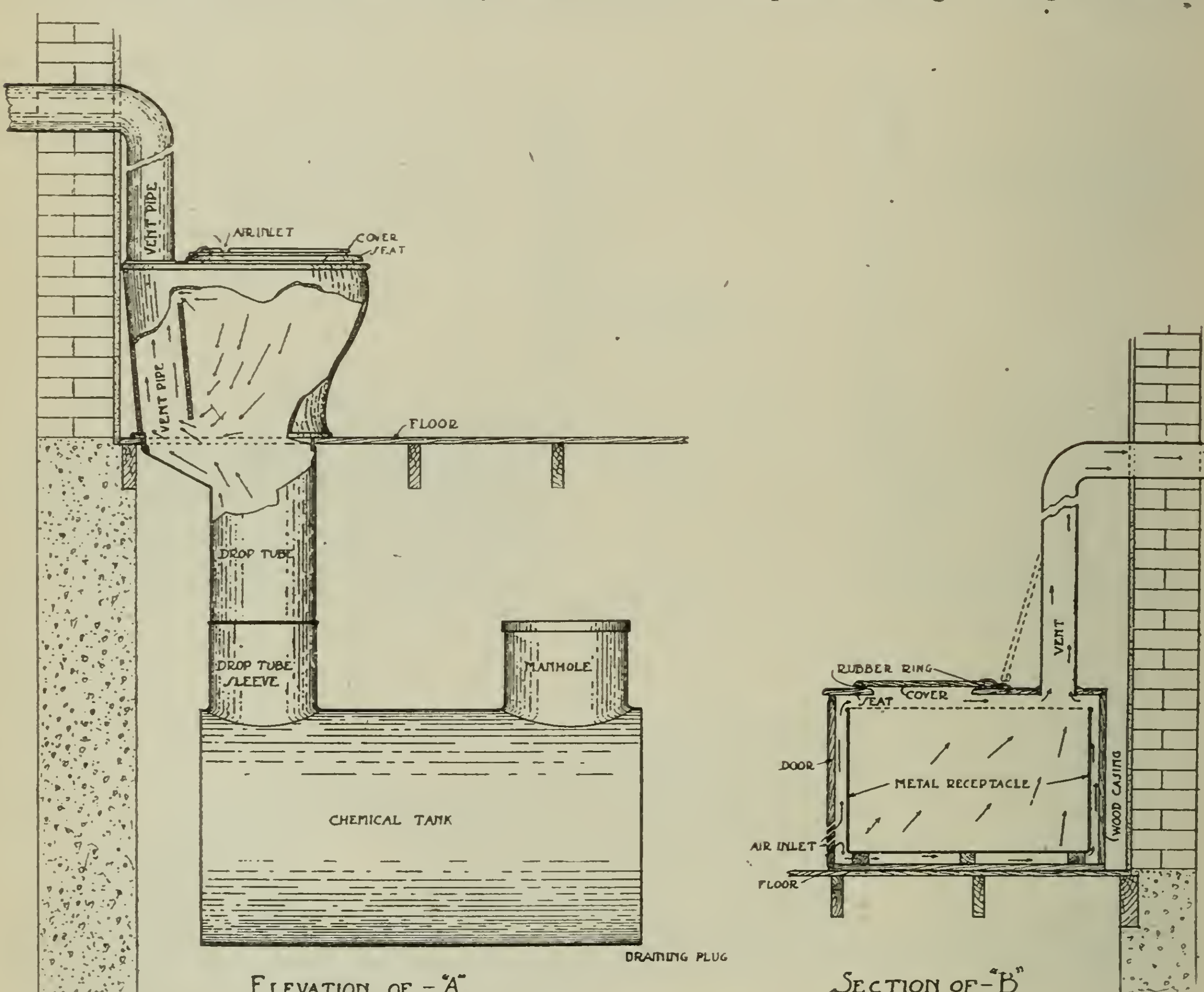


Fig. 41.—Two types of chemical closets.

large institutions, hospitals, summer resorts, etc. The smallest size made has a tank of 125 gallons capacity. A new feature about it is an agitator in the tank for stirring up and mixing the sewage and chemical solution, thereby promoting more rapid destruction of the sewage.

The chemical closet has many advantages over the outside privy. It is located inside and for this reason is greatly appreciated in the winter time, it is more sanitary, it is not infested with flies that may carry disease germs about to endanger health, and it is cheap to install and easy and cheap to operate. Since Boards of Health recognize their value and recommend them—as do those who have used them in their homes—they surely deserve favorable consideration in this treatment of methods of sewage disposal for rural homes. Ask your plumber or hardware dealer about them.

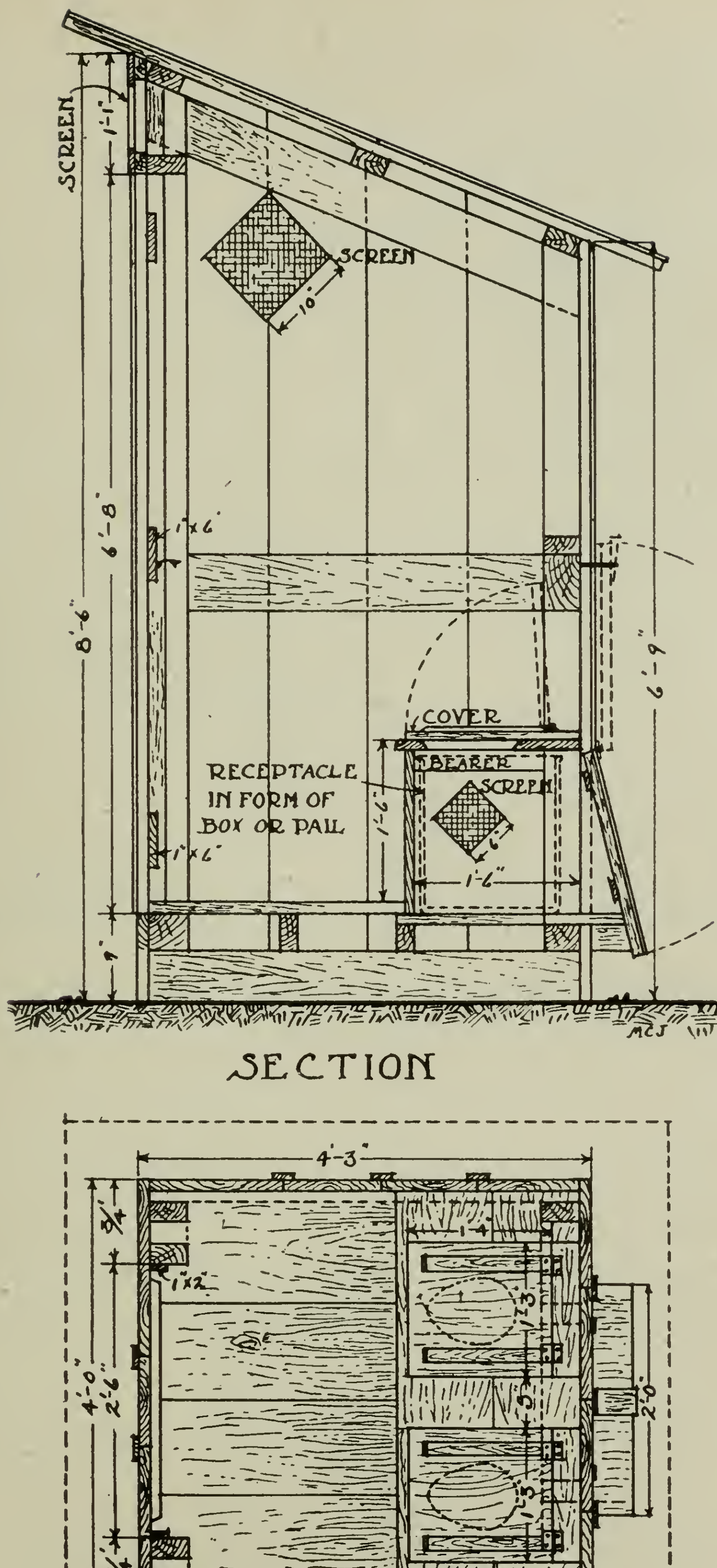


Fig. 42.—Section and plan of outside privy.

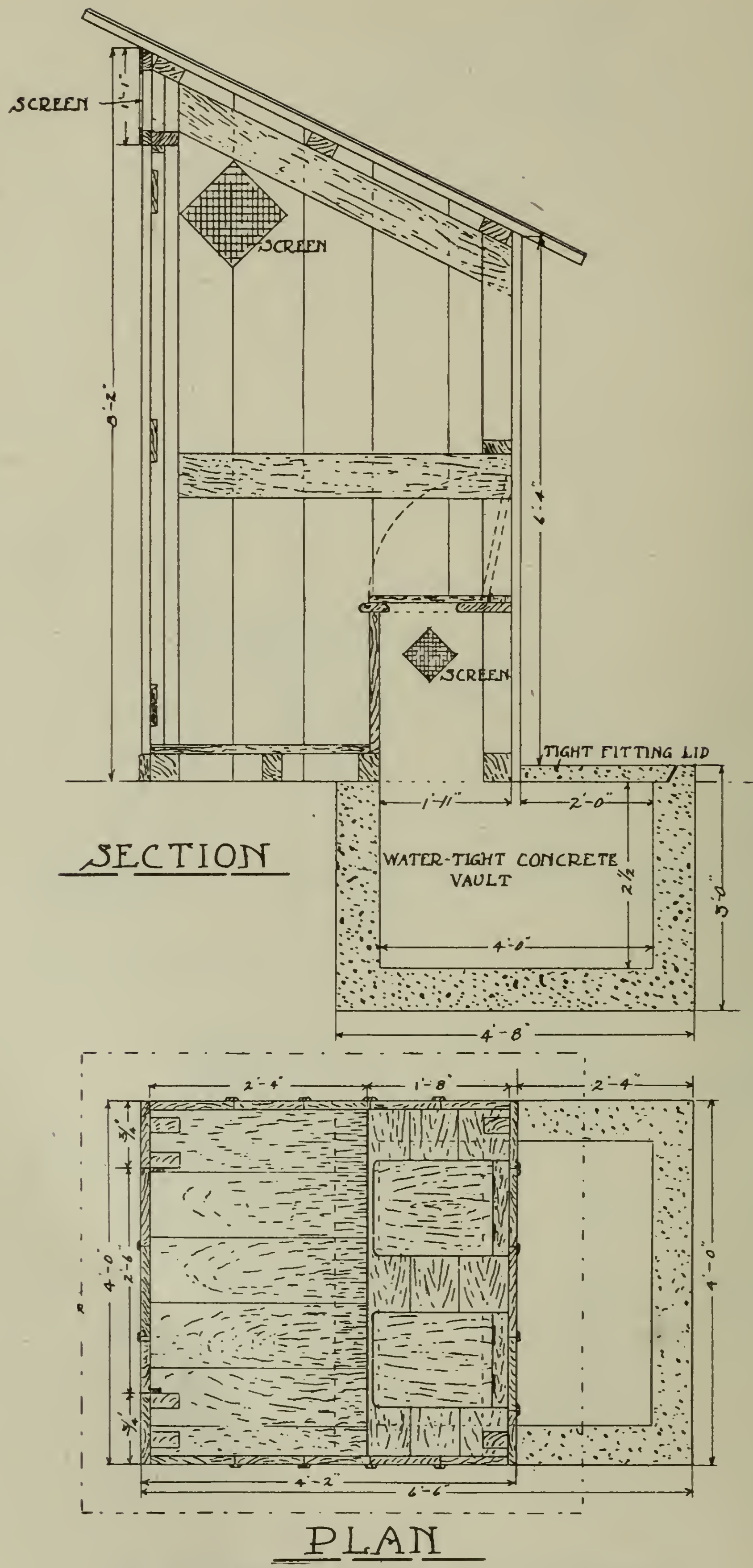


Fig. 43.—Section and plan of outside privy.

OUTSIDE PRIVIES.

The two most satisfactory types of outside privies are illustrated in Fig. 42 (*a*) and (*b*). The chief difference between them is in the kind of receptacle used; in the former it is a pail or box, while in the latter an underground watertight vault. The designs are recommended by the Provincial Board of Health, Toronto, and a full treatment of the subject is given in their circular No. 39, entitled "Sewage Disposal," 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 should be used liberally on the contents of the receptacle or vault while it is in use. If the privy is built and attended to as herein specified it may be located quite close to the house, preferably inside or 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.

SEWAGE DISPOSAL IN RELATION TO 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.

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 page 48 and Fig. 34, 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 favorable 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 facultative 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-irrigation 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 compounds 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 odors 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 gases, 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 odors and its full 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 sub-soil. When this becomes water-logged the sewage rises more or less to the surface, thus becoming a nuisance, giving foul odors 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 water-logged, 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.

Appendices

APPENDIX I.

INFORMATION BLANK RE HYDRAULIC RAM

Persons wishing advice re hydraulic ram installations should fill out every blank and forward this sheet with their letter to the Department of Physics, O.A.C., Guelph; or, if writing for quotations, all these points must be given before the firms can quote on proper outfit.

Name ....

Address ....

Date ....

1. How many gallons per minute flowing from the spring or stream can be supplied to the ram? ....

   NOTE.—Do not say supply fills a certain size pipe, as the flow through a pipe varies with the fall. See page 31 for method of measuring flow of spring.

2. How many gallons per 24 hours do you need at the tank? ....
   See page 34.

3. What is the vertical fall in feet from the spring water level to the point where the ram will be located? ....

4. What is the distance between the source and the point where the ram will be located? ....

5. What is the vertical height, in feet, the water must be lifted from the ram to the tank? ....

6. What is the length of pipe necessary between the ram and tank? ....

7. Is there good drainage for the waste water? ....

8. Do you expect to use an elevated or a pneumatic steel tank? ....

9. Make a sketch of the proposed lay-out on the back of this sheet.

APPENDIX II.

INFORMATION BLANK RE WATER SYSTEM

Persons wishing information in regard to the installing of water supply systems would do well to fill out this form and enclose with their letter to the Department of Physics, O.A.C., Guelph; or if writing a firm for quotations on a system this information if sent direct would enable them to decide what equipment, both as to kind and capacity, would be most suitable.

Name ....

Address ....

Date ....

1. What is the source of your water supply? ....

2. (a) If well, state: Type .... Depth ....Lowest level of water ....

   Whether well ever goes dry ....

   (b) If spring or stream, state gallons per minute ....

3. Which is higher, source or buildings? ....

   How many feet fall between them? ....

4. Distance between source and buildings ....

5. For what service is the water required—house, barns, lawns, gardens, etc.?....

   If for stock, what kind and how many? Horses...... Cows...... Pigs......

   Sheep ....

6. How many persons will use the service? ....

7. Do you require both hard and soft water services? ....

8. What is your estimate of the gallons of water required per day? ....

9. Is the pumping to be done by hand, windmill, gasoline engine, electric motor,

   or hydraulic ram? ....

   If electric motor, give the following information:

   (a) Direct Current? ...... If so, what voltage? ....

   (b) Alternating Current? ...... Cycles ...... Phase ...... Voltage ......

   NOTE.—If in doubt about these, ask the company that supplies your electric current.

10. What system do you propose to use?

11. Describe your present pumping machinery, if any, and we will advise you whether it can be used in connection with your proposed system or not.

12. Make on the back of this sheet a sketch showing relative positions of source of water supply and pumping machinery, tank, etc., marking in the distances vertical and horizontal.

APPENDIX III.

DIRECTIONS FOR TAKING A SAMPLE OF WELL WATER FOR BACTERIAL ANALYSIS

1. It is essential that the bottle to contain the sample and also the cork stopper 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 IV.

DIRECTIONS FOR TAKING A SAMPLE OF WATER FOR CHEMICAL ANALYSIS

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 scalded 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 analyzed. 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 Chemical Department, Ontario Agricultural College, and prepay express charges on the same.

APPENDIX V.

INFORMATION BLANK RE WELLS

Persons enquiring about wells, either from the standpoint of construction, improvement, bacteriological analysis or chemical analysis, should fill out this form in full and enclose with their letter to the proper Department.

Name ....

Address ....

Date (when sample is sent) ....

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 last five years ....

REMARKS ....

....

....

INDEX

PAGE
Air, Weight of 13
Air-bound Pipes, Cause and Remedy 26
Air-compressor 20
Air Dome of Force Pump 18
Air Dome of Hydraulic Ram 28
Altitude in Relation to Pumps 15
Artesian Wells 4, 12
Atmosphere, Height of 13
Atmospheric Pressure, How to Measure 15
Attic Tank System 34
Auger, Use of 9
Bacteria and the Water Supply 48
Bacteria, Nature of 48
Bacterial Action in the Dry Closet 71
In Cess-pools 72
Bacterial Action in the Septic Tank System of Sewage Disposal 70
Bacterial Test of Water Offered 51
Bacteria, Natural Water 48
Barometer, Principle of 14
Capacity of a Pump 21
Cess-pool 64
Chemical Analysis of Water Offered 56
Chemical Closets 66
Chemistry of the Farm Water Supply 52
Check Valve in Well 9
Cistern 26
Cistern Pumps 16
Compression Water Supply System 35
Concrete as Backing 8
Contamination of Water Supply 8, 52
"Deep Well" Pumps 15
Directions for Taking Samples of Well Water 77
Directions for Bacterial and Chemical Analyses 77
Double-acting Force Pumps 20
Double-acting Hydraulic Ram 33
Drilled Wells 12
Driven Wells 10
Dry Wells 10
Dug Well 4
Elevated Water Tank in Yard 35
Engines, Cost of, for Pumping 24
Foot Valve and Strainer 13, 20
Force Pumps 11, 12
Force Pumps, Double-acting 20
Forked Twig 6
Fresh-water System 42
Friction in Pipes 20
Gasoline Engines for Pumping 21
Gravity Water System 26
Grease Traps 65
Ground Water Level 4
Hardness of Water 55
Hydraulic Ram 28
Air Dome of 28
Calculating Its Capacity 30
Cost of Installing 33
Description 28
Double-acting 33
Efficiency of 30
How to Install 31

Hydraulic Ram—*Continued* PAGE
Information Blank *re* 73
Principle of 28
Relation of Head to Lift 31
Where Practicable 33
Impurities of Water, Objectionable 53
Organic 53
Inorganic 54
Impurity of Water, How Produced 52
India, Water-finder in 7
Intestinal Bacteria Found in Water 50
Kitchen Slops 65
"Lift" Pump, Principle of 16
Motors, Cost of, for Pumping 24
Organic Matter 53
Plumbing Fixtures 42
Poor Wells, How to Improve 9
Power Pumping 21
Power Pumps, Types of 20
Privies, Outside 69
Public Health Act 69
Puddled Clay as Backing 8
Pump, Capacity of a 21
Pump Cylinder, Height Above Water 8, 12, 15
Pumping Water, Work of 21
Pump, Parts of 12
Purification of Water 50, 55
Quantities of Water Required per day 34
Quicksand in Driven Well 10
Regulating Tanks 45
Regulating Valves 47
Sand Pumps, use of 10
Sea Level, Standard Pressure at 15
Set Length Pipe 13
Septic Tank System 57
Absorption Bed of 61
Care of Tank 64
Construction 61
Cost of 62
Fittings for 60
Installation of Tank 61
Material for 62
On Sloping Ground 62
Priming the Siphon 61
Sewage Disposal in Relation to Water Supply 69
Sewage Disposal Systems 57
Siphon, Action of in Septic Tank 58
Siphon Water Supply System 26
Soil Bacteria Found in Water 48
Speed of Pulleys, How to Calculate 22
Springs 4
Stable, Water Systems for 45
Subterranean Streams 6
Sucker, Height Above Water 8, 12, 15
Suction Pumps, Action of 15
Underground Streams 6
Wash Water 65
Water-diviners 6
Water-finder 6
Water, Purification of 50, 55
Water Requirements 34
Water Supply Paper 416, U.S. Geological Survey, Washington 6
Water Systems for Stable 45
Water Systems, Chief Features of Good 34
Water Systems, Information Blank *re* 75
Wells, Information Blank *re* 78
Well Water, Directions for Taking Samples of 77
Windmill for Pumping 21
Windmill Quadrants 21, 22

BULLETIN 268] [JANUARY, 1919

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

FARM CROPS

Results of Experiments at the Ontario Agricultural College

C. A. ZAVITZ.

INTRODUCTION.

Within the past few years the farmers of Canada have worked hard to secure surplus food materials to be shipped to the Allies. The present demand is as great or even greater to furnish food to millions of people in Europe, many of whom are at the point of starvation.

Field Husbandry Building.

In the United States Year Book for 1916 an article entitled "A Graphic Summary of World Agriculture" contains some interesting information. For three years previous to the war, viz., 1911, 1912 and 1913, estimates were made regarding production of food materials from farm crops in the principal agricultural countries of the world. The following table is based on the information gleaned from this article:—

Comparative Estimates of Different Countries on the Basis of 100.

Countries.	Areas in Farm Crops.	Areas in Farm Crops per Capita.	Production per capita of Food Materials from Farm Crops.
Canada	11.6	67.1	**100.0**
Argentina	19.1	100.0	**80.0**
United States	100.0	46.0	**64.3**
Australia	4.6	39.5	**35.0**
German Empire	20.6	13.1	**30.2**
Austria-Hungary	19.5	17.1	**29.8**
France	18.6	19.7	**25.4**
Russian Empire	86.5	21.0	**24.7**
Italy	16.1	18.4	**13.6**
India (British)	68.8	11.8	**11.0**
United Kingdom	6.0	5.2	**8.0**

Owing to the lack of available statistics the Chinese Empire is not included in the above list.

It will be seen that the United States comes highest in area of farm crops, and that Argentina comes first in area of farm crops per unit of population. It will also be seen that Canada produced per unit of population more food materials obtained from farm crops than any of the other principal countries of the world. It is the amount of surplus over home consumption in the production of food materials which is the important factor in supplying the real necessities of life to the starving populations of other countries. This being true, Canada occupies a unique position in furnishing food materials from farm crops for export, as indicated in the tabulated results here presented.

Field Experimental Work.

The experimental grounds at the Ontario Agricultural College, under the direction of the Field Husbandry Department, consist of about seventy-five acres of land divided into approximately two thousand five hundred plots, and on which experiments are being conducted with varieties of grain, root, tuber, grass, clover, fodder, silage, and other crops; with artificial, green and barnyard manures; with methods of cultivation, selection of seed, dates of seeding, mixtures of grains, pasture grasses, etc. In addition the Department directs the co-operative experimental work on about four thousand farms throughout the Province.

A greater portion of the experimental grounds has a gentle slope towards the south-west, and a smaller area has a slope towards the north-east. The soil is what might be termed an average clay loam. The lower portions of the land contain rather more vegetable matter than the higher sections. The greater portion of the land has a four years' rotation, the rotation being: First, grain crops; second, cultivated crops; third, grain crops; and fourth, pasture. This is a special rotation particularly well suited to the experimental work as carried on at the College. About one-quarter of the land is manured each year with twenty tons of farmyard manure per acre; thus most of the land receives an application of farmyard manure once every four years. The manure is applied previous to the cultivated crops.

No commercial fertilizers are used except in distinct fertilizer experiments, and these occupy a comparatively small area each year. Within the past sixteen years one green crop has been ploughed under on each section of the grounds. The plots vary in size according to the requirements of the different experiments, and the yields per acre are determined from the actual yields of the plots in every instance. All of these experiments are conducted with the greatest care, and for several years in succession in order to secure strictly accurate results. These experiments deal with the crops grown on fully nine-tenths of the cultivated lands of Ontario. An immense amount of thought and care is required in planning, supervising and examining these plots, and in studying, comparing and summarizing the results for presentation in reports, bulletins, newspaper articles, and lectures.

There are but few lines of work in which it is absolutely necessary to use so much care in the details. It is also exceedingly important to repeat the experiments for several years in order to get results which are as reliable as possible. All of our field experiments are conducted for at least five years before they are dropped, and many of them are continued for a much longer period of time. For the results of some of the tests which were carried on for five or more years previous to 1918 the reader is referred to former reports and bulletins. The results of some of the experiments which have as yet been conducted for one or two years are held over until the test can be carried through a longer period of time. As different seasons vary so much in temperature, rainfall, etc., the average results of experiments continued for several years are of much greater value than those secured from one or two seasons' work. Owing to the great care exercised in the work, and the number of years through which the experiments are continued, we are able to present the results with much confidence in their reliability and in their practical value.

Western Section of Experimental Grounds.

Field Experiments by Farmers.

During the past thirty-three years, a large amount of co-operative experimental work has been conducted throughout Ontario through the medium of the Ontario Agricultural and Experimental Union. Thousands of farmers have carried on this work successfully in their own fields. The material has been forwarded from the College and full details have been given regarding the operations for each experiment. The work was started in 1886 with only 12 experimenters. It has increased gradually and substantially until, within the last few years, from three to five thousand farmers have taken up the work each year. There are now fully thirty distinct and separate spring experiments, and also six experiments for the autumn. The experimenters make their choice from these two lists. The development of this work can be understood to a certain extent by a knowledge of the increase in the number of experimenters in agriculture for the past thirty-three years. The following figures give the average annual number of farmers who have been acting as experimenters on their own farms, the results being presented in three periods of **Eleven Years** each:—

Periods.	Years.	Average Number of Experimenters per Annum.
1886-1896............	11	720
1897-1907............	11	3,386
1908-1918............	11	4,288

It is impossible to estimate the great good which has been brought about in various ways through the medium of the co-operative experimental work. The principal conclusions from the carefully conducted experiments carried on throughout the Province are presented and discussed each year at the annual meeting of the Experimental Union. Any interested farmers of Ontario are always welcome to this gathering. The proceedings of the annual meeting with the results of the co-operative experiments are printed in the annual report of about one hundred pages, and some 32,000 copies are issued. The proceedings of the last meeting were printed as Bulletin No. 260, in addition to the Annual Report, the bulletin being issued early in the spring so that the information could reach the farmers before the time of spring seeding. Either or both of these can be obtained by writing to the Department of Agriculture, Parliament Buildings, Toronto.

Weather Conditions.

As it is important for a proper understanding of the results of experiments with farm crops to have a knowledge of the weather conditions in the locality in which the experiments have been conducted, the amounts of rainfall and the mean temperature in the six months of the growing season in each of the past **Nineteen Years** are here presented. These have been carefully determined in each of these years by the Department of Physics at the College, from which department we have received the information.

INCHES OF PRECIPITATION DURING THE SIX GROWING MONTHS.

Year.	April.	May.	June.	July.	August.	September.	Total.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
1900...........	1.69	1.03	4.47	3.05	.87	1.52	**12.63**
1901...........	2.24	3.26	1.53	4.07	3.51	2.45	**17.06**
1902...........	2.43	1.67	3.06	6.43	2.18	3.58	**19.35**
1903...........	2.69	2.44	3.05	2.67	3.47	1.48	**15.80**
1904...........	2.10	3.01	2.86	4.99	3.88	2.80	**19.64**
1905...........	1.82	3.89	3.24	4.60	1.98	2.85	**18.38**
1906...........	1.44	2.71	4.06	4.65	2.13	2.49	**17.48**
1907...........	1.66	2.64	1.11	1.92	.62	2.87	**10.82**
1908...........	1.33	3.47	3.21	3.25	2.75	.73	**14.74**
1909...........	3.60	3.43	1.33	4.54	.89	.86	**14.65**
1910...........	3.13	2.75	.78	2.09	3.18	3.00	**15.02**
1911...........	1.67	1.64	.89	1.95	2.53	3.42	**12.10**
1912...........	1.14	5.64	1.51	2.53	6.07	3.08	**19.97**
1913...........	3.53	1.37	2.03	3.26	2.88	1.49	**14.56**
1914...........	2.86	2.04	2.76	1.23	4.21	1.96	**15.06**
1915...........	2.23	2.24	2.27	5.87	6.16	3.92	**22.69**
1916...........	3.53	4.41	4.46	1.21	1.68	1.83	**17.12**
1917...........	3.36	3.29	6.40	7.54	3.28	1.41	**25.28**
1918...........	2.38	4.22	4.56	1.47	5.18	4.06	**21.87**
Average 19 years.	**2.36**	**2.90**	**2.82**	**3.54**	**3.02**	**2.41**	**17.05**

The record of the rainfall for the past nineteen years forms interesting material for study. A bulletin was issued on "Farm Crops" giving results of experiments up to the autumn of 1914. In that bulletin the amount of rainfall for the six growing months was given for each of fifteen years finishing with 1914. Since that time we have the record of rainfall for the six growing months in each of four years, from 1915 to 1918 inclusive. The following table gives the average amount of rainfall for each of the two periods:—

Period.	April.	May.	June.	July.	August.	September.	Total.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
1900–1914....... (15 years)	2.22	2.73	2.39	3.40	2.74	2.32	**15.82**
1915–1918....... (4 years)	2.88	3.54	4.42	4.02	4.08	2.81	**21.74**

It will be seen that the amount of rainfall during the months of the growing season of the last four years has been exceptionally heavy, the average amount being about one-third greater than that for the fifteen years previous. The total rainfall for the growing season at the Ontario Agricultural College was from 1.3 to 9.5 inches greater per season in the last four years than for the average season of the fifteen years previous. For the fifteen years from 1900 to 1914 inclusive, 12 per cent. of the individual months had from 4 to 6.4 inches of rainfall, and for the four years from 1915 to 1918 inclusive, 42 per cent. of the individual months had from 4 to 7.5 inches of rainfall. The large amount of precipitation occurred in July and August in 1915, in May and June in 1916, in June and July in 1917, and in May, June, August and September in 1918. Whether or not the discharge of tremendous amounts of high explosives in Europe had any influence on the amount of rainfall at Guelph, Ontario, is a problem for the meteorologists to try and solve.

The following table gives the average temperatures at the Ontario Agricultural College during each month of the growing season in each of the past **Nineteen Years**:—

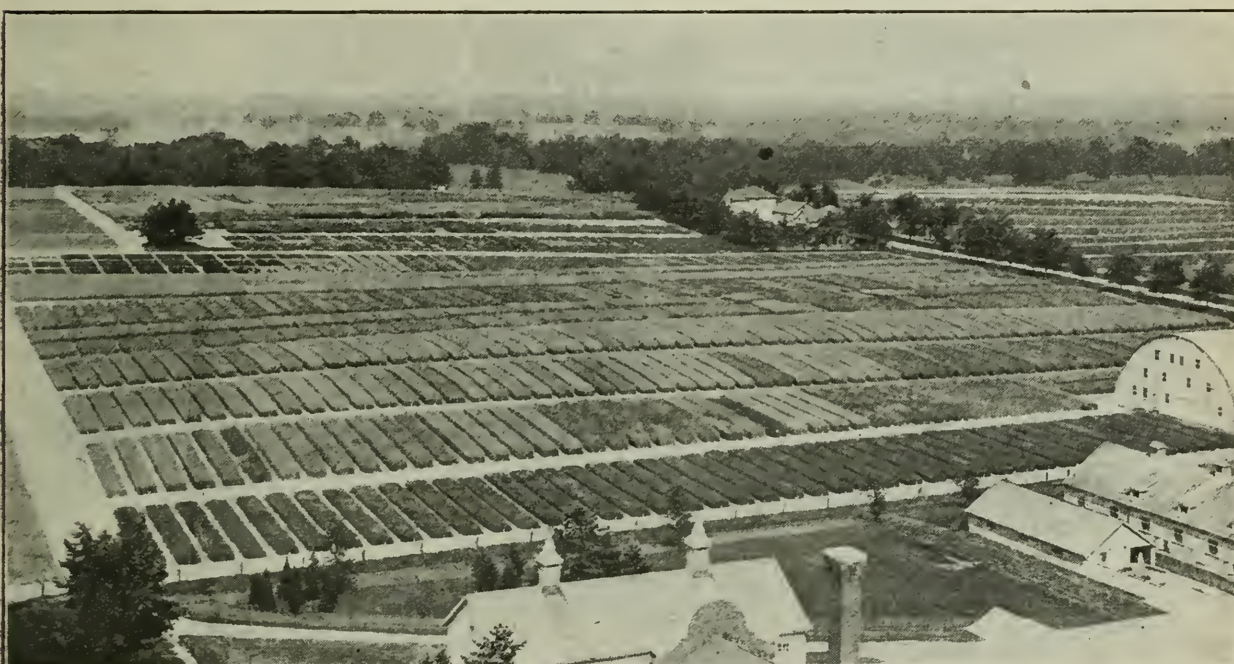
Year.	April.	May.	June.	July.	August.	September.	Average 6 months.
1900............	44.2	55.2	64.6	68.4	71.7	64.5	**61.4**
1901............	45.8	53.8	64.3	73.0	65.4	60.7	**60.5**
1902............	39.7	52.8	57.8	68.7	63.2	59.3	**56.9**
1903............	42.2	56.6	60.1	69.5	62.5	63.1	**59.0**
1904............	34.0	53.3	62.5	65.7	64.0	58.2	**56.3**
1905............	41.2	52.8	62.6	67.7	63.9	61.6	**58.3**
1906............	44.2	55.2	65.2	67.7	69.5	63.6	**60.9**
1907............	38.7	48.6	61.4	66.4	68.7	62.7	**57.8**
1908............	38.8	55.9	65.4	69.5	65.2	64.5	**59.9**
1909............	39.3	50.6	64.9	68.2	67.7	57.9	**58.1**
1910............	45.9	51.5	63.3	69.5	66.3	56.1	**58.8**
1911............	40.3	61.7	65.4	71.0	71.6	59.7	**61.6**
1912............	41.3	51.7	62.4	67.1	61.5	61.8	**57.6**
1913............	43.9	52.5	63.4	67.6	67.0	57.4	**58.6**
1914............	39.7	56.6	62.0	68.6	66.3	58.3	**58.6**
1915............	48.4	49.6	60.1	65.8	63.6	61.9	**58.2**
1916............	42.6	52.8	56.2	73.8	69.0	58.0	**58.7**
1917............	40.1	47.4	59.9	69.0	64.9	55.2	**56.1**
1918............	42.9	58.2	60.6	67.5	69.5	53.0	**58.6**
Average 19 years .	**41.7**	**53.5**	**62.2**	**68.7**	**66.4**	**59.9**	**58.7**

It will be seen from a study of the data given under weather conditions that for the months of the growing season of each of the past four years, the mean temperature has been about normal, but the rainfall has been exceptionally high.

Rotation of Crops.

The cropping of the College farm follows mainly along a four year rotation, as follows: One year, cultivated crops; one year, grain crops; and two years, hay and pasture. In our experimental grounds, it is necessary to grow a comparatively large amount of grain in order to meet the requirements of the various tests. The main rotation used, therefore, on the land devoted to the testing of varieties, dates of seeding, methods of cultivation, etc., extends over four years and is as follows: First year, cultivated crops; second year, grain crops; third year, pasture; and fourth year, grain crops. In another section of twenty-five acres in the experimental grounds a three-year rotation is conducted as follows: First year, cultivated crops; second year, grain crops; and third year, leguminous crops.

It is highly important that each person adopt on his own farm the rotation of crops which is likely to give the best results to meet the conditions of the farm and the requirements of the system of farming. While it is true that no one rotation is the best under all conditions, it is equally true that certain underlying principles should be applied as much as possible in each rotation. The rotation should be so arranged that the crop of each year should not only be the suitable crop for that season, but would also in some way or other for a preparation for the crop of the following year. A crop such as corn, roots, or potatoes when carefully cultivated assists the following crop by the destruction of weeds and of weed seeds and by liberating plant food. The grain crops should be sown in such a way that they not only furnish good results themselves but make good nurse crops for seeding with grasses, clovers, or alfalfa. The leguminous crops, such as the clovers and the alfalfa, not only furnish a large amount of nutritious feed, but also improve the mechanical condition of the soil, and add to the land some of the free nitrogen of the atmosphere in the root residue, thus improving the land for the crops following. Any person who has not given the subject of crop rotation his careful thought and attention has not lived up to his opportunities in making use of one of the best features in high crop producion from an economical standpoint.



Central Section of Experimental Grounds.

STANDARD WEIGHTS PER BUSHEL AND PER BAG.

The standard weight per bushel of turnips, carrots, and beets was changed from 60 to 50 pounds in January, 1915. In giving yields per acre, the standard weights are used in all instances in this bulletin unless special reference is made to bushels by measurement.

The following are at present the legal standard weights per bushel within the Dominion of Canada :—

Products.	Pounds.	Products.	Pounds.
Blue Grass seed	14	Onions	50
Oats	34	Indian Corn	56
Hemp seed	44	Rye	56
Parsnips	45	Flax seed	56
Barley	48	Artichokes	56
Buckwheat	48	Wheat	60
Timothy seed	48	Peas	60
Turnips	50	Beans	60
Beets	50	Clover seed	60
Carrots	50	Potatoes	60

The following are at present the legal standard weights per bag within the Dominion of Canada:—

Article.	Weight in Dominion Standard Pounds.
Artichokes	84
Beets	75
Carrots	75
Onions	75
Parsnips	65
Potatoes	90
Turnips	75

Any person who sells or offers for sale by the bag any of these articles which do not contain at least the number of Dominion standard pounds stated in the foregoing table is liable on summary conviction to a penalty not exceeding $25 for the first offence, and, for each subsequent offence, to a penalty not exceeding $50.

Copies of the Act and of the Amendments may be obtained from the Minister of Trade and Commerce, Ottawa, Ontario.

Continuous Growing of Farm Crops without Change of Seed.

We have had in our experimental grounds twenty-eight varieties of oats, barley, spring wheat and winter wheat which have been grown without change of seed from an outside source for twenty-four to thirty years. Some of these are common varieties, such as, the Common Six-rowed barley, Dawson's Golden Chaff winter wheat. Red Fife and Wild Goose spring wheat, etc. Other varieties are not quite so well known in Ontario, such as, Waterloo oats, Oderbrucker barley, Herison Bearded and Medeah spring wheat. The twenty-eight varieties included in this experiment covered a wide range of characteristics and should be suitable for a test of this kind. The results are interesting.

In certain localities in Ontario, it is still considered necessary by some farmers to change the seed quite frequently from one soil to another. The question of a frequent change of seed has been discussed and argued for many years. There are some strong advocates for a frequent change of seed, while other men are just as strong in advocating the continuous growing of varieties on the same farm for a number of years, and especially if they have choice varieties and have been careful in the selection of seed from year to year. A large number of practical farmers are realizing more and more the fact that in very many cases they are able to grow the same varieties for a considerable period of time without any change of seed, providing proper care is taken in growing varieties suitable for the soil, in the careful selection of the seed, and in the cultivaiton of the land. In the experiments which have been conducted at Guelph within the past thirty years, care has been taken to have the crops grown under as nearly normal conditions as possible. The soil on which these crops have been grown has changed but little in fertility, and no commercial fertilizers were used on the land. They simply fitted into the four-year rotation, which is considered by practical farmers to be a more severe rotation than the one used on the College farm, as in our experimental grounds in the four-year rotation, two crops of grain and one cultivated crop are removed from the land, the crop in the other year being used for pasture. No plant selection was used in this test, but good seed was sown each year.

The following table gives the average annual yield per acre of each variety for the last **Five Years** in comparison with that for the whole period including 1918:—

Crop.	Length of Whole Period. (Years)	Variety.	Average Yield per Acre (bushels).	
			Five Years, 1914–1918.	Whole Period including 1918 24 to 30 Years.
Oats	30	Siberian	87.7	89.4
		Probsteier	89.4	86.4
		Oderbrucker	87.1	85.9
		Waterloo	84.8	84.8
		Bavarian	90.7	84.1
		Joanette	75.1	83.3
		Egyptian	78.4	76.4
		Black Tartarian	72.8	70.1
Six-rowed Barley	29	Mandscheuri	63.2	68.3
		Oderbrucker	59.3	62.3
		Common Six-rowed	47.2	57.7
		Mensury	49.7	56.8
Two-rowed Barley	29	French Chevalier	58.5	56.1
Hulless Barley	29	Black Hulless	44.9	44.3
Winter Wheat	24	Dawson's Golden Chaff	37.7	48.2
		Early Red Clawson	37.3	44.2
		Bulgarian	37.3	40.6
		Treadwell	33.3	39.1
Common Spring Wheat	28	Saxonka	40.2	33.7
		Red Fife	37.1	32.6
		Pringle's Champion	40.3	32.4
		Red Fern	38.2	32.4
		White Russian	37.8	32.0
		Herison Bearded	40.3	31.8
		Colorado	35.7	29.6
Durum Spring Wheat	28	Wild Goose	41.5	37.6
		Medeah	36.1	33.4
		Sorentina	37.0	32.4

Of the twenty-eight varieties included in this test, only ten varieties gave a lower average yield per acre for the last five years than for the whole period of from twenty-four to thirty years. It will be seen that all varieties of spring wheat, durum wheat, hulless barley, two-rowed barley, and all of the varieties of oats except two have given a greater average yield per acre in the past five years than in the whole period in which they have been under test. The varieties of winter wheat and barley and the Siberian and the Joanette varieties of oats have given a lighter yield in the shorter period. It will be remembered that the winter wheat crop has been exceptionally light in Ontario in each of the past two years, and especially is this true in the season of 1918. Owing to severe winter conditions, the winter wheat was a partial failure in each of these two seasons. The weather conditions were rather unfavorable for barley production in Ontario in both 1914 and 1916. The season of 1918 was exceptionally favorable for the production of spring wheat throughout the Province.

The average results for the twenty-eight varieties show that the yield per acre has been slightly higher during the past five years than for the whole period of twenty-four to thirty years. The results of this experiment are very suggestive and show that varieties of grain crops may be grown in Ontario over a long period of time without change of seed and with very satisfactory results if care is exercised in the use of seed of good quality.

Comparative Results from Different Classes of Farm Crops.

In each of the past eighteen years two leading varieties of oats, barley, spring wheat, field peas, spring rye, hulless barley and emmer have been grown in our experimental grounds under uniform conditions of soil and climate. The object of this experiment has been not so much to compare one variety with another, as to secure definite information regarding the relative productiveness of different classes of farm crops. It is strange but nevertheless true that but little definite work has been done at Agricultural Experiment Stations in comparing in this positive and comprehensive way the relative productiveness of our most common grains. As the experiment was conducted in duplicate each year, it will be seen that we now have the results of 36 separate and distinct tests conducted in the eighteen-year period with these seven classes of farm crops. In some years the experiment was conducted on high land, in other years on low land, and in others upon land which had a gentle slope; in some seasons facing the north-east and in others the south-west. On no occasion was this experiment conducted on particularly heavy or especially light soil, but on loam which varied somewhat from year to year, from fairly light to medium heavy. The results of this experiment are very interesting.

In order to add to the value of the results of this experiment, we have used the tabulated results of the digestible constituents of the different classes of crops as presented in the fifteenth edition of the book entitled "Feeds and Feeding," written by Henry and Morrison, and printed in 1915. By multiplying the yields per acre by the percentage of digestible constituents given for each crop, the amounts of digestible constituents per acre have been worked out. When these constituents are added, it gives the total amount of digestible constituents per acre for each crop. It should be understood that the digestible fat is usually estimated as being 2.25 times as valuable as an equal amount of digestible carbo-hydrates. The following table gives the average annual results of the 36 distinct experiments conducted within the past **Eighteen Years**:—

Class of Crop.	Straw (tons.)	Grain (lbs.)	Pounds of Digestible Constituents in Grain.			
			Crude Protein.	Carbo-hydrates.	Fat.	Total.
Barley	1.74	2673	240.6	1785.6	42.8	**2069.0**
Emmer	1.97	2548	242.1	1610.3	43.3	**1895.7**
Oats	2.30	2591	251.3	1349.9	98.5	**1699.7**
Wild Goose Spring Wheat	2.16	1955	215.1	1255.1	31.3	**1501.5**
Rye	2.17	1760	174.2	1203.8	21.1	**1399.1**
Field Peas	1.49	1815	344.9	1012.8	10.9	**1368.6**

It will be observed from the foregoing table that in the average of thirty-six separate tests covering a period of eighteen years barley gave the largest weight of grain and oats the largest weight of straw per acre. Rye gave the lowest yield of grain and field peas the lowest yield of straw. It will also be observed that for the eighteen-year period barley has given an increase over the oats of 82 pounds of grain per acre per annum.

In digestible food constituents per acre field peas was the highest in crude protein, barley in carbo-hydrates, and oats in fat. In total digestible constituents barley surpassed the oats by an average of 369 pounds per acre per annum.

The Bureau of Industries, located in the Parliament Buildings at Toronto, has gleaned statistics throughout the Province regarding crop production in each of the past thirty-six years. The results are given annually in bulletins and reports and furnish some interesting material for study. Grains are reported in bushels per acre. By multiplying the average number of bushels per acre by the standard weight per measured bushel of each class of grain a more definite comparison can be made. Again, by multiplying the pounds of grain per acre by the percentage of digestible constituents of each, the amount of digestible material per acre of each class presents even a more accurate determination of the real value of the feed produced per acre from the different classes of grain crops grown in Ontario. As a basis of study the results for the estimated crops of Ontario have been worked out in a similar way to those presented in the foregoing table in connection with a distinct experiment conducted at the College. The following table gives the estimated annual yields of grain per acre over a period of **Thirty-Six Years,** and in the case of each of eight classes of crops and the amount of digestible constituents in each instance:—

Class of Crop.	Grain (lbs.)	Pounds of Digestible Constituents in Grain.			
		Crude Protein.	Carbo-hydrates.	Fat.	Total.
Barley	1349	121.4	901.1	21.6	**1044.1**
Fall Wheat	1278	111.2	866.5	17.9	**995.6**
Field Peas	1146	217.7	639.5	6.9	**864.1**
Oats	1217	118.0	634.1	46.2	**798.3**
Wild Goose Spring Wheat	966	88.9	649.2	15.4	**753.5**
Spring Rye	924	91.5	632.0	11.1	**734.6**
Beans	978	183.9	501.7	7.8	**693.4**
Buckwheat	974	78.9	484.1	24.4	**587.4**

As emmer has been grown in Ontario for a comparatively short time and only to a limited extent it is impossible to give the results of this crop for the Province. Fall wheat, beans and buckwheat are not included in the experiment conducted at the College.

It will be noticed that barley gives the greatest weight of grain per acre throughout Ontario of the small grains grown during the past thirty-six years as based on the reports of the Ontario Bureau of Industries. As will be seen, barley has surpassed oats by an average annual yield per acre of 132 pounds of grain and of 245.8 pounds of total digestible matter.

In the two previous tables the grains occupy the same relative order in the production of total digestible food material with the single exception that the estimated yield of field peas throughout Ontario for the thirty-six year period stands higher in the list than the yield of field peas in the experiments at the College extending over a period of eighteen years.

Selection of Seed Grain.

An interesting and valuable experiment has been carried on at the College in which different selections of seed of various classes of grain have been tested from five to nine years. For this experiment seed was taken each year from a general crop of grain grown either on the College farm or in the Experimental Department. It will be understood that whatever difference there is from the influence of the selection of seed that difference is attributed entirely to the careful selection of the seed for the separate years in which the tests were made. The results show the influence of one year's selection, and are, therefore, of special interest to the practical farmer. For the large plump seed none but well developed grains were selected; for the small plump sample the grains selected were of a uniform character; and for the shrunken sample none but shrunken grains were used, the last selection being made regardless of the size of the kernels. The sample of broken grain in the case of barley, and also of rye, contained nothing but grains which had been broken crosswise; split grain, in the case of winter wheat, contained nothing but grains which were broken lengthwise; and split seed, in the case of peas, contained peas which were split and not broken. The grain from which these selections were made was all threshed with a grain separator, and the splitting and the breaking of the grains were, therefore, done in the usual process of threshing. In the selection of large, plump seed, one-half pound was carefully weighed from each class of grain. The number of large, plump seeds of each kind of grain was then counted, and a corresponding number was taken of the medium sized grain, the small, plump grain, and the shrunken grain. In the case of the broken or split grain, twice the number of the half kernels, as compared with the whole grains, were used. The different selections were carefully sown upon plots of similar size. The following table gives the average yearly results of each selection made from six different classes of grains:—

Comparative Results from Seed Selections with Grain.

Class of Grain.	Selections.	Number of Years Tests Repeated.	Weight per Measured Bushel (pounds.)	Average Yield per Acre per Annum.	
				Straw (tons.)	Grain by Weight (bushels.)
Oats	Large Seed	7	33.2	1.9	**62.0**
	Medium-sized Seed	7	32.2	1.8	**54.1**
	Small Seed	7	31.8	1.8	**46.6**
Barley	Large Plump Seed	6	49.5	1.5	**53.8**
	Small Plump Seed	6	48.8	1.5	**50.4**
	Shrunken Seed	6	49.1	1.4	**46.0**
	Broken Seed	6	48.6	1.3	**43.2**
Spring Wheat	Large Plump Seed	8	59.1	1.4	**21.7**
	Small Plump Seed	8	58.3	1.3	**18.0**
	Shrunken Seed	8	56.9	1.2	**16.7**
Spring Rye	Large Seed	5	53.3	2.0	**26.0**
	Medium-sized Seed	5	53.3	2.0	**24.4**
	Small Seed	5	53.5	1.9	**22.3**
	Broken Seed	5	52.8	1.6	**16.9**
Winter Wheat	Large Plump Seed	6	59.4	2.6	**46.9**
	Small Plump Seed	6	59.2	2.2	**40.4**
	Shrunken Seed	6	59.1	2.1	**39.1**
	Split Seed	6	54.2	.6	**9.3**
Peas	Large Seed	6	56.3	1.3	**28.1**
	Small Seed	6	56.3	1.1	**23.0**
	Sound Seed	9	58.1	1.4	**29.2**
	Split Seed	9	57.9	.6	**10.2**

One year's selection of seed grain has a marked influence on the resulting crop. In every instance, the large plump seed gave a greater yield of grain per acre than medium-sized, small, plump, shrunken or broken seed. In the average of the six classes of grain the large plump surpassed the small plump in yield of grain per acre by 19 per cent., and, in the average of the three classes of grain, the plump seed gave a yield over the shrunken seed of 20 per cent. It should be understood that equal numbers of seed were used in this experiment. The results throughout

Growth from Seed Oats of Different Selections.

show that a large plump seed will produce a larger, more vigorous and more productive plant than is produced from a small plump or from a shrunken seed. Other experiments are now being conducted in which different selections of seed are used at different rates of seeding. In all experiments the results are in favor of sound, plump seed of good size for grain production.

Influence of Root Seed Selection.

A large amount of experimental work has been conducted at the College within recent years to determine the influence of different selections of root seed upon the resulting crop. Four tests were made annually with the different selections of seed of the field roots. Duplicate experiments were conducted in which the seeds of the different selections were planted separately, and duplicate experiments were also conducted by planting three large, five medium, and eight small seeds at each place where it was desirable for a root to grow. The plants were thinned to one at each place, and at equal distances apart. When the roots were harvested the yields of the duplicate tests of each method were averaged. The following table gives average results of the duplicate test made by means of each of two methods of comparison in order to ascertain the amount of influence of the size of root seeds on the yield of the roots produced:—

Method of Planting.	Roots.	Number of Years' Tests.	Yield of Crop per Acre. Large Seed.	Medium Seed.	Small Seed.
			Tons.	Tons.	Tons.
Plots in which equal numbers of seeds were planted separately	Mangels	5	31.19	27.02	18.57
	Sugar Beets	5	23.25	21.32	13.48
	Swede Turnips	5	15.35	12.63	7.03
	Fall Turnips	5	26.72	22.00	13.55
	Field Carrots	5	22.32	19.31	13.59
Plots in which equal numbers of plants were left when thinned	Mangels	5	35.17	32.23	24.47
	Sugar Beets	5	22.54	22.37	15.05
	Swede Turnips	5	18.77	17.85	10.40
	Fall Turnips	4	26.14	25.35	24.00
	Field Carrots	5	26.62	25.13	18.87

Note.—In the case of mangels and sugar beets the seed clusters instead of the separate seeds were used.

In the table here presented we have the average of no less than ninety-eight distinct experiments conducted with large, medium, and small seeds of five distinct kinds of field roots. It will be noticed that in every instance the large seed produced greater yields than the medium sized seed, and that the medium sized seed produced greater yields than the small seed.

New and Better Varieties Originated at the College.

The results mentioned under the heading "Selection of Seed Grain" are of great value in showing that in ordinary farm practice it is advisable to clean seed grain very thoroughly so that none but the best is sown. For plant improvement work, however, from a scientific standpoint, it is necessary to go beyond the mere selection of seed and to make selections from individual plants, and when necessary to make use of cross-fertilization in order to produce new varieties which are likely to be superior to the older ones. The variety tests at the College have formed an excellent basis for this work. During the past few years much stress has been placed upon the improvement of those varieties which have given the highest tests in the carefully conducted variety experiments. For the work in selection thousands of plants of the same variety have been grown at equal distances apart so as to give an opportunity for a careful study of the individual plants. As a result of this work we are now growing a number of selected strains of much prominence. These will be referred to in detail in the future pages of this bulletin.

The O. A. C. No. 21 barley, which was started in 1903 from a single plant selected from about ten thousand plants, is now thoroughly established in Ontario. The O. A. C. No. 72 variety of oats is increasing very rapidly throughout the Province. The O. A. C. No. 3, one of the thinnest hulled varieties which has ever been grown at the College, is taking its place amongst the early oats of the Province. The O. A. C. No. 61 variety of spring rye has shown itself to be the largest yielder of all the spring ryes tested at the College. The O. A. C. No. 81 soy beans is one of the best grain producers of the different kinds of soy beans which will mature at Guelph. These and other examples which might be mentioned show that the work in plant selection which has been conducted at the College is now bearing fruit throughout the Province. The influence of this work is increasing in value from year to year.

A large amount of work in cross-fertilization has also been carried out at the College within the past few years. The object has been to secure new varieties which would be more suitable for Ontario than even the best of the named varieties which have been obtained through extensive experimental work and through selection of individual plants. We have a large number of cross-bred varieties of nearly all classes of grain crops and some of these are particularly promising, especially in certain characteristics.

It might be interesting in this connection to give the history of the O. A. C. No. 104 variety of winter wheat which has been originated at the O. A. C., and which was distributed to the farmers for co-operative experiments for the first time in the autumn of 1916, after being tested in the experimental plots at the College for a period of five years, the detailed results of which will be given in a later part of this bulletin.

In the summer of 1881 Robert Dawson, a farmer living near Paris, Ontario, had a promising field of the White Clawson variety of winter wheat. A very heavy

Laboratory in which a Study is being made of Selected and Hybrid Plants.

storm caused the grain on this field to become badly lodged. Mr. Dawson, while walking over the field of grain which had been flattened and partly beaten into the ground found one plant, the stems of which were mostly standing. He thought that possibly as this plant was more erect than the others it might be due to an unusually stiff straw. As the grain was ripened at the time he carefully saved the heads from this single plant. These were shelled by hand and the grains were sown in a little piece of ground near the house in the following autumn. As the growth was promising Mr. Dawson was soon enabled to increase the crop sufficiently to not only supply his own requirements but also to sell seed to his neighbors. A bag of the new wheat, under the name of Dawson's Golden Chaff, was entered at the Autumn Seed Fair at Guelph, and received first prize. It was tested in the experimental plots at the Ontario Agricultural College, and proved to be one of the stiffest strawed and most productive varieties under test. It was later distributed to farmers over Ontario through the medium of the Ontario Agricultural and Experimental Union. It was increased in various localities and has for a number of years past been the most popular and the most extensively grown winter wheat in Ontario. It has a stiff straw, a red beardless head, and white grain. Although the Dawson's Golden Chaff is a heavy yielder the grain is comparatively soft and is more suitable for the manufacture of pastry and of breakfast foods than of flour for manufacturing into bread.

Another important variety of winter wheat, known as the Bulgarian, has been under test at the College for many years. It is also a white wheat, but with a medium strength of straw and a medium yield of grain per acre. This variety, however, has made a high record for bread production, as shown by tests in the Bakery Department at the College. It was thought that if the Dawson's Golden Chaff and the Bulgarian varieties could be cross-fertilized and a new variety originated, eliminating the undesirable and retaining the most desirable characteristics of the two parents, a very valuable acquisition might be made to agriculture.

A complete flower consists of two essential parts, the stamen and the pistil, and two floral envelopes, the corolla and the calyx. The two former contain the organs of reproduction and the two latter give the brilliancy and the beauty to the flower. Either the corolla or calyx, or both, may be absent, in which case the flower is said to be incomplete. It is usual for the stamens and the pistil to be in the same flower. Sometimes they occupy separate flowers on the same plants, and occasionally the stamens are produced on one plant and the pistils on another. In the case of wheat both the stamens and the pistil are found in the same flower. In each flower there are three stamens and one pistil. The stamens contain the pollen grains, which are small, uniform, and yellow in color, and the pistil the egg cells. For reproduction to take place it is essential that each egg cell be fertilized from a pollen grain.

Some of the farm crops such as wheat, barley, oats, peas and beans are naturally self-fertilized owing to the fact that fertilization takes place before the flowers are opened and exposed. In other instances, however, such as corn and rye, natural cross-fertilization takes place. This is clearly demonstrated in the case of corn. Every silk emanating from an ear must receive a vital pollen grain before a kernel of corn can be produced. As the pollen grains are produced on the upper part of the plant and the ears of corn some distance below, the pollen is usually conveyed to the corn silks through the agency of the wind. This accounts for the frequent mixing of varieties when grown in near proximity to each other.

From what has been said, it is evident that in order to secure hybrid grains of wheat it is necessary to artificially cross-fertilize the flowers. The O. A. C. 104 variety of winter wheat originated from a single cross between flowers of a choice plant of each of the Dawson's Golden Chaff and the Bulgarian varieties. Soon after a head of Bulgarian wheat appeared above the sheath a flower was carefully opened and the three immature stamens were removed. These were replaced by ripened anthers and pollen grains taken from a choice head of the Dawson's Golden Chaff. In due time fertilization took place and a hybrid grain was produced. This grain in the course of a few years produced a great variety of plants possessing different combinations of the characteristics of the two parents. These were carefully studied, and the one which received number 104 was found to possess in itself a combination of a number of the most desirable features of the two parent varieties.

The O. A. C. No. 104 variety is a vigorous grower with a comparatively stiff straw. The grain is white and the variety resembles the Dawson's Golden Chaff in being beardless, and the Bulgarian in having a white chaff. It is to be hoped that this offspring may prove of even greater service than either of its parents.

For the results of this new hybrid wheat the reader is referred to the section of this bulletin under the heading "New Winter Wheats Originated at the O. A. C."

The Stinking Smut of Wheat and the Loose Smut of Oats.

Investigations have been conducted in the scientific departments of a number of institutions in a study of the best methods for treating the various smuts which occur in grain crops. As the result of these investigations certain recommendations have been made by different institutions. The Experimental Department at Guelph has made very careful tests in studying the practical application of some of the most highly recommended treatments for the destruction of the different kinds of smut. The results of these practical tests are of great value to the men actually engaged in the growing of grain crops in the Province of Ontario. We, therefore, present this information with the hope that it may exert a marked influence in largely preventing the ravages of these very troublesome fungus pests.

The spores of the smuts correspond with the seeds of the grains and germinate and grow when the conditions of heat, moisture and food become favorable. The smuts are fungus plants which enter the tissues of other plants, such as those of wheat, oats, barley and corn, where they live and grow, and finally produce smut spores. The reproductive organisms of the loose smut of wheat and the loose smut of barley may exist in the tissues of the ripened grains, and it is, therefore. difficult to kill these two smuts, and also to retain the vitality of the wheat and barley. Although the hot water treatment may be effectual in killing these smuts, it is rather difficult to carry out satisfactorily in ordinary farm practice. It is important to secure seed wheat and seed barley from farms which are not infested with the loose smut of these grains. There is no effectual method known for preventing the smut of corn by a simple treatment of the seed, as the disease may attack any part of the tender growing plants at any time. The smut masses of corn should be gathered and burned and the spores thus prevented from being scattered on the land or embodied in the manure.

The spores of the loose smut of oats and of the stinking smut of wheat which attach themselves on the outer surfaces of the ripened grains can be readily killed by treatment. This fact is of great agricultural and economic importance. The information here presented should prove of much value in showing by actual experimental evidence that the loose smut of oats and the stinking smut of wheat can be completely and satisfactorily destroyed, and the crops entirely free from these diseases can be procured. If farmers grow wheat and oats which are infested with these smuts, they have themselves to blame. With a little care they can keep their farms practically free from these two pests which have frequently caused heavy losses in past years.

For five years in succession experiments have been conducted at the Ontario Agricultural College for the prevention of the loose smut of oats and of the stinking smut of wheat. Careful determinations were made each year to ascertain the comparative influence of different treatments. There were in all seven treatments for oats and five for wheat. In every instance, one sample was left untreated as a basis of comparison. An experiment was conducted in duplicate with oats, and also with wheat each year, there being two varieties of each class of grain used for the experiment. The seed grain was obtained each year from a known source, and where no treatment for smut had been attempted for several years previously. The following treatments were used throughout, with the exception of numbers 3 and 6, which were omitted from the treatments for the stinking smut of wheat:—

(1) *Untreated.*—One sample of oats and one sample of winter wheat of each variety were left untreated, in order that the influence of the various treatments might be better observed.

(2) *Immersion in Hot Water.*—The grain was placed in a bag and immersed in water at about 115 degrees F. Soon afterwards it was placed in water which was kept at a temperature of between 130 degrees and 135 degrees F. The grain was occasionally stirred and was allowed to remain in the water for a period of fifteen minutes. It was then spread out on a clean floor to dry, where it was stirred occasionally.

(3) *Immersion in Bluestone Solution for Five Minutes.*—A strong solution was made by dissolving one pound of copper sulphate (bluestone) in one gallon of water, and the oats were immersed in the solution for a period of five minutes.

(4) *Immersion in Blue Solution for Twelve Hours.*—The bluestone solution was made by dissolving one pound of bluestone in twenty-five gallons of water, and the grain was immersed in this solution for a period of twelve hours.

(5) *Sprinkling with Bluestone Solution.*—The solution was made by dissolving one pound of bluestone in ten gallons of water, which was used for sprinkling over the grain until it was thoroughly moistened after being carefully stirred.

(6) *Immersion in Potassium Sulphide Solution.*—The potassium sulphide treatment consisted of soaking the oats for two hours in a solution made by dissolving eight pounds of potassium sulphide in fifty gallons of water.

(7) *Immersion in Diluted Formalin.*—The solution of formalin (40 per cent. formaldehyde) used for the immersion process with oats and with wheat was made by pouring one-half pint of the formalin into twenty-one gallons of water, and the grain was immersed in this solution for a period of twenty minutes, during which time it was stirred occasionally.

(8) *Sprinkling with Diluted Formalin.*—One-half pint of formalin was poured into five gallons of water and the grain was sprinkled with this solution and stirred until it was thoroughly moistened.

After the treatments had been made for a few hours, and the grain had become sufficiently dried, it was carefully sown on separate plots. When the winter wheat was about ready to cut, it was carefully examined and the heads containing stinking smut were gathered and shelled. The rest of the crop was then threshed and again examined for any smut balls from heads which had been missed in the standing crop. When the oats were coming into head they were examined frequently and all smutted heads were removed and carefully counted. The accompanying table gives the average results in the percentage of grains of winter wheat affected with stinking smut and of the heads of oats affected with loose smut in each of the **Five Years** during which each experiment was conducted. Besides this information, the average yield of winter wheat per acre for the three years and the average yield of oats per acre for five years are included:—

RESULTS OF EXPERIMENTS TO KILL THE STINKING SMUT OF WHEAT.

Materials.	Percentage of Smut. (Average 5 Years).						Average yield of Grain per Acie 3 Years (bush.)
	First Year Test.	Second Year Test.	Third Year Test.	Fourth Year Test.	Fifth Year Test.	Average 5 Years.	
1. Untreated	3.6	9.3	.6	.6	6.8	**4.2**	**38.0**
2. Hot Water	.0	.0	.0	.0	.0	**.0**	**40.6**
4. Bluestone—12 hours	.0	.0	.0	.0	.0	**.0**	**40.2**
5. Bluestone—Sprinkled	.0	.2	.0	.0	.1	**.1**	**41.1**
7. Formalin—Immersed	.0	.0	.0	.0	.0	**.0**	**43.3**
8. Formalin—Sprinkled	.0	.0	.0	.0	.0	**.0**	**36.3**

RESULTS OF EXPERIMENTS TO KILL THE LOOSE SMUT OF OATS.

Materials.	Percentage of Smut. (Average 5 Years).						Average yield of Grain per Acre 5 Years (bush.)
	First Year Test.	Second Year Test.	Third Year Test.	Fourth Year Test.	Fifth Year Test.	Average 5 Years.	
1. Untreated	5.5	3.9	11.6	4.3	3.4	**5.7**	**60.3**
2. Hot Water	.0	.0	.0	.1	.0	**.0**	**63.7**
3. Bluestone—5 minutes	1.7	.9	.7	.6	.1	**.8**	**58.5**
4. Bluestone—12 hours	.6	.0	.0	.1	.0	**.1**	**56.0**
5. Bluestone—Sprinkled	.9	2.0	1.4	.6	1.6	**1.3**	**61.8**
6. Potassium Sulphide	3.4	.1	.3	1.5	.7	**1.2**	**66.2**
7. Formalin—Immersed	.0	.0	.0	.0	.0	**.0**	**68.3**
8. Formalin—Sprinkled	.0	.1	.0	.0	.0	**.0**	**61.3**

The results here show that treatment No. 7 was not only effectual in killing the smut entirely, but it also was the means of giving the highest average yield of grain per acre of the various treatments used in the case of wheat and also oats. The immersion process is so complete in its results that it does not need to be repeated every year, providing care is exercised to prevent a further introduction of the smut spores. In preparing wheat for treatment, care should be taken to separate the unbroken smut balls from the wheat, either by cleaning the grain or by placing the seed in water and removing the smut balls as they float on the surface. Not only is it necessary to treat the grain, but the formalin solution should be used to kill the smut spores which are lodged in the bins, on the barn floors, on the bags, in the grain drills, or wherever the living spores have an opportunity of again coming in contact with the grain.

The sprinkling process is used by some farmers, but unless great care is taken this method is not complete in destroying all of the smut, and as a result it is frequently necessary to treat the grain every year. One of the best methods is to carefully moisten twenty-five bushels of wheat by shovelling it over on a barn floor when it is being sprinkled with a mixture of one-half pint of formalin and from fifteen to twenty-one gallons of water. When the grain is uniformly moistened it should be covered with bags or blankets for three or four hours, and then spread out to dry. Varying quantities should be treated proportionately.

Further experimental work in treating grain for smut is now being conducted. This includes not only the hand methods, but also the use of some machines which are manufactured for this purpose. Different strengths of solution for the sprinkling process have been used in each of the past two years. Ten different treatments were tested in duplicate in 1917 and thirteen in 1918, the latter including what is known as the dry method.

Smut Resistance in Oats.

We have very clear evidence that there is a great variation in different varieties of oats in regard to smut resistance. An examination of different varieties has shown that some kinds possess a very much larger amount of smut than other varieties when grown under similar conditions. This has been tested out in various ways. The number of smut heads per plot of all our varieties of oats have been determined annually for the last seventeen years. The following table gives interesting information regarding the number of smut heads per plot in each of five different varieties:—

Number of Smutted Heads per Plot	Year.	Early Ripe.	Joanette.	Siberian.	American Banner.	Black Tartarian.
Before Treatment.	1902	0	20	32	116	332
	1903	0	9	43	303	608
	1904	3	10	78	317	369
	1905	0	18	20	22	62
	Seed Treated in Spring of 1906.					
After Treatment.	1906	0	0	0	0	0
	1907–12 Average 6 years.	0	3	1	3	17
	1913–18 Average 6 years.	1	2	4	6	58

The foregoing results are very interesting. In the seventeen years the Early Ripe variety of oats had only six smutted heads, while the Black Tartarian had 1817. In the seventeen-year period the grain was treated for smut only in the spring of 1906. Although some of the varieties had been very badly smutted previous to that year it will be seen that in 1906 there was not a trace of smut in any one of the varieties. In the following twelve years, however, the oats had again become slightly smutted, the amount for the last six years being greater than that of the former six-year period. Two of the important points in connection with this test is the fact that the different varieties of oats vary so much in their susceptibility to smut and that if the treatment is carried on with care every particle of smut can be eliminated even from those varieties which are very susceptible to the attacks of smut in large quantities. The grain was treated as described under No. 7 method previously explained. This method has always proven very effectual in treating both oats for the loose smut and wheat for the stinking smut in the work in the Field Husbandry Department at the College.

Grains Grown in Combination.

According to the reports of the Ontario Bureau of Industries the areas used for mixed grains was 619,389 acres in 1918, 515,593 acres in 1917, and 485,986 acres in 1916. In no year did the acreage reach one-half million until 1917. It will, therefore, be seen that the farmers of Ontario are growing grains in combination in increasing quantities.

In the past twenty-four years a large number of experiments have been conducted at the College in growing different classes and different varieties of grain in combination for the production of green fodder, of hay and of grain. Many valuable results have been obtained. A number of these have already been presented in the annual reports of past years and other experiments are now under way.

The results of experiments show that for green fodder and for hay, a mixture of two bushels of oats, such as, the Siberian, the O. A. C. No. 72, or the Banner varieties and one bushel of peas, such as, the Multipliers, the Golden Vine, or the Prussian Blue varieties, makes an admirable seeding for growing in combination.

For grain production, one bushel of the O. A. C. No. 3, the Daubeney, or the Alaska oats combined with one bushel of the O. A. C. No. 21 barley have given excellent satisfaction as a farm crop. The O. A. C. No. 3 oats have largely taken the place of the Daubeney variety for this purpose. The results of our experiments have shown that a combination of the best variety of oats and the best variety of barley, grown together in the right proportion, will produce on an average fully two hundred pounds of grain per acre more than either one grown separately. The experiments, which have been conducted in the past at the College, seem to indicate that there is but little advantage from growing in combination two different varieties of the same class of grain, but there are often marked advantages from growing suitable varieties of different classes of grain together. Of all the combinations used, none have given as large a yield of grain per acre as the most suitable combination of oats and barley.

Sowing Spring Grains at Different Dates.

For five years in succession an experiment was conducted at the Ontario Agricultural College in sowing spring wheat, barley, oats and peas at six different dates in the spring, commencing as early as the land could be worked satisfactorily and allowing one week between each two dates of sowing. The varieties of grain used in this experiment were Herison Bearded and Pringle's Champion spring wheat. Mandscheuri and Kinna Kulla barley, Siberian, Oderbrucker, and Waterloo oats, and Early Britain and White Wonder peas. In each year the experiment was conducted in duplicate by sowing one plot at each date of seeding with the grain drill and another plot broadcast by hand. The result from the two methods were averaged each year. It will, therefore, be seen that there were ten separate tests in this experiment. The average results of the ten distinct tests conducted in the **Five-Year** period are as follows:—

Dates of Seeding.	Yield of Straw per Acre (tons.)				Weight of Grain per Measured Bushel (pounds).				Yield of Grain per Acre by Weight (bushels).			
	Spring Wheat.	Barley.	Oats.	Peas.	Spring Wheat.	Barley.	Oats.	Peas.	Spring Wheat.	Barley.	Oats.	Peas.
First........	1.2	1.2	2.0	.9	60.1	52.3	33.9	56.6	21.9	46.2	75.2	25.4
Second......	1.1	1.2	2.1	1.1	59.6	52.6	34.5	56.6	19.2	45.9	76.0	28.8
Third.......	1.0	1.1	1.8	1.1	59.0	51.8	32.1	57.6	15.4	39.8	64.2	28.5
Fourth......	.9	1.0	1.7	1.0	58.9	50.3	29.9	57.4	13.0	37.1	55.8	25.5
Fifth........	.6	.9	1.6	.9	56.5	48·2	27.3	57.0	8.4	27.6	45.2	21.5
Sixth........	.8	.9	1.7	1.0	54.0	45.1	24.2	57.0	6.7	18.4	35.0	19.5

The dates of starting and closing the test varied in different years according to seasonal conditions. The average dates of sowing were as follows:—1st, April 18th; 2nd, April 24th; 3rd, May 2nd; 4th, May 10th; 5th, May 17th; 6th, May 25th.

It will be seen that the best results were obtained from sowing both spring wheat and barley as soon as the land was in proper condition for cultivation in the spring. With oats it mattered but little whether seeding took place at the beginning or the end of the first week on which the land could be worked satisfactorily. The results from the tests with peas, however, show that the best returns were obtained from the second date of seeding, and that even the fourth date gave as large a yield of both grain and straw per acre and as high a weight of grain per measured bushel as was obtained from the first seeding. These results show the importance of sowing very early in the spring and in the following order: Spring wheat, barley, oats and peas.

It is interesting to note that there was a gradual decrease in crop production as the dates advanced from the beginning to the end of the test. According to the results of the experiment, there was an average decrease in yield per acre of 27 pounds of spring wheat, 47 pounds each of barley and of oats, and of 20 pounds of peas for each day's delay. It is, therefore, essential, if the best results are to be obtained, to sow these spring grains very early in the spring.

Dates of Sowing Emmer and Spelt.

Emmer and spelt are used in some countries to a limited extent for flour production. When used for this purpose, however, special machinery is required for separating the chaff or the hull from the grain, as the grain is usually surrounded by the chaff after being threshed. In this country these grains are considered from the standpoint of the amount of feed which they will produce for farm stock. Emmer is about equal to barley for feeding purposes.

In each of five years both emmer and spelt were sown on eight different dates in the spring, by making the first date in the season as early as the land was suitable for cultivation. One week was allowed between each two dates of seeding. The Common Emmer and the Red Spelt were the special varieties used. The average results of the experiment for **Five Years** are presented in the following table:—

Dates of Seeding.	Yield of Straw per Acre (tons).		Weight of Grain per Measured Bushel (pounds).		Yield of Grain per Acre (pounds).	
	Spelt.	Emmer.	Spelt.	Emmer.	Spelt.	Emmer.
First	1.6	1.9	28.3	40.1	2,377	2,747
Second	1.6	2.0	27.3	39.1	2,163	2,848
Third	1.7	2.0	26.3	39.1	1,898	2,646
Fourth	1.6	2.1	24.9	37.6	1,582	2,754
Fifth	1.5	2.1	24.2	36.7	1,287	2,569
Sixth	1.6	2.3	21.6	36.1	933	2,465
Seventh	1.5	2.4	19.6	35.4	685	2,312
Eighth	1.5	1.9	19.9	34.0	499	1,953

The figures representing the pounds per measured bushel and the pounds of grain per acre include the chaff or hull surrounding the grain, as well as the grain itself. In the examination of the results here presented, the reader will be impressed with the superiority of the emmer as compared with the spelt in weight of grain per measured bushel, and in yield of both straw and grain per acre. In no instance does the spelt show a better record than the emmer. It will be noticed that even the fourth seeding of emmer produced a higher yield of grain per acre than that obtained from the first seeding. The results, from this and the preceding experiment, seem to indicate that emmer may be sown at a later date than other classes of spring grain.

Varieties of Oats.

Of all the small grains grown in Ontario oats are decidely the most important. The market value of the oat crop of Ontario in 1917 was about $86,000,000, and in 1918 about $100,000,000, and the average for the past twelve years has been approximately $40,000,000 per annum. In 1918 there were 2,924,468 acres used for the production of oats. This was the largest area ever used for oats in this Province. The production of oats in 1918 was 131,752,601 bushels, while the average of the previous thirty-six years was 82,479,705.

Over three hundred varieties of oats have been carefully tested in the experimental grounds at the College, but many of these have been dropped after they have been grown for five years in succession owing to the fact that other varieties have proven more successful. Each year a few new varieties are added and a few of the inferior ones are dropped. Nine varieties of oats have been grown under test continuously at the College for the last twenty-nine years. The following gives the average percentage of hull for twelve years and the average yield of grain per acre for **Twenty-Nine Years** of each of the nine varieties here referred to:—

Varieties.	Percentage of Hull. Average 12 Years.	Yield of Grain per Acre. Average 29 Years (bushels).
Siberian	29.4	**89.9**
Probsteier	28.3	**86.9**
Oderbrucker	30.1	**86.3**
Waterloo	27.4	**85.4**
Bavarian	28.2	**84.5**
Joanette	23.8	**83.4**
American Banner	30.1	**82.8**
Egyptian	31.5	**77.0**
Black Tartarian	31.2	**70.7**

Of the nine varieties of oats here reported all are white in color of grain except the Black Tartarian, and all have spreading heads except the Egyptian and the Black Tartarian, each of which has a side head.

It will be seen that there is a variation in average percentage of hull from 23.8 for the Joanette to 31.5 for the Egyptian. One hundred pounds of the

Joanette to 31.5 for the Egyptian. One hundred pounds of the Joanette would therefore furnish 7.7 pounds more meal than a similar amount of the Egyptian variety. In yield of grain per acre over the twenty-nine year period there is a difference of 19.2 bushels per acre per annum in favor of the Siberian over the Black Tartarian. The Black Tartarian variety of oats was grown considerably and was fairly popular in Ontario about thirty years ago.

The full results of the experiment with all the varieties of oats grown under experiment in 1918 are not completed at the time of writing this bulletin. In the five years finishing with 1917, thirty-eight named varieties in addition to the various selections and hybrids have been under test. Of these thirty-eight varieties grown for five years, the highest average yields were produced by Yellow Sixty-Day, Prosperity, Alaska, Iowa Silver Mine and Sixty-Day White. In the five-year period those varieties which gave the smallest average amount of hull per acre were Joanette, Early Ripe, and Daubeney; and those which had the greatest percentage of hull were Pioneer, Early Dawson, White Superior Scotch, Garton's Record, Storm King, and Egyptian.

Some of the new varieties of oats originated at the College by selection from individual plants, and particularly from cross-fertilization, have given a less percentage of hull than any of the three hundred named varieties of oats secured from different parts of the world. The two varieties of oats originated at the College from selection in our trial grounds have been introduced and are now grown extensively throughout Ontario under the names of O. A. C. No. 72 and O. A. C. No. 3. The record of these two varieties will be reported more fully under a separate heading and in comparison with two old standard varieties.

Two New Valuable Varieties of Oats.

Two varieties of oats have been originated at the College by selection through the medium of nursery plots. These varieties of oats have been tested at the College and throughout the Province, and are now grown extensively on thousands of farms in Ontario.

In the spring of 1903 about ten thousand grains of the Siberian oats were planted separately at equal distances apart in a large nursery plot. This gave the separate plants an opportunity for development under fairly uniform conditions. When the grain was ripe the plants were all carefully examined, and those presenting the most desirable characteristics were harvested separately and carefully stored. The selected plants were afterwards given a more critical examination in the plant breeding laboratory, and those possessing the largest amount of the best seed were retained for future work. In the spring of 1904 a certain number of the seeds from each of the plants were planted by hand in separate rows which furnished an opportunity for a study of the characteristics of the progeny of the individual plants. A critical study was made of these different strains, and only the best were continued in the test. From seed obtained in the rows plots were sown and the crops were compared with other selections, hybrids and varieties. As the result of this careful investigation it was found that what is now called the O. A. C. No. 72 seemed to possess the greatest combination of the most desirable characteristics. This variety has now been tested in the large plots in each of the past twelve years, the results of which are here presented, in comparison with those of the American Banner oats which were grown under similar conditions. The American Banner has been the variety which has been most extensively grown in Ontario during the past number of years.

The O. A. C. No. 3 variety of oats originated from a single plant selected from the regular variety plot of the Daubeney oats in 1904. The writer at that time selected a number of plants which apparently combined the most desirable characteristics. These plants were threshed separately, and the grain was carefully retained for future work. After careful tests were made with the individual strains, it was found that the oat which now receives the name of O. A. C No. 3 contained the greatest number of valuable points. The results of this particular strain are presented in comparison with those obtained from the Daubeney oats, from which the plant was originally selected. These are both exceptionally early varieties and are suitable not only for growing as separate varieties, but also for combining with barley when it is desired to grow the two in combination for grain production.

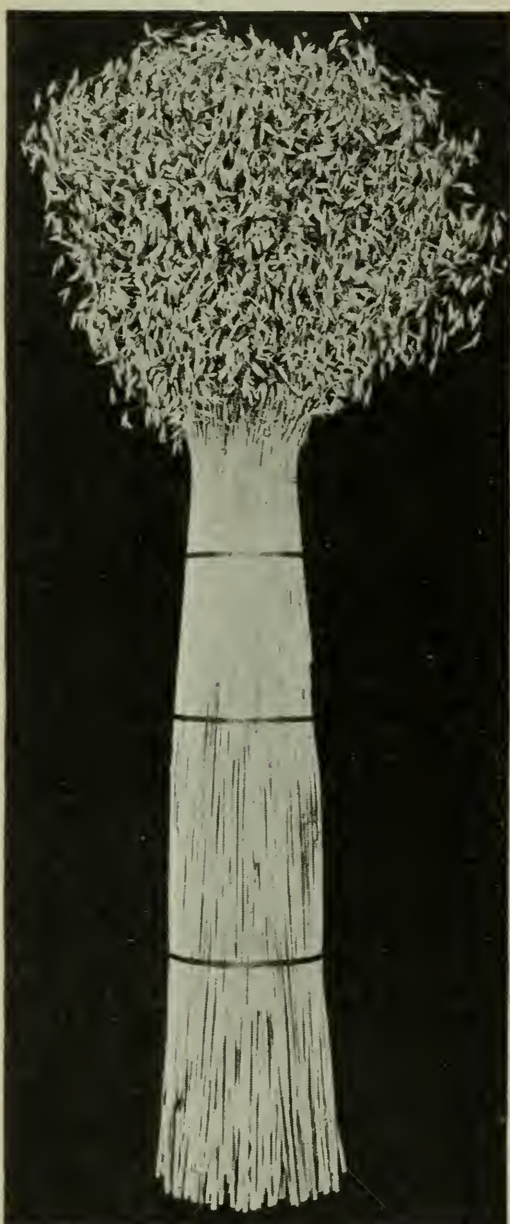
The following table gives the percentage of hull and the yield per acre of the O. A. C. No. 3 in comparison with the Daubeney, and the O. A. C. No. 72 in comparison with the Banner in each of the past **Twelve Years**:—

Sheaf of O. A. C. No. 3 Oats.
(Reduced to one-eighth.)

Years.	Percentage of Hull.				Yield of Grain per Acre (bushels).			
	Early.		Late.		Early.		Late.	
	Daubeney.	O. A. C. No. 3.	Banner.	O. A. C. No. 72.	Daubeney.	O. A. C. No. 3.	Banner.	O. A. C. No. 72.
1907	24.7	24.7	28.3	27.2	80.79	86.29	65.94	76.38
1908	23.8	23.6	28.6	25.4	88.97	89.24	83.50	86.82
1909	25.4	24.8	29.6	28.7	98.35	104.88	70.41	102.94
1910	24.9	24.4	29.6	28.6	87.00	90.35	73.62	93.59
1911	26.2	25.0	31.3	27.8	42.12	49.76	30.41	43.97
1912	24.6	23.8	35.5	28.0	76.47	91.65	73.44	114.12
1913	24.5	23.0	29.2	25.6	60.41	94.12	74.38	105.74
1914	25.9	24.3	30.7	28.9	63.88	57.53	88.00	88.50
1915	23.9	21.7	29.1	28.4	73.21	76.00	92.76	103.53
1916	26.1	27.2	32.0	32.9	53.91	74.91	67.56	65.91
1917	23.8	22.7	27.2	26.1	100.24	111.68	101.74	86.59
1918	25.2	23.0	28.5	27.8	92.29	105.32	85.27	89.18
Average 12 Years	**24.9**	**24.0**	**30.0**	**28.0**	**76.47**	**85.98**	**75.59**	**88.11**

As the Daubeney amongst the early, and the Banner amongst the late varieties of oats have been the standard varieties of Ontario for many years, it was interesting to compare the new varieties with these standard sorts.

The tabulated results here presented for each year show that in percentage of hull in only one instance was the O. A. C. No. 3 greater than that of the Daubeney, and in only one year was that of the O. A. C. No. 72 greater than that of the Banner. The average percentage of hull for the twelve-year period shows the O. A. C. No. 3 to be about one per cent. less than the Daubeney, and the O. A. C. No. 72 two per cent. less than the Banner. The detailed results show that, in yield of grain per acre, the O. A. C. No. 3 surpassed the Daubeney in eleven out of the twelve, and the O. A. C. No. 72 surpassed the Banner in ten out of the twelve years. The average results show that the O. A. C. No. 3 surpassed the Daubeney by an annual yield of 9.5 bushels per acre per annum, and the O. A. C. No. 72 surpassed the Banner by 12.5 bushels per acre per annum.



Sheaf of O. A. C. No. 72 Oats.
(Reduced to one-tenth.)

In average annual yield in tons of straw per acre, the four varieties of oats gave the following returns: Daubeney, 1.86; O. A. C. No. 3, 1.89; Banner, 2.03; and O. A. C. No. 72, 2.15.

The average number of days from the time the seed was sown until the crop was ready to harvest for the twelve-year period is as follows: Daubeney, 104; O. A. C. No. 3, 102; Banner, 111; and O. A. C. No. 72, 111.

It will, therefore, be seen that the O. A. C. No. 3 is a very early, thin hulled, high yielding oat with a fair amount of straw, and that the O. A. C. No. 72 ripens at practically the same time as the Banner and has surpassed the latter variety in yield of grain, quality of grain and in yield of straw.

In the co-operative experiments throughout Ontario, the O. A. C. No. 72 variety has headed the list in yield per acre in each of the past six years.

The O. A. C. No. 72 variety of oats appears to be displacing many of the old varieties of oats, even the Banner, which has for many years been the most extensively grown variety in the Province. In 1913 only one farmer had a sufficiently large field of the O. A. C. No. 72 to enter it in the Field Crop Competition in his locality and this field received the first prize. Since that date, this variety has increased rapidly in connection with the Standing Field Crop Competitions in Ontario. The O. A. C. No. 72 and the Banner varieties have each taken first prize in the Ontario Field Crop competition as follows:—

Year.	Banner,	O.A.C. No.72.
1913	41	1
1914	34	20
1915	33	48
1916	26	76
1917	25	85

At the Provincial Winter Fair, entries have been made of the O. A. C. No. 72 oats in recent years as follows: 1913, 3; 1914, 36; 1915, 57; 1916, 71. In 1916 and 1917 there were more entries for this oat than for all other oats combined, and fully three times as many as those for the Banner. The average yield of oats per acre on nearly three million acres throughout Ontario in 1918 was 42.6 bushels. This average yield per acre has not been surpassed during the thirty-seven years in which the statistical information has been gleaned throughout Ontario through the medium of the Bureau of Industries for the Province. This popular oat is having a marked influence in increasing production, and it is even now worth millions of dollars to Ontario annually.

A Test of the Stooling of Oats.

The stooling of grains is influenced by the fertility of the soil, the conditions of the weather, the thickness of seeding, the variety of grain, etc. The fertility of the soil, the thickness of the sowing and the varieties used are largely under the control of the farmer. In the results of our experiments in each of the past ten years, the varieties of oats have shown very marked differences in their stooling properties. We here present the **Ten Years'** results of each of a number of varieties of oats which were grown under uniform conditions:—

Varieties.	Average Number of Stools per Plant.										
	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	Average 10 Years.
Joanette	21	18	15	26	16	16	19	9	15	13	**16.8**
Burt	22	13	17	19	18	17	20	9	15	11	**16.1**
Early Ripe	19	13	16	19	16	19	21	10	16	12	**16.1**
Yellow Kherson,	19	13	15	18	15	13	18	9	14	12	**14.6**
Daubeney	18	11	14	14	12	9	15	9	12	10	**12.4**
Sixty-Day	17	12	13	14	10	10	13	8	9	10	**11·6**
American Banner	17	10	13	14	10	11	13	9	9	9	**11·5**
Siberian	14	12	11	12	9	11	13	9	10	8	**10.9**
Reg. Abundance.	11	10	11	14	10	11	13	8	9	8	**10.5**
Storm King	8	6	6	9	6	6	8	5	5	5	**6.4**
Tartar King	8	5	6	8	6	6	6	5	4	4	**5.8**

Great care was exercised in the sowing of the oats in this experiment, the seed being planted in squares one foot apart in each direction. In this way the plants had an opportunity for the development of stools and to bring out the characteristics of the individual varieties. It will be seen that there is a variation in the average number of stools from 5.8 in the case of the Tartar King to 16.8 in the case of Joanette. It will also be seen that the three lightest stooling varieties are the Tartar King, the Storm King, and the Regenerated Abundance, three varieties of oats brought to Canada by the Garton Bros., of Warrington, England. Both the Storm King and the Tartar King are light yielders of grain. The American Banner of the late oats and the Daubeney and the Sixty-Day of the early oats have almost equal stooling properties. The heavy stooling varieties in comparison with the light stoolers, when sown broadcast under average conditions, have given a somewhat higher yield of grain per acre.

Percentage of Hull in Oats.

The quality of the oat crop is determined to a greater extent by the percentage of hull than many people realize. Until recently, but little attention was given to the percentage of hull in oats, either in this country or in Europe. As a result, we find that in the past a number of thick hulled and consequently inferior varieties of oats were introduced and grown in Canada. The percentage of hull in oats is considered of so much importance that it is thought advisable to draw particular attention to the differences in this respect as shown by varieties over a series of years. Four varieties have, therefore, been selected to show the importance of paying more attention to this important characteristic. The chemical composition of oats varies considerably, and these variations are largely due to the percentage of hull found in the different varieties:

Year.	Percentage of Hull.			
	Joanette.	Daubeney.	Early Dawson.	Pioneer.
1902	22.5	26.1	32.6	48.1
1903	23.1	25.1	33.7	36.8
1904	22.5	23.0	32.4	36.9
1905	24.0	26.3	36.0	36.8
1906	25.2	26.3	38.1	42.8
1907	23.4	24.7	33.7	38.8
1908	23.9	23.8	36.6	37.4
1909	25.4	25.4	36.8	36.7
1910	23.9	24.9	31.4	33.5
1911	23.9	26.2	34.1	36.8
1912	24.3	24.6	35.8	37.0
1913	22.4	24.5	33.1	35.3
1914	24.3	25.9	34.4	36.7
1915	23.1	23.7	31.7	35.1
1916	24.2	26.1	39.9	40.2
1917	21.6	23.8	35.2	34.7
1918	25.5	25.2	34.5	35.6
Average 17 Years	**23.7**	**25.0**	**34.7**	**37.6**

The four varieties of oats included in the preceding table have all been grown in Ontario more or less extensively in recent years. The tabulated results show very clearly the great differences in the amount of hull of different varieties. They also show that these differences are fairly constant from year to year. With only three slight exceptions, the Joanette proved to be thinner in the hull than any of the other three varieties in any of the past seventeen years. The Daubeney was thinner in the hull than the Joanette by .1 per cent. in 1908, and by .3 per cent. in 1918, and the two varieties possessed exactly about the same amount of hull in 1909. Without a single exception the Early Dawson possessed a thicker hull than the Daubeney, and, with only two slight exceptions, the Pioneer produced a thicker hull than the Early Dawson. In the average of the seventeen-year period, it will be seen that the Pioneer had an annual percentage of hull of 14.9 over the Joanette. This would mean that the Joanette would contain approximately fifteen pounds of meal more than the Pioneer for each average one hundred pounds of oats. As the average value of the oat crop of Ontario amounts to about fifty million dollars annually, it will be seen that a difference of one per cent. in the hull of oats

Sheaf of O. A. C. No. 21 Barley.
(Reduced to one-tenth.)

would make a difference approximately one-half million dollars in the value of the oat crop of Ontario in a single year. This point is worthy of careful consideration by the farmers of Ontario.

Varieties of Spring Barley.

With the exception of oats, barley is grown more extensively in Ontario than any of the other small grains. In 1918, 24,247,673 bushels of barley were grown in Ontario on 660,404 acres. This is a yield of 36.7 bushels per acre, which is the highest recorded in the last thirty-seven years, the next greatest yield per acre being 36 bushels, which was the average for 1915. The barley crop is, therefore, exceedingly important in connection with the agriculture of this Province. As is shown in the earlier part of this report, it is the highest in the production of digestible food constituents of all the small grains grown in Ontario.

Spring barley as grown in the Experimental Department at Guelph can be divided into three distinct classes, viz.: the six-rowed, the two-rowed and the hulless. These three classes differ from each other in several respects. As a rule, the six-rowed barleys are earlier in maturing and give comparatively larger yields of grain per acre than the two-rowed. The hulless barleys have a standard weight per measured bushel of 60 instead of 48 pounds. The straw is usually short and somewhat inclined to lodge.

Classes and Varieties.	Bearded or Bald.	Color of Grain.	Average Results for Five Years.					
			Average Height (ins.).	Per Cent. of Rust.	Days to Reach Maturity.	Weight per Measured Bushel (lbs.).	Yield per Acre.	
							Straw (tons).	Grain (bush.).
Six-rowed—								
California Brewing	Bearded	White	30	5	104	48.00	1.75	**65.79**
O. A. C. No. 21	"	"	39	3	104	49.20	1.95	**63.39**
Mandscheuri	"	"	38	4	104	49.55	1.92	**63.15**
Zulu King	"	Black	29	5	103	49.35	1.58	**59.70**
Oderbrucker	"	White	38	3	104	50.40	1.83	**59.29**
Oregon	"	"	29	3	111	45.40	1.67	**53.48**
Mensury	"	"	34	4	103	53.15	1.73	**49.71**
Success	Bald	"	33	3	98	48.40	1.40	**48.52**
Common Six-rowed	Bearded	"	36	3	103	52.35	1.73	**47.20**
Two-rowed—								
Binder Barley	Bearded	White	31	4	108	54.65	1.81	**65.95**
Gold Barley	"	"	30	3	108	55.30	1.89	**63.13**
Svalof's Hannchen	"	"	31	3	108	53.80	1.78	**59.66**
Hanna No. 5590 (Iowa)	"	"	31	3	108	54.15	1.90	**59.13**
French Chevalier	"	"	32	3	109	53.10	1.94	**58.48**
Two-rowed King	"	"	30	3	108	52.05	1.77	**54.62**
Svalof's Princess	"	"	30	3	110	53.05	1.80	**52.16**
Two-rowed Canadian	"	"	33	5	109	52.30	1.50	**42.84**
Duckbill	"	"	33	6	110	51.05	1.62	**41.47**
Hulless—								
Black Hulless	Bearded	Black	28	2	102	62.85	1.64	**44.88**
Purple	"	Purple	27	3	102	63.05	1.63	**42.51**
Winnipeg No. 2	"	White	25	3	103	59.55	1.81	**41.80**
Guy Mayle	"	Green	25	4	100	60.35	1.44	**41.61**
New White Hulless	Bald	White	26	4	106	60.40	1.63	**33.18**

The California Brewing barley, which has given the highest yield of grain per acre is a comparatively poor variety in all respects except in productiveness. It is a coarse, stiff bearded, thick hulled barley which weighs comparatively light per measured bushel and which has short, weak straw. The grain is usually very dark in color and is often used for class-room work as an inferior type of barley. It is quite possible that it may grow a grain of better quality in California than it does in Ontario. Although there is not much difference in the results of the O. A. C. No. 21 and the Mandscheuri in the record of the past five years, the O. A. C. No. 21 has made the best all-round record both at the College and especially in the co-operative experiments throughout Ontario. The O. A. C. No. 21 is a stiff strawed, large yielding barley, and the grain is of excellent quality. The two-rowed barleys have given unusually large yields during the last few years of abnormal seasons. Two-rowed barleys are grown quite extensively in England and in other parts of Europe, but have not as a rule given as good results as six-rowed barleys in Ontario. The reader will notice from the earlier part of this report that during the last four years there has been an exceptionally large amount of rainfall in Ontario. This produced conditions more nearly resembling those of Great Britain than occurs in normal years. Under normal conditions, six-rowed barleys surpass the two-rowed barleys in productiveness. It should be clearly understood that the standard weight per measured bushel of hulless barley is 60 instead of 48 pounds.

The O. A. C. No. 21 variety of barley has become exceedingly popular throughout the Province and is supplanting all other varieties, even the Mandscherui, which the College introduced about thirty years ago and which has done so much in the improvement of barley growing in Ontario. It is now estimated that about 95 per cent. of all the barley which is grown in Ontario belongs to the Mandscheuri or the O. A. C. No. 21 varieties, the latter largely predominating.

Field of O. A. C. No. 21 Barley on the College Farm.

Of about forty entries of barley at the Provincial Winter Fair, held in each of the past three years, with only one exception in one year, all the entries were of the O. A. C. No. 21 variety. In the competition of Standing Field Crops throughout Ontario last year, there were 53 fields of barley entered. Of this number, 44 were of the O. A. C. No. 21 and 8 of the Mandscheuri variety, leaving only one entry of any other kind. In the Standing Field Crop Competitions throughout Ontario for the past three years, the O. A. C. No. 21 has taken first place without an exception in all the twenty-eight separate competitions with barley, there being at least ten fields entered in each competition.

Winter Barley.

Winter barley is not grown as a commercial crop in Ontario. Experiments have been conducted at the College, however, with several varieties of winter barley obtained from different sources, one object being to test the different kinds of winter barley in existence, and another to ascertain whether by continuous growing of winter barley at the College over a long series of years the hardiness of the grain could be improved. The following gives the average of **Six Years'** results of each of five varieties of winter barley:—

Varieties.	Weight of Grain per Measured bushel (pounds).	Yield per Acre.	
		Straw. (tons).	Grain (bushels).
Tennessee....................	49.7	1.4	56·2
Wood's......................	49.4	1.3	51.7
Groninger New..............	48.9	1.1	38.2
Groninger No. 1	47.9	1.1	38.1
Groninger No. 2	48.7	1.0	34.0

In height, the first two named varieties had an average of 34 inches each, and the last three from 30 to 31 inches.

We have now had one strain of winter barley under experiment at the College in each of the past twenty-five years. In three of these years the crop was an entire failure owing to winter killing. Those three years, however, occurred within the first six years of the experiment. There has been no complete failure with the crop since 1900. The average yield per acre for the twenty-two out of the twenty-five years in which the barleys survived winter was 48.2 bushels per acre per annum, and the average weight per measured bushel was 52 pounds. The yield in bushels per acre during the past nineteen years has had a range of from 42.3 the lowest to 52.5 the highest. The yield per acre in 1918 was 48.5 bushels as determined in the experimental grounds.

Varieties of Winter Wheat.

About three hundred varieties of winter wheat and many selections and crosses have been grown under experiment at the Agricultural College within the past twenty-nine years. Nearly all of the varieties have been carefully tested in each of five years, after which the inferior kinds have been discarded and those which have given the best results have been continued in the experiments. Of the named varieties fourteen have been grown in each of twenty-three years, and the results of these are of special value. The following table gives for each of these fourteen varieties the average weight per measured bushel for twenty-two years, and the average yield of both straw and grain per acre for the **Twenty-Three** year period:—

Varieties.	Color of Grain.	Pounds per Measured Bushel. Average 22 years.	Yield per Acre. Average 23 Years.	
			Straw (tons).	Grain (bushels).
Dawson's Golden Chaff.	White	59.5	2.8	48.7
Imperial Amber	Red	60.8	3.1	46.8
Egyptian Amber	Red	61.2	3.1	44.9
Early Genesee Giant...	White	59.8	2.9	44.6
Early Red Clawson....	Red	58.6	2.7	44.3
Rudy..................	Red	61.0	2.7	43.4
Tasmania Red	Red	61.4	2.8	43.3
Tuscan Island.........	Red	61.0	2.8	43.0
Turkey Red...........	Red	61.1	2.7	42.3
Geneva	Red	61.6	2.9	42.2
Kentucky Giant.......	Red	60.6	2.7	41.7
Bulgaria	White	60.4	2.7	40.9
McPherson	Red	61.5	2.5	40.7
Treadwell	White	59.5	2.7	40.1

The average results of the fourteen varieties for the whole period are as follows: Yield of grain per acre 43.4 bushels, yield of straw per acre 2.8 tons, and weight per measured bushel 60.6 pounds.

The Dawson's Golden Chaff is still the most extensively grown variety of winter wheat in Ontario, according to information secured through correspondence with practical farmers. This variety, in the results of Guelph for twenty-three years, has given an annual average yield of grain per acre of 1.9 bushels over the next highest variety, and of 8.6 bushels per acre over the lowest yielder of the fourteen varieties included in the test, all of which were grown under similar conditions. The Dawson's Golden Chaff was originated in Ontario thirty-seven years ago. It produces a very stiff straw of medium length, beardless heads with red chaff, and white grain which weighs about the standard per measured bushel. It is probable that the Dawson's Golden Chaff is improving slightly in quality for bread production.

The following table gives the average yield per acre for **Nine Years** of each of **Twenty-Eight** varieties: —

Varieties.	Bearded or Bald.	Color of Chaff.	Color of Grain.	Yield per Acre. Average 9 Years. Bushels Grain.
American Banner	Bald	Red	White	57.3
No. 6	"	"	"	56.2
Dawson's Golden Chaff	"	"	"	56.0
Prize Taker	"	"	"	54.9
Superlative	"	"	"	54.8
Forty Fold	"	"	"	52.2
Early Genesee Giant	Bearded	"	"	51.3
Egyptian Amber	"	White	Red	50.2
Russian Amber	"	"	"	50.2
Imperial Amber	"	Red	"	50.1
Paramount	Bald	"	"	49.9
Genesee Reliable	Bearded	White	"	49.6
Turkey Red	"	"	"	49.1
Treadwell	"	"	White	48.7
Harvest King	Bald	Red	Red	48.5
Rudy	Bearded	White	"	48.4
McGarvin	Bald	Red	"	48.3
Kentucky Giant	Bearded	White	"	48.0
Michigan Amber	"	"	"	48.0
Buda Pesth	"	"	"	47.9
Early Red Clawson	Bald	Red	"	47.9
Amherst Isle	Bearded	White	"	47.7
Geneva	"	"	"	47.4
Economy	Bald	"	"	46.7
Bulgarian	Bearded	"	White	45.6
Tuscan Island	"	"	Red	45.3
Tasmania Red	"	Red	"	44.9
McPherson	Bald	White	"	44.6

It will be noticed that each of the six highest yielding varieties have beardless heads, red chaff and white grain. The seven highest yielding varieties are white, and with one exception the fourteen lowest yielding varieties are red-grained.

The American Banner is identical in all essential characteristics with the Dawson's Golden Chaff.

The variety of winter wheat known as "No. 6" closely resembles in appearance the Dawson's Golden Chaff, except that the head is less tapering and the upper portion of the straw is somewhat colored. In the average of nine years' experiments at the College it has yielded fully epual to the Dawson's Golden Chaff and has produced grain which is of somewhat better quality for bread production. The No. 6 variety was originated by Ira W. Green, at Avon, N.Y., and is at present the most popular winter wheat grown in the Genesee Valley, New York State. This wheat is also grown under different names, including "Gold Coin."

To supplement the seed wheat in Ontario, the writer went to New York State and made special arrangements by which a good supply of the best seed obtainable of No. 6 wheat was secured from farms in the western section of the Genesee Valley. This wheat was cleaned at the local elevators and carefully recleaned at Niagara Falls. The wheat was then distributed in car load lots this autumn to Hamilton, Meaford, Napanee, Bolton, Toronto, Mitchell, St. Mary's, Dundas,

The O. A. C. No. 104 variety of Winter Wheat with its two parents, the Dawson's Golden Chaff and the Bulgarian.

Streetsville Junction, and Caledonia. The record of this new importation will be watched with interest in these different localities.

According to the Monthly Bulletin on Agricultural Statistics for the Dominion of Canada for June, 1918, the number of acres of winter wheat in Ontario was given as 277,200 in 1918, and as 656,500 in the year previous. This reduction was largely due to adverse weather conditions at the time of seeding in the autumn of 1917 and to the exceptionally severe winter which caused much killing. It is estimated that 56 per cent. of the winter wheat of Ontario was ploughed down in the spring of 1918. According to the reports of the Bureau of Industries for

Ontario the average number of acres of winter wheat for the past thirty-six years has been 825,923.

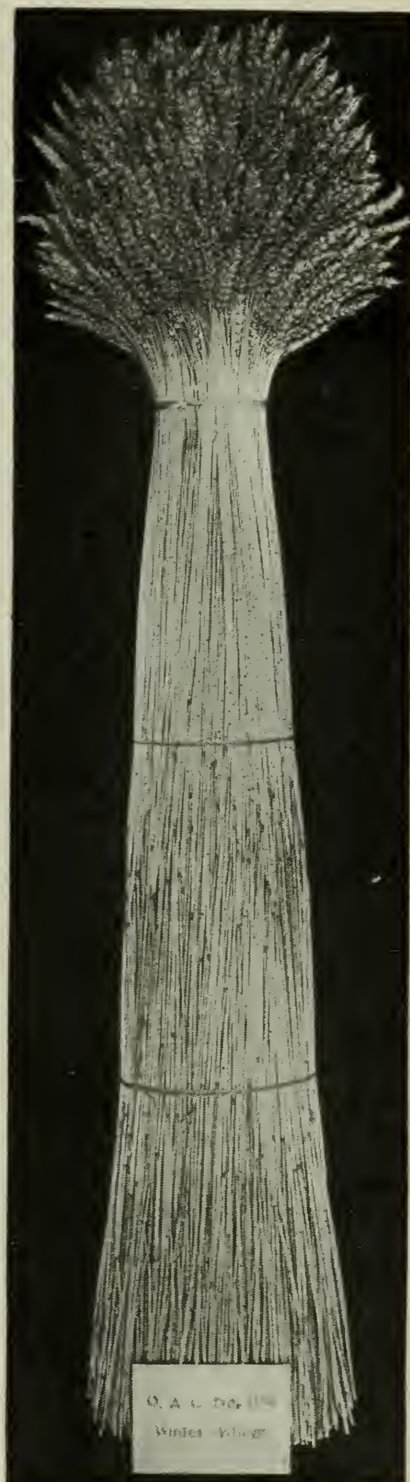
The results of twelve separate tests made at the College show an average increase in yield of grain per acre of 6.8 bushels from large as compared with small seed, of 7.8 bushels from plump as compared with shrunken seed, and 35.6 bushels from sound as compared with broken seed. Seed which was allowed to become thoroughly ripened before it was cut produced a greater yield of both grain and straw and a heavier weight of grain per measured bushel than that produced from wheat which was cut at any one of four earlier stages of maturity.

In each of two years when winter wheat was sprouted in the fields, germination tests of the grain were made. The following results show the average percentages of germination from each selection: Skin over germ, unbroken, 94; skin over germ, broken, 76; sprouts one-quarter inch long, 30; and sprouts one inch long, 18. Not only were the sprouted seeds low in germination, but the plants produced were very uneven in size.

In the average of eight separate tests, land on which field peas were used as a green manure yielded 6.5 bushels of wheat per acre more than land on which buckwheat was used as a green manure.

In the Experimental Department, winter wheat which has been grown on clover sod has yielded much better than that which has been grown on timothy sod.

In the average of five years' experiments varieties of winter wheat gave practically the same results when sown separately as when sown in combination.



Sheaf of O. A. C. No. 104 Winter Wheat.
(Reduced to one-eighth.)

New Winter Wheats Originated at the O. A. C.

With the object of originating better varieties than those already in cultivation, crosses have been made between Dawson's Golden Chaff and some of the varieties of particularly high quality for bread production such as Tasmania Red, Crimean Red, Turkey Red, Buda Pesth, Bulgarian, and Imperial Amber. In the average tests for five years crosses between the Dawson's Golden Chaff and the Tasmania Red, Turkey Red and Bulgarian have each surpassed in average yield of grain the highest yielder of all the named varieties.

A cross made between the Dawson's Golden Chaff and the Bulgarian has surnished a new variety which in eight years has surpassed both its parents in average yield per acre and is about equal to the Bulgarian in bread production. This variety has been given the name of "O. A. C. No. 104." The following gives the average results of the O. A. C. No. 104 in comparison with each of its parents for a period of **Eight Years**:

Varieties.	Weight per Measured Bushel (pounds.)	Yield per Acre.	
		Straw (tons.)	Grain (bushels.)
O. A. C. No. 104	60.1	2.64	**45.7**
Dawson's Golden Chaff	58.4	2.29	**42.4**
Bulgarian	59.3	2.37	**36.6**

In the experiments at the College the O. A. C. No. 104 proved to be one of the hardiest varieties in the past year, when so much damage was done by winter killing. It has been distributed throughout Ontario in connection with the co-operative experiments in each of the past three autumns. In each of the two years for which we have returns it has proven both productive and popular with the experimenters.

The O. A. C. No. 104 variety is not yet obtainable in large quantities, but there will probably be some seed available from the co-operative experimenters by next autumn.

Sheaf of Marquis Spring Wheat.
(Reduced to one-eighth.)

SPRING WHEAT.

The area of spring wheat grown in Ontario was 351,423 acres in 1918, 182,957 acres in 1917, 144,305 acres in 1916, 162,142 acres in 1915, 118,607 acres in 1914, and 116,581 acres in 1913. Although there had been a general decrease in the acreage of spring wheat from 1884 to 1913, it will be seen that the increase during the past five years has been quite marked. It is estimated that the total production of spring wheat in Ontario for 1918 is 8,186,191 bushels, the yield per acre being 23.3 bushels. As spring wheat has done so well during the past year throughout the Province of Ontario it is quite probable that there will be a considerable acreage devoted to this crop in the next few years. The crop requires about the same amount of labour as oats, barley, rye or buckwheat and considerably less labor than any of the cultivated crops.

Spring wheat can be grown successfully on a variety of soils. It thrives particularly well, however, on well drained, rich loam containing a fair amount of decaying vegetable matter. Fertile clay soils when well drained usually give satisfactory results in spring wheat production.

In crop rotations such as those followed in Ontario, spring wheat fits in very nicely. In experiments conducted at the Ontario Agricultural College it has given good results when sown after corn, potatoes, swede turnips, fall turnips, carrots and rape. It usually gives satisfactory results when sown on sod land ploughed in the autumn or on land which has grown beans or peas, and which has had thorough preparation so as to permit of early seeding in the spring. Spring wheat forms one of the very best nurse crops with which to seed grasses and clovers, either singly or in combination.

Twenty-one varieties of spring wheat, exclusive of Emmer, Spelt and Einkorn, have been under uniform tests at the Agricultural College in each of the past six years. The experiment was conducted on what might be termed an average clay loam. In part of the years the plots were located on a ridge and in other years on lower, sloping land. The following table gives the average results of the **Six Years'** experiment with each of twenty-one varieties of spring wheat:

Varieties.	Bearded or Bald.	Average Height. (inches)	Per Cent. Rust.	Days to Reach Maturity.	Weight per Measured Bushel. (pounds)	Yield per Acre.	
						Straw (tons.)	Grain (bushels.)
Flour Wheats—							
Saxonka	Bearded	48	9	117	60.66	2.61	**40.54**
Climax	"	47	6	117	59.72	2.68	**40.51**
Pringle's Champion	"	48	7	117	60.66	2.60	**39.70**
Marquis	Bald	41	10	113	61.14	2.13	**39.08**
Minnesota No. 163	"	45	7	117	58.83	2.42	**38.65**
Herison Bearded	Bearded	46	6	117	61.28	2.50	**38.38**
White Russian	Bald	44	7	116	58.18	2.45	**37.97**
Hungarian	Bearded	42	9	113	61.93	2.36	**37.73**
Red Fern	"	48	8	116	60.28	2.44	**37.46**
Red Fife	Bald	44	8	116	58.99	2.40	**37.04**
White Fife	"	42	9	118	57.98	2.32	**36.15**
Colorado	Bearded	47	7	116	60.27	2.38	**35.54**
Prelude	"	36	12	104	62.21	1.67	**28.69**
Durum Wheats—							
Arnautka	Bearded	46	3	116	62.30	2.22	**41.55**
Roumania	"	46	3	116	61.74	2.14	**40.55**
Wild Goose	"	47	3	116	61.75	2.28	**40.03**
Kubanka	"	47	4	116	61.56	2.20	**38.90**
Sorentina	"	46	4	114	60.74	2.14	**35.55**
Medeah	"	46	4	113	61.29	2.10	**34.00**
Turgid Wheat—							
Seven Headed	Bearded	47	11	118	58.31	2.33	**33.37**
Polish Wheat—							
Polish	Bearded	42	10	117	57.16	2.00	**26.19**

The Saxonka, the Climax and the Pringle's Champion, which occupy the three highest places in yield per acre of the flour wheats, are not grown extensively in Ontario. The Marquis variety of spring wheat which occupies fourth place in average yield per acre, is a hybrid wheat originated at the Central Experimental Farm, Ottawa, from crossing the Calcutta Hard Red and the Red Fife. It is not only a good yielder, but it is a wheat of excellent quality for bread production and one which is increasing substantially in the Western Provinces and in Ontario. It occupies a somewhat similar position amongst the spring wheats as does the O.A.C. No. 21 barley, the O.A.C. No. 72 oats and the O.A.C. No. 61 spring rye amongst other classes of spring grain. Of the Durum wheats, the Wild Goose variety has been grown for many years in Ontario and is popular amongst the farmers. The Arnautka is very similar to the Wild Goose but is not grown much in Ontario under that name.

In each of the years 1915 and 1916, the varieties of spring wheat were milled and uniform quantities of flour were tested for bread production in the Bakery branch of the Chemical Department at the College. The leading varieties in volume of loaf are given in the following order: Prelude, Marquis, White Fife, White Russian, Hungarian and Minnesota No. 163. Those varieties which produced the lowest volume of bread were Polish, Seven Headed and Medeah. The Prelude, which came first in size of loaf, was also originated at the Central Experimental Farm. The Saxonka, which secured highest place of the flour wheats in average yield of grain per acre for five years, occupied fourteenth place in comparative size of loaf in the baking tests of two years, but in this respect slightly surpassed both the Pringle's Champion and the Climax varieties.

A new hybrid variety of spring wheat has been originated at our College by crossing the Red Fife and the Herison Bearded varieties, and it has given an average yield of grain of 42.2 bushels per acre per annum in the experiments for the last six years. This is a higher average yield per acre than any of the named varieties. In comparative size of loaf, from a definite quantity of flour, it was surpassed by nine of the twenty-one named varieties reported in the previous table. This new variety has not been distributed for general cultivation.

Tests have been made at the College in comparing the results in growing spring wheat after potatoes and fall turnips for each of three years, and after corn, swede turnips, carrots and rape for one year. The results show very good yields of spring wheat per acre after each of these cultivated crops, and particularly good returns after potatoes and corn. It is of great importance to have land either ploughed or cultivated in the autumn so as to permit of early seeding of the wheat in the following spring.

Spring wheat was sown at the College with a tube drill and broadcast by hand on well cultivated land at each of six different dates in each of five years. The results go to show that in yield of grain per acre of the five separate dates for which we have complete returns, the drilled grain gave the highest yields in the average of each of four dates, and the grain which was sown broadcast by hand gave the highest returns in the average of one date. In averaging the results for all dates of sowing, there was but slight difference in the returns from the two methods of seeding. If the land had been poorly prepared and lumpy, it is quite likely that the grain which was sown with the tube drill would have produced a considerably higher yield than that which was sown broadcast.

Emmer, Spelt and Einkorn.

In the case of each of three types or species of wheat, there is not a clear separation of the chaff and the grain in the process of threshing. These include the emmer, the spelt and the einkorn. Emmer and spelt are used in some countries to a limited extent for flour production. When used for this purpose, however, special machinery is required for separating the chaff or the hull from the grain. In this country these grains are considered from the standpoint of the amount of feed which they will produce for farm stock. Emmer is considered about equal to barley for feeding purposes. The following table gives the average of **Thirteen Years'** results of each of four varieties of emmer and four varieties of spelt:

Classes of Crop.	Varieties.	Per Cent. of Hull (Average 12 Years.)	Per Cent. of Rust.	Per Cent. of Crop Lodged.	Weight per Measured Bushel. (pounds).	Yield per Acre.	
						Straw (tons).	Grain (pounds).
Emmer	Common	19.75	2	21	39.58	1.93	2,779
	Emmer No. 1529	19.54	2	14	39.17	1.89	2,738
	Russian	19.96	2	15	39.59	1.75	2,712
	Iowa	19.10	2	18	39.69	1.78	2,680
Spelt	Alstroum	28.65	13	4	27.40	1.52	2,140
	Red	28.14	10	7	27.88	1.53	2,117
	White Summer	29.17	13	3	27.26	1.56	2,087
	Triticum Spelta	26.07	10	14	29.35	1.57	2,061

A few years ago emmer was introduced by some of the seedsmen under the name of spelt and was advertised very extensively both in Canada and the United States, and most extravagant claims were put forward for this grain. The results of experiments conducted at Guelph are of value in giving some true and reliable information regarding the two species of grain and the comparative results of some of the varieties of each type. It will be seen that each of the four varieties of emmer gave a much higher average yield of both grain and straw per acre than each of the varieties of spelt. The percentage of hull of emmer is only about two-thirds as great as that of spelt and is only about two-thirds as great as the percentage of hull of the average variety of oats. Common emmer in yield of grain per acre has been a close rival to the best varieties of barley and the best varieties of oats. Throughout Ontario, however, in connection with the co-operative experiments, the O.A.C. No. 21 barley has given rather better results in grain production than Common emmer.

Varieties of Winter Rye.

In 1918 there were 112,726 acres of rye grown in Ontario. This includes the rye which was sown in the spring as well as that which was sown in the autumn. The latter, however, comprises the greater part of the rye crop of the Province. Four varieties of winter rye have been under test at the Ontario Agricultural College in each of the past **Fifteen Years.** The following gives the average results for the whole period:

Varieties.	Per Cent. of Crop Lodged.	Weight per Measured Bushel (pounds).	Yield per Acre.	
			Straw (tons).	Grain (bushels).
Mammoth White...	11	57.1	3.9	**57.2**
Washington	20	57.3	3.7	**54.4**
Common	11	57.4	3.8	**53.3**
Thousand Fold	18	57.0	3.8	**52.9**

The results show that all varieties of winter rye produced a high average yield of grain per acre. It should be understood that these have been grown on similar soil to that used for the other cereals under experiment. In many cases over Ontario, winter rye is sown on soil which is so poor that it will scarcely grow any other crop. If winter rye were sown under similar conditions as winter wheat over Ontario, the yields per acre would undoubtedly be higher than they are at the present time.

For seven years in succession the Petkus variety of winter rye has been included in the experiments and, with three slight exceptions has surpassed all other kinds in each of the seven years. The average yield per acre per annum of the Petkus winter rye surpassed that of the next highest yielding variety by four bushels in the seven years' test.

Varieties of Spring Rye.

Spring rye is not grown as extensively in Ontario as that which is sown in the autumn. Some farmers, however, grow a limited quantity of this crop. An experiment has been conducted at the College with four varieties throughout the past **Eleven Years** with the following results:

Varieties.	Yield of Straw per Acre (tons).	Weight of Grain per Measured Bushel (pounds).	Yield of Grain per Acre by Weight (bushels).
O. A. C. No. 61 ..	2.26	54.1	**31.6**
Saatroggen	2.29	54.4	**30.7**
Common	2.13	54.1	**27.8**
Prolific	2.08	54.2	**27.7**

Some years ago a valuable variety of winter rye was obtained from Germany. This was gradually converted into a spring variety in the tests at the College and is reported in the foregoing table as Saatroggen. From the Saatroggen rye, a number of the choice plants were selected and were grown separately. The O.A.C. No. 61 variety was originated from one of these selections. Its history, therefore, traces back to a single selected plant obtained at the College from the Saatroggen variety.

Varieties of Buckwheat.

In 1918 there were 223,662 acres of buckwheat grown in Ontario in comparison with 153,457 acres in 1917. The average number of acres of buckwheat in Ontario for the past 36 years has been 118,648 acres per annum. The following table gives the average results of **Thirteen Years'** tests with each of four varieties of buckwheat grown in the Experimental Department:

Variety.	Weight per Measured Bushel (pounds).	Yield per Acre.	
		Straw (tons).	Grain (bushels).
Rye or Rough	50.1	2.4	**30.3**
Common Grey	45.9	3.0	**21.7**
Silver Hull	50.2	3.0	**21.2**
Japanese	45.0	3.2	**21.2**

In each of ten out of the thirteen years, the Rye or Rough buckwheat gave a higher yield of grain per acre than any one of the three other varieties. This buckwheat is not grown extensively in Ontario but it has been produced to a considerable extent in the Maritime Provinces and especially in Nova Scotia. The flour of the Rye buckwheat has a slightly yellowish color. The grain itself is not as attractive as that of the Silver Hull variety and it is possible that the hull may be a little thicker than that of the last named variety.

Varieties of Field Peas.

The number of acres of field peas in Ontario in 1917 was 90,322 and in 1918, 113,862. In the past year the total production of peas in this Province amounted to 2,381,937 bushels and the average yield per acre was 20.9 bushels as against 16.7 bushels in 1917, 13.0 bushels in 1916, and 19.1 bushels as the average of the past thirty-six years. In order to give as much assistance as possible, the College has tested a large number of varieties of field peas obtained from different parts of the world to determine the most suitable kinds for grain production in Ontario. As in the case of other kinds of grain the lower yielding varieties have been dropped after being carefully tested and only the most productive kinds have been retained for more than five years. The following table gives the average results of experiments for the past **Five Years** for each of nineteen varieties which have been tested at the College:

Varieties.	Color of Grain.	Per Cent. of Peas Weevilly.	Days to Mature.	Length of Vines (ins.).	Weight per Measured Bushel (lbs.).	Yield of Straw per Acre (tons).	Yield of Grain per Acre (bus.).
Shannon Peas	Light Brown	41	104	49	56.3	1.70	**37.97**
Spanish No. 22077 (Wash.)	Brown	14	106	43	66.9	1.72	**36.50**
No. 18806 Green (Wash.)	Green	21	101	36	59.7	1.28	**35.27**
Small Blue Peas	Blue	12	104	29	62.1	1.19	**32.23**
Potter	White	10	112	51	61.3	1.58	**32.07**
Concordia Blue	Blue	9	110	30	62.5	1.35	**31.61**
Clamart	White	9	110	47	61.6	1.50	**31.22**
New Canadian Beauty	White	15	113	46	61.9	1.78	**31.11**
Black Eyed	Smoky White	9	114	47	61.1	1.66	**30.61**
Arthur	White	7	111	38	63.1	1.44	**30.35**
White Wonder	White	10	107	26	62.8	1.35	**30.48**
White Marrowfat	White	16	114	47	61.9	1.71	**28.39**
Early Britain	Light Brown	6	112	45	60.4	1.65	**26.65**
Prussian Blue	Bluish Green	13	116	49	62.5	1.72	**26.49**
No. 20467 (Wash.)	Brown & Green.	8	110	46	60.9	1.73	**25.03**
Golden Vine	White	8	115	50	63.1	1.75	**24.14**
Multipliers	White	9	116	52	62.9	1.81	**24.10**
No. 12887 (Wash.)	Brown	14	113	44	61.7	1.64	**23.13**
Solo Peas	Greenish Brown.	8	111	45	60.9	1.48	**22.14**

The Shannon variety of field peas which comes at the head of the list is a light brown pea and the pods when green are dark purple in color. Although the Shannon pea has given a comparatively large yield per acre it has been surpassed by some of our new hybrid varieties in the tests of the past four years. As for instance, one hybrid surpassed the Shannon in yield of grain per acre by 6.9 bushels in 1915, 7.5 bushels in 1917, and 6.8 bushels in 1918 but in 1916 this hybrid was surpassed by the Shannon by an average of one bushel per acre. More information will be given regarding our new hybrid peas in the near future, providing the results prove satisfactory in every way and the new varieties can be increased so as to be included in our co-operative experiments throughout Ontario.

It will be observed that the longest strawed varieties are the Multipliers, the Potter and the Golden Vine. These are particularly suitable varieties for mixing with oats in the production of green fodder or of hay from which satisfactory results have been obtained by using a mixture of one bushel of peas and two bushels of oats or a total of three bushels per acre.

Varieties of Field Beans.

The average acreage of beans in Ontario for the past thirty-six years according to the Ontario Bureau of Industries Report is 47,046, and the area in each of the past two years has been over 100,000 acres. The average yield of beans per acre in Ontario for the thirty-six year period has been 16.3 bushels, but the last four years being abnormal in respect to high rainfall have given less than normal yields. Those counties of Ontario which have given the greatest attention to the production of field beans are Kent, Huron, Elgin, Welland, Middlesex and Norfolk. The following gives the average weight per measured bushel and yield of beans per acre of each of seven varieties tested over **Seventeen Years**:—

Varieties.	Weight per Measured Bushel (pounds).	Yield of Grain per Acre per Annum (bushels).
Pearce's Improved Tree	64.3	**21.9**
Scholfield Pea	65.2	**21.0**
White Wonder	64.6	**19.8**
Medium or Navy	64.9	**19.6**
Marrowfat	64.6	**19.2**
Small Pea	64.5	**17.5**
Large White Haricots	59.8	**17.1**

The beans here reported are all white in color and are all suitable for commercial purposes. The Pearce's Improved Tree bean which comes at the head of the list will probably not be grown as much in general cultivation as the Small White Pea variety owing to the fact that it is a little later in reaching maturity. Selections of the Pearce's Improved Tree beans are now being made with the object of retaining the good yielding quality and hastening somewhat the maturity of this valuable variety.

In the average results for the past five years in which we have had rather abnormal weather conditions, some of the varieties which come highest in yield per acre are Marrowfat, Pearce's Improved Tree, White Wonder, and New Prize Winner. The lowest yielders of the seventeen varieties for the five-year period are: Wardwell Kidney, Black California Pea, Yellow California Pea and White Kidney. In 1918 those varieties which gave the highest yields per acre were Marrowfat and Pearce's Improved Tree and those which gave the lowest yields per acre were the Black California Pea, Wardwell Kidney, and Yellow California Pea.

A considerable amount of work is being carried on not only to improve the

Plant of Pearce's Improved Tree Bean.

productiveness of beans by selection of individual plants but also to try and secure strains of varieties as immune as possible to the attacks of anthracnose and other diseases which are troublesome to this crop.

Varieties of Soy or Soja Beans.

Numerous experiments have been conducted at the College with different varieties of Japanese beans, usually termed Soy or Soja. This class of crop has not been grown extensively in this country but is being used to a limited extent by some of the progressive farmers. Many of the varieties which are grown in the central or southern States are entirely too late to mature in this Province. We have been testing some of the most promising varieties obtained from Japan, Russia and the United States with the idea of ascertaining whether or not any of these sorts would give satisfactory results in the Province. Seed of one or two of the best varieties has been distributed for co-operative experiments in the spring of the year for a number of seasons.

Soy beans furnish exceedingly rich feed for farm stock and the plants may be cut and converted into silage or they may be allowed to ripen for the production of grain. Upwards of thirty varieties have been under experiment at the College. In 1918 eighteen varieties and selections of soy beans were grown under similar conditions in the experimental grounds at the College. Of this number twelve varieties have been grown in competition in each of the past **Five Years** in succession, and the following table gives the average number of pounds per measured bushel and the average number of pounds of grain per acre of each of the varieties:

Varieties.	Average Number of Pounds per Measured Bushel.	Average Number of Pounds of Grain per Acre.
O. A. C. No. 111	54.9	**946**
Buckshot (No. 17251, Wash.)	55.9	**945**
Habara (No. 20405, Wash.)	56.0	**940**
Chernie (No. 18227, Wash.)	58.1	**927**
Brown	58.5	**918**
Quebec No. 92	58.5	**886**
Early Yellow	56.1	**851**
Tsurunoko	58.1	**839**
Quebec No. 537	56.8	**815**
O. A. C. No. 81	58.0	**805**
Ito San	57.0	**800**
Medium Green	....	**370**

Three varieties were obtained through the Department of Agriculture at Washington and these occupy second, third and fourth places in the list in average yield per acre for five years. All varieties, however, were surpassed by a selection made at the College which was started from an individual plant selected from the Early Yellow variety. We obtained two selected varieties from the Macdonald College, Quebec, under the name of Quebec No. 92 and Quebec No. 537. The former occupies sixth and the latter ninth place in average yield of grain per acre. In 1918, the highest yield in the duplicate experiment was obtained from the Habara.

In each of the past few years two varieties have been distributed for co-operative experiments. The Brown variety has proven early and in some seasons and under certain conditions has given a little higher results than the O.A.C. No. 81. In normal years the O.A.C. No. 81 has surpassed the Brown variety.

Hairy Vetches and Spring Vetches for Seed.

Common spring vetches have been grown in Ontario to a limited extent for a good many years, especially for mixing with oats and peas for the production of fodder. Hairy vetches, however, are a more recent introduction and may be grown in the fall or in the spring. They are used for the production of green fodder and of hay and as a cover crop in orchards. The vetches are leguminous crops and furnish feed which is rich in nutritive constituents. The Common vetches have been tested at the College and when grown separately have usually proven a failure from the standpoint of seed production.

The seed of the Hairy vetches has been mostly imported and is very expensive. It has been found through experiments that the seed can be grown in Ontario with a fair amount of satisfaction. In experiments covering a period of seventeen years in which Hairy vetches were grown in the autumn for the production of seed in the following year an average of 7.85 bushels of seed per acre has been obtained. In three of these years the yield was upwards of 18 bushels per acre per annum and in four other years less than two bushels per acre. In 1913 the crop was a failure owing to the fact that it was killed out in the winter and the early spring more than any other year during the entire experiment. In 1918 the yield of seed was 11.66 bushels per acre. The Hairy vetches which have been grown at the College for several years have produced about forty per cent. greater yields of seed per acre than the Hairy vetches which have been imported more recently.

In the southern part of Ontario some farmers are sowing rye and vetches together. The rye tends to keep the vetches from the ground and to increase the production of a good quality of seed. This seems to give rather better satisfaction than when the Hairy vetches are grown by themselves. In experiments conducted at the College during the past three years interesting results have been obtained by sowing in the autumn Hairy vetches with each of three kinds of grain, viz., winter wheat, winter rye and winter emmer. The highest yield of vetch seed has been obtained from the Hairy vetches and the winter rye sown in combination.

Occasionally Hairy vetches are sown in the spring of the year for seed production but the results are not nearly as satisfactory as those obtained from the autumn sowing. The autumn sowing usually produces about double the amount of seed obtained from the spring seeding.

Grass Peas.

Some years ago grass peas were grown as a regular grain crop in Ontario. They were also used to a limited extent for the production of fodder. The grain was ground into meal and the meal which was rich in valuable food constituents was used in small quantities to increase the value of the meal ration of other grains.

The grass pea is an annual legume. The stems of the plants are flat and the whole crop, when used as a green fodder, is greatly relished by animals. The flowers are white in color and the grain is angular in form, very hard, and immune to the attacks of the pea weavil, commonly called pea bug.

In the experimental tests over a period of ten years, the yield was about 12 bushels per acre. In 1918 on a plot of about a quarter of an acre, the yield was at the rate of 16 bushels per acre. The grass peas thrive best when the weather is comparatively warm with not a very large amount of rainfall. As some of the recent years have had an abnormally large amount of rain, this crop has not grown as successfully as it did a few years ago. Many farmers who formerly grew grass peas as a farm crop have discarded them but they are still grown to a limited extent.

Cow Peas.

Nearly all the varieties of cow peas are quite unsuitable for this Province. In years past, we have grown many varieties but practically all have required too long a season for development and the crop has usually been a failure. The two varieties grown in 1918, viz., the Whip-poor-will and Wonderful, did not even produce pods before the plants were frozen in the autumn. Although much is said and written in regard to the value of the cow peas for the southern states, we must remember that the conditions in Ontario are quite different. The farmers of Ontario should give their attention to those classes of farm crops which will prove the most suitable for their conditions. The common red clover occupies about the same position in the agriculture of Ontario as do the cow peas in the southern states.

Varieties of Corn for Grain Production.

In 1918, 195,310 acres were used in the Province of Ontario for the production of corn for husking. The highest acreage used for husking corn in Ontario in the last thirty-seven years occurred in 1903 when 378,924 acres were used for this purpose. The tendency during the past few years has been to increase the fodder or the silo corn and decrease somewhat the corn for husking purposes. The area for husking corn in 1918 was lower than in any previous year since 1892. This will probably be accounted for largely by the scarcity of good seed and the lack of labor, as a large amount of labor is required in cultivating the corn and in husking the crop.

Experiments have been conducted at the College with a large number of varieties of corn, some of which do not ripen sufficiently to obtain satisfactory yields of matured seed when grown over a series of years. In the average of ten years' experiments the following yields in bushels per acre have been obtained by those varieties which have usually ripened the grain fairly well: Early California Flint, 52.1; Hammond's White Cap Yellow Dent, 49.4; Salzer's North Dakota, 48.9; Duke's Longfellow, 45.3; Zavitz' White Cap Yellow Dent, 43.6; Genesee Valley, 42.1; Duke's Compton's Early, 40.9. These yields are comparatively low owing to two or three poor seasons for grain production for the different varieties of corn. In 1918, the highest number of bushels per acre were obtained from Early California Flint, 40.8; Hammond's White Cap Yellow Dent, 39.4; and Salzer's North Dakota, 37.3. It will, therefore, be seen that the same three varieties gave the highest yield per acre in 1918 as in the comparative test for ten years. Such varieties as the Leaming, Wisconsin No. 7, and Mammoth Southern Sweet, do not ripen sufficiently well at Guelph to give satisfactory returns for grain production.

Some interesting and valuable experiments are under way in testing the comparative value of planting corn by the use of six different quantities of seed per acre in the case of both flint and dent varieties. By having the rows equal distances apart and the plants at one inch, two inches, three inches, six inches, nine inches, and twelve inches apart, some valuable results are being secured as the chemical analyses as well as the actual yields per acre are being obtained. This experiment will likely continue for two or three years more before the results are compiled and ready for publication.

Another experiment is under way in which large, medium, and small kernels of corn are being tested for crop production. Up to the present time the large kernels have produced the largest, most vigorous and most productive plants.

The results of varieties of corn for fodder and the silo are presented in the latter part of this bulletin.

Varieties of Sorghum for Seed.

More than thirty varieties of sorghum have been tested at the College within the past few years. These include different varieties of broom corn, saccharine sorghum (also called sugar cane), kaffir corn, Jerusalem corn, milo maize, etc. There are marked differences between the classes of sorghum and also between the varieties of the different classes. The sugar canes or more properly sugar sorghums contain a high percentage of sugar, while all of the other types of sorghum are non-saccharine.

In 1918 there were eighteen varieties of sorghum under experiment for seed production. Owing to an abnormal season of high rainfall the seed production was almost a failure. The greatest yields were produced by the Black Amber sugar cane and by the Ontario grown Early Amber sugar cane. As a rule, however, the highest yields have been produced by the broom corns, as they are somewhat earlier than the sugar sorghums. Three varieties of sorghum which have been grown for seed production in each of ten years have given an average yield of seed per acre as follows: Improved Evergreen Broom Corn, 1,025 pounds; California Golden Broom Corn, 1,017 pounds; and Early Japanese Broom Corn, 1,009 pounds.

The sorghums appear to do particularly well on warm, rich, sandy loams. They are sown and cultivated in much the same way as corn but the rows are usually placed a little closer together. The Early Amber sugar cane which has been grown in Ontario for some years and which has had a certain amount of selection is at present the most promising of the saccharine sorghums.

Sunflowers for Seed.

Sunflowers have been grown to a limited extent for the production of seed. The seed of the sunflowers has been quite highly recommended as a poultry feed. Evidently but little work has been done, however, in the testing of different varieties of sunflowers as crop producers at experiment stations in the United States or in Canada other than at Guelph. A number of years ago, seven varieties of sunflowers were obtained and grown under uniform conditions on our experimental grounds. In a short time some of these varieties were dropped but those which made the highest records were continued in the experiments. Sunflowers are planted in rows about forty inches apart and are cultivated in much the same way as corn, the plants being about a foot apart in the rows. The following table gives the average height and the average yield of grain per acre for **Eighteen Yea r** in the case of each of three varieties:

Varieties.	Height.	Yield of Seed per Acre.	
		Bushels. (20lbs.per bush.).	Pounds.
Black Giant	105	72.7	**1455**
Mammoth Russian....	100	71.5	**1430**
White Beauty........	89	70.3	**1406**

The sunflowers are very hardy and sometimes produce good returns when other crops are partial failures.

Varieties of Flax for Seed and for Fibre.

Flax growing in Ontario has received new impetus recently owing to the limited supply in Europe and the great demand for the flax fibre for use in the manufacture of the covering for the wings of aeroplanes. Although the requirements for this purpose will likely be reduced greatly it is quite probable that the demand for flax fibre in Ontario will be considerable until the European countries reach their normal condition of flax production. We have had under experiment at the College seven varieties and strains of flax in each of the past eight years. The following table gives the average results of each variety for the **eight-year** period:

Varieties.	Weight per measured Bushel (pounds).	Yield of Flax Seed per acre (bu. 56 lbs.)	Yield of Flax Straw per acre (tons).
O. A. C. No. 114	54.6	16.7	2.35
Minnesota No. 25	55.2	21.2	2.26
Primost...............	55.0	20.0	2.15
Common	53.6	19.9	2.15
Argentine.............	53.3	18.3	2.10
O. A. C. No. 116	54.1	19.7	2.09
Manitoba..............	53.7	19.1	2.04

In 1918, nine varieties of flax were under test, the Minnesota No. 25 producing the highest and the Lavanian Long Stem the second highest yield of fibre straw per acre. The greatest yield of seed was produced by the O. A. C. No. 116 and the second highest yield of seed by the Minnesota No. 25.

In each of the past fourteen years Common Ontario and Common Manitoba flax have been under test. The Ontario strain gave an average of 2.45 tons and the Manitoba strain 2.41 tons of fibre straw per acre per annum for the fourteen-year period. The Manitoba seed gave an annual average yield of 19.6 and the Ontario seed of 19.2 bushels per acre, 56 pounds being allowed as the standard weight per bushel.

Different Quantities of Flax Seed per Acre.

In each of five years four varieties of flax were sown at the rate of one peck, two pecks, three pecks, eight pecks, twelve pecks and sixteen pecks per acre, making in all twenty-four plots in the experiment each year. The following table gives the average results of the experiments for the **five-year** period:

Amount of Seed Sown.	Straw or Fibre Producing Material.		Weight per Measured Bushel.	Yield of Grain per Acre.	Yield of grain per acre, less amount of seed sown.
	Height of Crop.	Yield of Straw.			
	inches.	tons.	pounds.	bushels.	bushels.
1 peck per acre	29	1.55	54.9	14.9	14.6
2 pecks " "	29	1.68	54.7	15.2	14.7
3 " " "	29	1.96	54.8	18.6	17.8
8 " " "	28	2.24	54.6	19.9	17.9
12 " " "	27	2.35	54.3	20.2	17.2
16 " " "	26	2.24	54.2	18.0	14.0

It will be seen that the longest straw was produced when less than one bushel of seed per acre was used. It will also be noticed that the greatest yield of straw was produced when two bushels or more were used per acre. It should be remembered that the thin seeding encourages a considerable amount of branching of the stems. while the thick seeding produces straight stems with but little branching.

In the average yield of seed per acre it will be seen that where twelve pecks of seed were used, slightly over twenty bushels of flax seed were obtained. Where the amount of seed used, however, is subtracted from the amount of seed produced, the greatest yield has resulted from eight pecks per acre, which is only slightly more than that obtained from three pecks per acre.

Flax Production and Soil Fertility.

The actual amount of fertilizing constituents taken from the soil by different crops is an important matter from the farmer's standpoint. To secure this information it is necessary to have a knowledge of both the yields and the chemical composition of the crops. Unfortunately, the statistics gleaned by both the Dominion and the Provincial Governments do not furnish sufficient data for these calculations. In 1918 the first estimate of flax was made by the Bureau of Industries and was 12.3 bushels per acre. No estimates have been made for the straw of flax or of cereals. At the Agricultural College, however, accurate determinations are made from year to year of the yields of both grain and straw per acre of the different farm crops.

Flax, winter wheat, oats and barley have been grown under similar conditions in the experimental grounds at Guelph in each of the past twelve years. The varieties used for these determinations of the comparative exhaustiveness of soil fertility were Common flax, Dawson's Golden Chaff winter wheat, Banner oats and Mandscheuri barley. In each case the chaff was included with the straw. The flax was grown in duplicate plots each year with an average of 77 pounds of seed per acre, and the average returns, therefore, represent twenty-four tests in the twelve-year period.

For the chemical composition the figures used were obtained from the 1915 edition of "Feeds and Feeding" by Henry and Morrison with the exception of those of flax straw which are not given in that publication. For the chemical composition of the flax straw use has been made of the figures determined by Kennedy in his thesis prepared at the Ontario Agricultural College. The flax was obtained from the Field Husbandry Department, and it was analyzed in the Chemical Department of this institution. The following gives the average annual yields for the **Twelve-Year** period and the amount of fertilizing constituents obtained through the sources previously indicated:

Varieties.		Yield per Acre.		Nitrogen. (N).		Phosphoric Acid. (P_2O_5).		Potash. (K_2O).	
		Bushels and Tons.	Pounds.	Per Cent.	Total in Crop (lbs.)	Per Cent.	Total in Crop (lbs.)	Per Cent.	Total in Crop (lbs)
Common Flax	Seed	18.3	1024	3.62	37.1	1.50	15.4	.95	9.7
	Straw	2.45	4900	.72	35.3	.31	15.2	1.02	50.0
Dawson's G. C. Winter Wheat	Seed	43.2	2590	1.87	48.4	.85	22.0	.52	13.5
	Straw	2.22	4440	.50	22.2	.13	5.8	.74	32.9
Banner Oats..............	Seed	75.0	2550	1.98	50.5	.81	20.7	.56	14.3
	Straw	2.07	4140	.58	24.0	.21	8.7	1.50	62.1
Mandscheuri Barley	Seed	63.4	3043	1.84	56.0	.85	25.9	.74	22.5
	Straw	1.89	3780	.56	21.2	.18	6.8	1.20	45.4

The yields of all four crops are considerably larger than the average yields of the province. It should be clearly understood, however, that the experiments have been conducted under uniform conditions. The crops were grown during the twelve years immediately previous to 1917. The land received a four year's rotation during which three crops were removed from the soil. Farmyard manure was applied every four years at the rate of twenty tons (about twelve good sized loads) per acre. No commercial fertilizers were used with any of these crops.

In the growing of flax both the seed and the straw are frequently sold outright. The market value of these crops per acre, however, are usually the lowest for oats and barley and decidedly the highest for flax. It is interesting to note that the value of fibre per ton and of seed per bushel of flax in Ontario in each of three years was as follows: 1915, $400, $1.60; 1916, $600, $3.00; and in 1917, $1,100, $5.50.

According to the Monthly Bulletin of Agricultural Statistics for the Dominion of Canada for February, 1918, the fibre yield of flax for Western Ontario for 1917 was 350 pounds per acre, valued at 55 cents per pound, and the yield of seed 9 bushels per acre, valued at $5.50 per bushel. This would give a return from both the seed and the fibre of $242 per acre.

Varieties of Millet for Seed Production.

Millet sometimes forms an important crop in Ontario, more particularly to supplement the hay crop when it is found that there are poor prospects for a good crop of hay. It is grown largely for the production of green fodder but is also grown to a limited extent for the production of seed. Twenty varieties were under experiment in 1918 and the yield of seed varied from 5.9 to 30.4 bushels per acre. Those varieties which produced more than twenty-six bushels per acre were the Steele Trust, Holy Terror Gold Mine, Golden Wonder, and a selection of the Siberian. The following are the average results of each of seven varieties of millet over a period of **Thirteen** years:

Varieties.	Weight per Measured Bushel. (lbs.).	Yield of Seed per Acre. (bush.).
Siberian	53.3	**43.9**
Steele Trust	54.2	**42.7**
Hungarian	53.5	**40.0**
Holy Terror Gold Mine	51.0	**36.7**
Golden Wonder	52.1	**35.1**
Common	53.8	**32.0**
German or Golden	53.1	**31.8**

In the average of five years' experiments with each of sixteen different varieties the greatest yields were produced by Kursk, 36.9; Golden Wonder, 36.1; Siberian No. 92, 35.1; and Siberian No. 91, 34.1 bushels per acre. The Kursk, which is evidently also called the Canary Bird millet has given practically four bushels of seed per acre more than the Hungarian Grass, and about twelve bushels per acre more than the Common millet. This variety was obtained in 1910 from Northrup, King and Company, Minneapolis, Minnesota. Both the Kursk and the Siberian millets have given excellent results for seed production in the tests at the College.

Experiments with Potatoes.

A bulletin of eighty-five pages on "Potatoes" was prepared by the writer and was printed by the Ontario Department of Agriculture in 1916. Copies of this bulletin can be obtained by request to the Department of Agriculture, Parliament Buildings, Toronto. The bulletin deals in a comprehensive way with all experiments conducted at the College with the potato crop for a period of twenty-six years and includes the following: Soils, Rotations; Cultivation of Soil, and Cutting and Planting Potatoes; Change of Seed; Varieties, and Variety Tests; Description of each of Ten Varieties of Potatoes; Early Varieties for Early Use; Co-operative Experiments with Varieties of Potatoes; Table Quality of Potatoes; Potato Improvement, including Selection and Hybridization; Planting Potatoes at Different Dates; Different Exposures of Seed Potatoes for Three Weeks Before Planting; Planting Whole and Cut Potatoes; Planting Sets of Different Sizes, with One Eye in Each Set; Planting Sets of Different Sizes and at Different Distances Apart; Planting Sets of Equal Size with a Varying Number of Eyes; Planting Single Eyes from Different Parts of the Seed Tubers; Planting One, Two and Four Potato Sets per Hill; Influence of Plaster and Lime when Sprinkled on Freshly Cut Seed Potatoes; Planting Potato Sets at Different Times After Cutting; Planting Seed Potatoes at Different Depths; Methods of Cultivation; Exposure in the Sun of Seed Potatoes and of Furrows at Time of Planting; Application of Manures and Fertilizers; Co-operative Experiments with Potatoes and Fertilizers; Spraying with Bordeaux Mixture for the Prevention of Late Blight, Early Blight and Tip Burn; the Resistance of Potatoes to Rot; Rot in Stored Potatoes of Different Varieties; Treatment for the Prevention of Rot in Stored Potatoes; Treatment for Potato Scab; Suggestions for Eradicating Potato Diseases from an Ontario Farm; Ontario Free from Some Serious Potato Diseases; Treatments for the Colorado Potato Beetle; Methods of Handling the Potato Crop for Satisfactory Results; Cost per Acre of Growing Potatoes, and Organized Agencies in Connection with Potato Production.

In the results of experiments conducted at the Ontario Agricultural College it has been found that the yield of potatoes has been increased by the use of tubers grown in certain northern districts, or by the use of home-grown seed potatoes which have not reached maturity. The real value of northern-grown seed potatoes appears to be that they have been produced in a comparatively cool climate, with no setback in development caused by droughts in July or August, and the vines are usually green when the potatoes are harvested. There are many illustrations of the value of northern-grown seed as the result of experiments and of the experience of practical potato growers both in America and in Europe. Whether or not fully as good results can be obtained from home-grown seed which is protected by mulching or in some other way, and which is harvested when still immature, has not been definitely determined. At the present time it seems advisable to introduce into southern Ontario a fair proportion of seed potatoes from northern sections. In experiments conducted at Guelph over a series of years in testing potatoes obtained from New Brunswick and from Muskoka in comparison with home-grown seed, it has been ascertained that in each year the highest returns were obtained from the seed secured from Muskoka. In the past year seed potatoes obtained from north of Lake Superior gave very excellent results both at Ottawa and at Guelph.

It was the privilege of the writer, in company with Mr. Justus Miller and Mr. W. A. McCubbin, to visit in July and August of 1917 the potato-growing sections of nine districts in Northern Ontario, and with Mr. Miller and Professor Howitt to visit in the latter part of August and in early September three of the sections in Southern Ontario where potatoes are grown extensively for commercial purposes. As the results of experiments and investigations it seems quite evident that Northern Ontario has very favorable conditions for the production of seed potatoes of high quality. At the present time the potato diseases are much less troublesome in the northern as compared with the southern part of the Province. It is interesting to note that in average annual yield of potatoes per acre, 1912, 1913 and 1914 produced the highest, and 1915, 1916 and 1917 the lowest of any period of three consecutive seasons in the past thirty-five years. The last three years referred to have been abnormal seasons and have apparently furnished conditions favorable for the development of certain diseases in the potato crop.

A conference was called by the Commissioner of Agriculture, and held in the Parliament Buildings at Toronto on the 30th and 31st of October, 1917, to discuss the best methods for improving the potato industry of the Province. A committee, of which the speaker was chairman, was appointed to make recommendations regarding the varieties of potatoes most suitable for growing for commercial purposes throughout Ontario. The Association finally adopted the following recommendation:

"That the Irish Cobbler be recommended as a standard early variety for commercial purposes and the Early Ohio as an extra-early variety for market gardeners to meet the requirements of special markets. The Green Mountain was recommended as a standard late variety, with certain other late varieties, as Carman No. 1, Dooley, Rural New Yorker No. 2, etc., recognized as standard varieties, and be recommended for those districts where conditions are peculiarly favorable to their growth. Where a variety was found especially suited to the conditions, farmers were advised to confine their attention to such variety."

The Extra Early Eureka is very similar to the Irish Cobbler, and if these two varieties were shipped in the same car for commercial purposes no serious results would follow. The same could be said in regard to the Davies' Warrior and the Green Mountain. Both the Irish Cobbler and the Green Mountain varieties are well established in Ontario, and in many localities it is believed that either one or the other of these varieties might be grown to the exclusion of other kinds. By so doing, more satisfactory results could be obtained from potato production in Ontario.

Root Crops in Ontario.

Before corn was grown extensively in this Province the root crops occupied an exceedingly important place in connection with crop production. With the gradual increase of the corn crop, especially for fodder and for silage, there has been a tendency to reduce the acreage devoted to the cultivation of field roots. From a study of the statistical reports of the Bureau of Industries for Ontario we find that with practically all classes of root crops there has been a considerable decrease in acreage. In 1900 the turnip crop reached its maximum for Ontario with 156,583 acres. By 1910 the acreage was down to 108,360 acres and in 1918 to 85,449. The mangel crop had its greatest acreage in 1903, reaching 80,918 acres in that year, and in the present season the area used for the mangel crop was 40,714 acres. In 1895 there were 13,002 acres used for the cultivation of field carrots in Ontario, and in 1917 the acreage was 2,920.

The combined estimated market value of the root crops of Ontario, not including potatoes, amounted to $13,404,317 in 1917. These figures show that the root crops of Ontario still occupy an important place in the agriculture of the Province.

Varieties of Mangels.

The estimated market value of the mangel crop to Ontario now amounts to about two and one-half million dollars annually. In 1917 the value of this crop in Ontario was estimated at $3,898,525.

Mangels are classified as long, medium, tankard or globe, according to their shape, and each class is represented by a number of varieties. Some of these varieties vary greatly not only in shape but also in size and color. In our experimental grounds we have tested mangels under about one hundred and thirty different names. In a few cases, however, the mangels under different names resemble one another so closely that they may be considered as the same variety, and yet we frequently find differences in purity of seed, in germination, and in productiveness even of these mangels, owing no doubt to the varying conditions under which the seed has been grown, harvested, stored, transported, etc. It is very difficult indeed to get a definite knowledge of the different varieties of mangels from seedsmen's catalogues. The importance of carefully conducted experimental work is evident in order that the different varieties may be grown and studied under uniform conditions.

The real mangel seeds are about the size of the seeds of common red clover. The seed, however, is produced in the form of clusters. These clusters as bought through the seed trade may contain one seed each or they may contain even up to seven seeds per cluster. There has not as yet been any satisfactory way of breaking the clusters so as to get a suitable separation of the individual seeds. In practically all cases, therefore, it is the clusters which are sown in the case of mangels and also in the case of sugar beets.

Great emphasis has been placed on the germination of mangel seed in the experimental work conducted at the College with different varieties. The varieties have all been planted from two to three times each season. In every instance the land has been marked in both ways and exactly the same number of clusters have been planted. After germination has taken place and the young plants have reached a height of about two inches, the young plants have been carefully counted and records made. The plants have then been thinned so as to leave one plant in each place. In a few instances, however, the germination has been so poor that even with the great care taken and the large amount of seed used, it has been exceedingly difficult to secure a perfect stand. As the work has been repeated each year, however, and has been conducted from season to season, we present the average results in yield per acre and in percentage of germination as shown by the different varieties and the different strains of the varieties with a considerable amount of confidence. The following table gives the average results for the past **five years.**

Varieties,	Percentage Germination from Clusters in the Field	Weight per Root (lbs.)	Yield of Tops per Acre (tons).	Yield of Roots per Acre.	
				Tons.	Bushels.
Garton's Large Red Intermediate	104	2.67	2.66	26.85	1074.0
Yellow Leviathan (Simmers')	76	2.83	4.28	24.08	963.2
Yellow Leviathan (Rennie).............	89	3.00	4.27	24.04	961.6
Yellow Leviathan (Bruce)	97	2.81	3.84	23.60	944.0
Steele, Briggs' Giant Yellow Intermediate	87	2.89	3.96	23.48	939.2
Yellow Leviathan (Steele, Briggs')......	74	3.39	3.77	22.86	914.4
Sutton's Mammoth Long Red	82	2.52	4.14	22.67	906.8
Yellow Leviathan (Keith)	93	2.45	3.66	22.52	900.8
Carter's Sugar	73	2.55	3.75	22.49	899.6
Sutton's Prize Winner Yellow Globe	102	2.42	2.17	22.49	899.6
Carter's Dreadnought Yellow Oval Shape.	83	2.41	1.83	21.90	876.0
Yellow Leviathan (Ferry)	67	2.88	4.18	21.83	873.2
Steele, Briggs' Prize Mammoth Long Red.	95	2.43	4.32	21.57	862.8
Keith's Prize Taker....................	97	2.27	1.85	21.32	852.8
Ideal (Ontario Seed Co)	95	2.46	2.66	21.30	852.0
Rennie's Selected Mammoth Long Red...	103	2.36	4.44	21.20	848.0
Yellow Globe Selected (Steele, Briggs') .	66	2.52	1.95	20.80	832.0
Yellow Leviathan (Hewer)	51	3.35	4.12	20.31	812.4
Simmers Mammoth Prize Long Red	83	2.49	4.14	19.40	776.0
Bruce's Gate Post Mammoth Long Red..	88	2.39	4.17	18.28	731.2

It will be seen from the foregoing table that the highest half dozen lots of roots in average yield per acre were all of the intermediate class, four of them being the Yellow Leviathan, as sold by four of our Ontario seedsmen. It will be noticed that the Yellow Leviathan has varied greatly in accordance with the source of the seed. In the five years' experiments, Yellow Leviathan obtained from one seedsman came second from the top of the list, and Yellow Leviathan from another seedsman, third from the bottom of the list, in yield of roots per acre, the difference being an average annual yield of 151 bushels per acre. It is interesting to note that Simmers' Yellow Leviathan comes second highest in yield and Simmers' Mammoth Prize Long Red, second lowest, in average yield per acre. It will again be noticed that one of Bruce's mangels comes fourth from the top, and another variety of mangels, the seed of which was obtained from the same seedsman, is at the very bottom of the list.

It will be seen that in only three cases was the percentage germination from clusters in the field over one hundred per cent., and two of these were from seed which was imported directly from England. The lowest average percentage of all the mangel seed obtained for the five-year period was for the Yellow Leviathan obtained from Hewer, of Ontario, and the highest percentage was from the Garton's Large Red Intermediate obtained from Garton, of England.

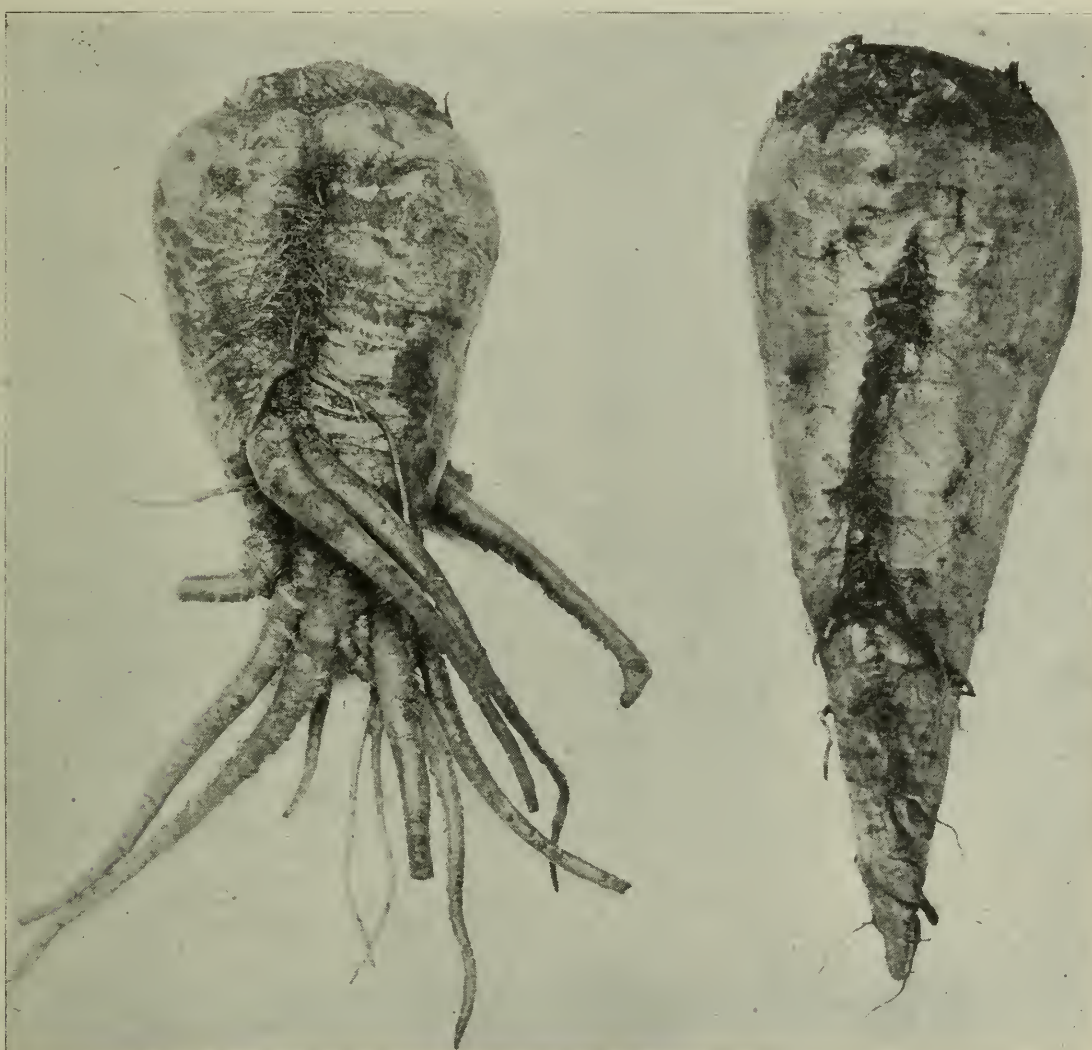
Varieties of Sugar Beets and of Sugar Mangels.

In 1901, four sugar beet factories, with an aggregate capacity for slicing two thousand two hundred tons of beets per day were built at Berlin, Waterloo County; at Wiarton, Bruce County; and at Wallaceburg and Dresden, Kent County. In 1904, the Dresden Sugar Company removed their factory to the State of Wisconsin, and the Wiarton Sugar Manufacturing Company suspended operations. In 1915 and 1916, an exceptionally fine sugar beet factory was erected at Chatham, and in 1917 and in 1918 beet sugar was manufactured by the

Dominion Sugar Company at their three factories in Kitchener, Wallaceburg and Chatham.

In the past few years the sugar beets grown in Ontario have given an average of about ten tons per acre and of sixteen and one-half per cent. of sugar. In consideration of the great scarcity of sugar throughout the world it seems reasonable to expect that a sufficient quantity of sugar beets of high quality will be grown in Ontario to supply the three factories to the limit of their capacity.

The percentage of sugar amounts to approximately five per cent. in mangels, ten per cent. in sugar mangels and fifteen per cent. in sugar beets. There are,



Kleinwanzlebener Sugar Beets.

of course, quite decided variations in the percentage of sugar, owing to varieties used and methods of cultivation practised. Mangels grow largely above the ground, sugar beets almost completely under the surface of the soil, and sugar mangels occupy an intermediate position in this respect. Mangels and sugar mangels are grown for feed production and sugar beets for the manufacture of beet sugar.

Numerous experiments have been conducted at the Ontario Agricultural College in growing mangels and sugar mangels as feed for farm stock, and in growing sugar beets to determine the quantity and the quality of the roots produced in Ontario for sugar production.

For six years in succession fourteen varieties of sugar beets and sugar mangels were carefully tested under uniform conditions in the Field Husbnadry Department at the College. The tests were made in the experimental field, which is composed principally of an average clay loam. The land received one application of farmyard manure in each rotation of four years, no commercial fertilizers being used. The roots followed grain crops, the land being ploughed in the autumn. The rows were 21 inches apart and the roots 7 inches apart in the rows. At the time of harvest, careful determinations were made of the weights of both the roots and the tops and of the number of roots of each variety. A number of average roots were collected each year and taken to the Chemical Department, where they were analyzed. The following table gives the average results of the **six years'** experiments in showing the yields per acre and the quality of the roots for sugar production:

Varieties.	Average 6 Years.		Average 5 years.		Average 6 Years.		
	Analysis of Juice.		Length of Roots.		Weight per Root (lbs.)	Yield per Acre.	
	Per Cent. Purity.	Per Cent. Sugar.	Above Ground (ins.)	Below Ground (ins.)		Tops (tons).	Roots (tons).
1. Giant White Feeding ...	72.2	8.4	3.78	4.68	1.49	3.48	**29.91**
2. Royal Giant	79.7	9.9	3.50	5.27	1.36	2.95	**26.97**
3. Giant Rose Feeding	81.7	10.3	3.22	5.15	1.29	2.48	**25.93**
4. New Danish Improved..	80.3	10.8	2.66	5.59	1.27	6.66	**25.20**
5. Red Top,..............	81.4	10.9	2.72	5.47	1.24	3.96	**24.54**
6. Red Skinned...........	80.8	11.7	1.83	6.22	1.18	4.45	**22.94**
7. Green Top White	81.0	12.6	1.08	5.77	1.15	5.72	**22.61**
8. White Silesian.........	83.0	13.7	1.14	6.14	1.19	5.77	**22.57**
9. Lane's Improved.......	82.5	12.8	1.61	5.73	1.11	5.22	**21.54**
10. Champion	85.0	15.6	1.31	6.77	1.05	7.79	**20.69**
11. Kleinwanzlebener......	87.8	16.6	.58	6.02	1.04	8.47	**20.68**
12. Petzscheke's Elite	87.1	16.1	.62	5.97	1.06	6.62	**19.07**
13. Improved Imperial.....	88.5	17.0	.57	5.66	.99	5.98	**18.42**
14. French Yellow.........	82.7	12.7	1.45	6.36	.95	4.59	**17.81**

Of the fourteen varieties of roots included in the table here presented, the Kleinwanzlebener gave the highest average total yield of sugar per acre, when both the yield and the quality of roots were taken into consideration. This variety originated in Germany by selecting for many years only those roots which had a very high sugar content. The Kleinwanzlebener variety of sugar beets has been used more extensively for sugar production in America than any other variety. It will be seen that those varieties of beets which gave the highest percentages of sugar produced medium sized roots, which grew almost entirely underground. In comparing the different varieties it will be noticed that as the percentage of sugar decreased there was usually an increase in the yield of roots and a decrease in the yield of tops. There are, however, some marked exceptions to this rule, as the New Danish Improved gave a very large yield of tops and a comparatively low percentage of sugar, and the French Yellow variety which furnished an average amount of sugar was the lowest yielder of roots on the list.

As a farm crop, however, it will be seen that the Giant White Feeding gave practically thirty tons of roots per acre. This is a large yield and is about three tons per acre greater than the next variety on the list. A larger percentage of the roots grew above the surface of the ground than that of any other variety reported. In this respect, and in the percentage of sugar, this variety more closely resembles the mangels than any of the other kinds here mentioned.

Six varieties of sugar beets and of sugar mangels have been grown under similar conditions in the experimental grounds in each of nineteen years. The following gives the average results for the nineteen-year period in tons of roots per acre per annum: Giant White Feeding, 25.8; New Danish Improved, 21.8; Royal Giant, 21.7; Giant Rose Feeding, 21.4; White Silesian, 20.3, and Improved Imperial, 17.1.

In each of the past five years, Ontario grown seed, from a special variety of sugar beets particularly rich in sugar content, has been obtained from the Dominion Sugar Company. This variety and the Kleinwanzlebener have been grown in the experimental plots under similar conditions for the five-year period. The following gives the results of this experiment in yield per acre of both tops and roots:

Varieties.	Tons of Tops per Acre.					Tons of Roots per Acre.				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Kleinwanzlebener	6.1	13.6	1.8	5.5	8.7	15.4	18.8	3.9	14.6	18.5
Dominion Sugar Co.	6.3	15.9	2.1	6.3	8.4	15.6	19.8	5.0	15.8	18.4

It will be seen that the new strain which is now being grown and used by the Dominion Sugar Company has produced a higher yield of roots per acre than the Kleinwanzlebener variety in four out of the five years.

As sugar beets are grown with the definite object of sugar production, the growers of the beets and the manufacturers of the sugar should work in wholesome co-operation. The sugar manufacturers furnish seed of high quality at low prices, give directions regarding cultivation and offer to buy the beets under contract. Ontario farmers desiring to grow sugar beets should, therefore, make their contracts before planting.

For fuller information regarding sugar beets the reader is referred to Bulletin No. 262, printed in March, 1918, and entitled "Sugar Beets." Copies of this bulletin can be obtained by writing to the Department of Agriculture, Parliament Buildings, Toronto, Ontario.

Varieties of Swede Turnips.

Even at the time of great scarcity of labor there were 85,449 acres of turnips grown in Ontario in 1918. This, however, was the smallest acreage used for the turnip crop in Ontario during the past thirty-seven years. The highest acreage during that period was in 1900, when there were 156,583 acres of turnips grown in the Province. In securing the information in regard to the acreage devoted to turnips in Ontario no separation has been made between the Swede turnips and the Fall or soft varieties. In 1918, twenty-three varieties of Swede turnips were grown at the College, in addition to a number of strains of home-grown seed. Of this number, sixteen varieties have been grown in each of the past four years, and the following table gives the average results:

Varieties.	Yield of Tops per Acre (tons).	Yield of Roots per Acre (tons).
Garton's Superlative	4.29	**20.01**
Garton's Invicta	5.30	**19.75**
Garton's Model	5.45	**19.58**
Ne Plus Ultra (Dupuy & Ferguson)	4.75	**19.34**
Perfect Model (Dupuy & Ferguson	4.01	**19.29**
American Purple Top (D. M. Ferry)	3.94	**18.87**
Steele, Briggs' Durham Swede	4.93	**18.87**
Simmers Ne Plus Ultra	5.37	**18.68**
Good Luck (Steele, Briggs)	5.42	**18.66**
Carter's Best of All	5.02	**18.55**
Improved Hall's Westbury (J. A. Bruce)	4.03	**18.43**
Bruce's Giant King	4.00	**18.31**
Sutton's Magnum Bonum	4.72	**17.58**
Canadian Gem (Darch & Hunter)	4.37	**17.23**
Simmers' Defiance	4.40	**16.46**
Hartley's Bronze Top	4.41	**16.35**

On examining the turnips for shipping quality in each of the past few years, it has been found that the Perfect Model and the Garton's Model stand particularly high, while some of the other varieties also give comparatively good results. It will be seen that the Hartley's Bronze Top, an old variety which at one time occupied an important place in turnip growing in Ontario, is now at the bottom of the list in yield of roots per acre.

The Garton's Superlative has given the highest average yield per acre, produces roots purple in color, oval in form and with comparatively short necks.

Of each of six varieties which have been under test for twelve years in succession, the greatest yields in tons of roots per acre have been produced by the Carter's Invicta, 19.0; Good Luck, 18.9; Improved Hall's Westbury, 18.2; Sutton's Magnum Bonum, 18.1; Simmers' Defiance, 17.6, and Hartley's Bronze Top, 17.1.

Varieties of Fall Turnips.

There is a limited acreage of fall turnips grown in Ontario each year. Roots of this class usually yield more per acre than the Swede turnips but they do not keep so late into the winter. Other names for fall turnips are Soft turnips or White Flesh turnips.

Two varieties of fall turnips have been grown under test at the College in each of the past seventeen years, and the following gives the average annual results in tons per acre of tops and of roots for each of the varieties: Red Top White Globe, 4.0 and 26.3, and Cow Horn, 5.8 and 19.7 In 1918, the Red Top White Globe gave 21.2 and the Cow Horn 15.5 tons of roots per acre. In comparison with these in the test of the past year the Sutton's Purple Top Mammoth gave 20.8, the Sutton's Imperial Green Globe, 18.8, and Kelway's Green Globe, 16 tons per acre.

Varieties of Field Carrots.

Although field carrots are not grown as extensively in Ontario as they were a few years ago, there is still about three thousand acres devoted to this crop annually. The area in 1917 was 2,920 acres and the estimated value of the crop $151,658. The largest amount of carrots is grown in Carleton County, where last year over one hundred thousand bushels were produced.

Five varieties of field carrots have been tested under similar conditions in each of the past nineteen years. The following table gives the average yield in tons per acre per annum for each of the five varieties for the **nineteen-year** period:

Varieties.	Color.	Length of Roots. (ins.).	Yield per Acre. (tons).
Steele Briggs' Improved Short White............	White.	8.4	26.6
Bruce's Mammoth Intermediate Smooth White ..	"	8.7	26.3
Simmers' Improved Giant Short White	"	8.3	25.9
Large White Belgian	"	10.6	23.7
Carter's Gate Post Orange Long	Yellow	8.8	21.9

The Steele, Briggs' Improved Short White variety which gave the highest yield of roots per acre of five varieties for nineteen years, occupies third place in yield per acre of seven varieties grown in the past seven years, the highest yields being produced by Rennie's Mammoth Short White, 23.5 tons, and by Simmers' Improved Giant Short White, 23.1 tons. In 1918, the highest yield of carrots with seven varieties under test was 30.4 tons produced by each of Rennie's Mammoth Short White and Keith's Improved White Intermediate varieties.

Varieties of Kohl Rabi.

Kohl Rabi resembles cabbage in its development of roots, and swede turnips in the appearance of its leaves. The valuable part grows about three inches above ground in the form of a bulb. These bulbs are used as a vegetable for the table or as feed for farm stock. When grown as feed for farm stock, they may be pastured in the field by sheep or harvested and stored for winter feed somewhat similar to mangels and turnips. In England, Kohl Rabi is grown much more extensively than in Ontario.

In order to secure information as to the value of this crop in Ontario, a number of varieties of Kohl Rabi were formerly grown in our experimental grounds. After these had been carefully tested, the number of varieties was reduced to two. Each of these two varieties have now been grown under test for **seventeen years**, and the average results are as follows:

Varieties.	Weight per Root. (lbs.).	Yield per Acre,	
		Tops. (tons).	Roots. (tons).
Early White Vienna	1.5	3.1	16.7
Goliath Purple..............	1.3	7.1	13.6

The Early White Vienna surpassed the Goliath Purple variety in yield of roots per acre in each of fourteen out of the seventeen years. The kohl rabi is not equal in yield per acre to the leading varieties of mangels, turnips or carrots in the experiments conducted at the College. This crop, however, may have a limited place in the agriculture of Ontario, but will not likely be used by more than a few farmers in this Province.

Varieties of Parsnips.

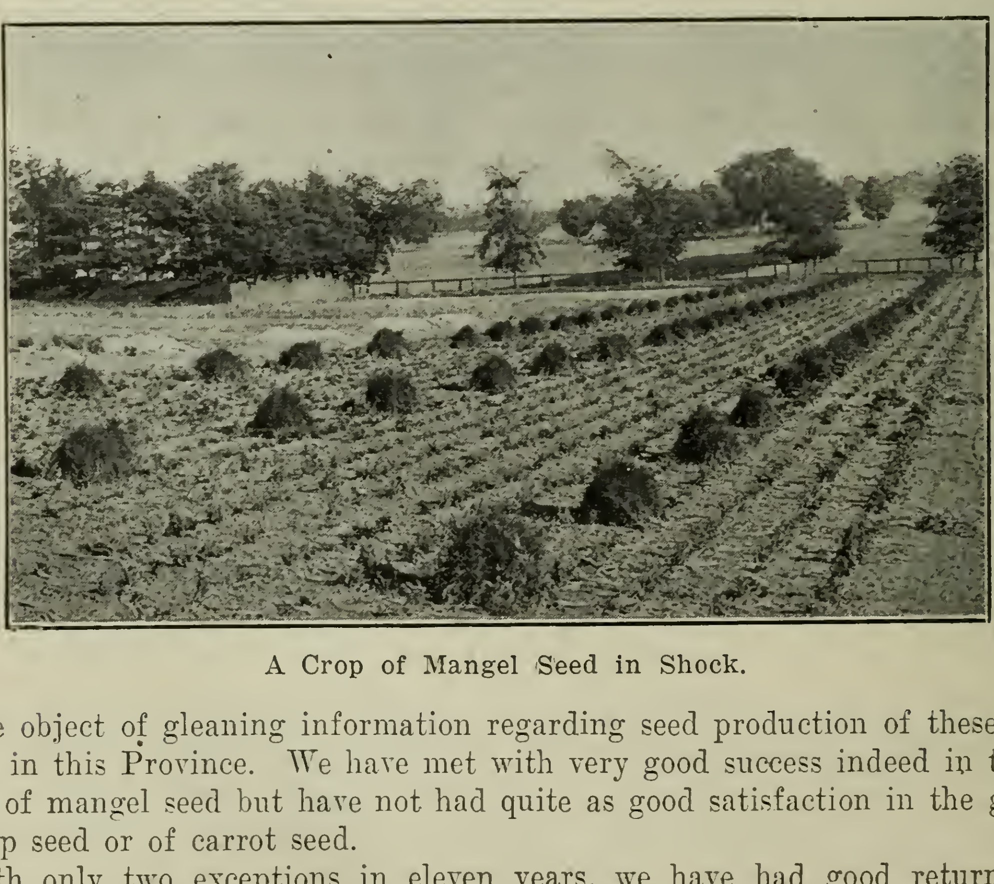
Enquiries have been made on different occasions regarding the value of parsnips as a root crop for stock feeding in Ontario. They have been grown only to a very limited extent in this Province. Several varieties were tested at the College, but each of these has been dropped from the test with the exception of three kinds, two of which have been grown for **eighteen years** in succession with the following results:

Varieties.	Yield of Tops per Acre (tons).	Yield of Roots per Acre (tons),
Sutton's Cattle	4.0	**10.8**
New Ideal Hollow Crown.....	3.8	**10.6**

Another strain of the Hollow Crown variety, the seed of which was produced in Ontario, has been under test in each of the past six years during which time it has been given an average of 11 tons of roots per acre in comparison with 9.9 tons produced by the Sutton's Cattle during the same period. In 1918 the Ontario grown seed of the Hollow Crown variety gave 11.1 tons per acre in comparison with 10.1 tons produced by the Sutton's Cattle and 7.2 tons by the New Ideal Hollow Crown. It will be seen that the parsnips have not produced as large a yield per acre as the Kohl Rabi which, in turn, gave a lower yield per acre than the other classes of field roots grown in Ontario.

The Production of Field Root Seed in Ontario.

During the past eleven years experimental work has been conducted at the Ontario Agricultural College in the growing of mangel, turnip and carrot seed



A Crop of Mangel Seed in Shock.

with the object of gleaning information regarding seed production of these classes of roots in this Province. We have met with very good success indeed in the production of mangel seed but have not had quite as good satisfaction in the growing of turnip seed or of carrot seed.

With only two exceptions in eleven years, we have had good returns from mangel seed production at the College. Six years ago the mangel seed germinated only 27 per cent. from the clusters. This was probably owing to the fact that we had a frost in the early part of September and the mangel seed was not harvested until the latter part of the month. Again, two years ago mangel seed production was a failure in Ontario. The seed produced at the College germinated only about 10 per cent. We had one acre of mangels for seed which looked promising, but when the plants were in bloom we had an exceptionally hot, dry spell, which seemed to seriously affect the plants. At harvest time many of the plants had a good appearance, but they contained no vital seeds. Not only was this true in our own experimental grounds at the College, but the conditions were very similar throughout the Province. This was a great disappointment, as we had been working on a special strain of the Yellow Leviathan variety, which we had carefully selected. In July, 1915, we planted seed of this special strain and produced about fifty thousand stecklinge. In the spring of the following year not only did we plant about six thousand of these stecklinge ourselves, but we distributed about forty thousand to some twenty-five progressive farmers throughout Ontario. Had the season been favorable, we would probably have had from six

Cutting a Crop of Mangel Seed.

to ten tons of seed of this special strain of the Yellow Leviathan mangel, which would have been of great service for the production of more stecklinge in the spring of 1917. In 1917 we planted at the College a little less than an acre of stecklinge of another selected strain of the Yellow Leviathan mangel. This area gave us 1,363 pounds of well-matured, thoroughly cleaned mangel seed which gave a germination of over two hundred per cent. from the mangel clusters. The most of this seed was sold in the spring of the present year at $1.50 per pound as stock seed for the production of more stecklinge. We could evidently have sold our complete supply at that price, but kept a few hundred pounds for fear of shortage in 1918. If we had sold the entire amount it would have brought over two thousand dollars for the amount of seed produced on less than one acre. The seed for 1918 has not yet been weighed, but the yield will probably be about one thousand pounds per acre on an area of one and one-half acres of the Yellow Leviathan strain.

In the average results for ten years at our College, very careful field tests show that our home-grown mangel seed gave an average percentage of germination from the clusters of 119 per cent., while in the average of the same ten years, the imported seed obtained through three of the leading seed houses gave 77, 77 and 76 per cent. We have not obtained imported seed from any source which has given us as high a percentage of germination over a series of years as we have obtained from the seed produced at Guelph.

If farmers, who have some good mangels stored in their root cellars, would next spring, when the growth of vegetation is starting, plant these on a piece of well-tilled land, they would be able to grow seed for home use. As near perfect roots as possible should be selected and these should be planted about thirty inches apart each way. We have occasionally obtained as high as a pound of seed per plant, but this is exceptional and it would not be wise to count on more than from four to eight ounces of seed per plant on the average. By transplanting from fifty to one hundred plants in the spring, a nice quantity of seed should be obtained. This would greatly help out the situation in furnishing home-grown seed and in showing what can be done in seed production in different localities throughout the whole Province. In former years our mangel seed was nearly all imported from Europe and the stocks of European seed have become practically all exhausted. It is well for us to continue our experimental work in the production of mangel seed and it is quite possible this might eventually develop into a new industry in this country.

Varieties of Corn for Silage and for Fodder.

In 1892 there were 91,403 acres of silo corn grown in Ontario. The area for this crop gradually increased until 1902, when it amounted to 209,859 acres. There was then a yearly decrease until 1906, at which time 180,796 acres were used for this crop. From 1906 to 1917, with only one slight exception, there was a yearly increase up to 511,329 acres. In 1918, however, the crop dropped to 380,946 acres. The great drop in the acreage of silage and fodder corn in the past year has undoubtedly been due to the great scarcity of both seed and labor. Those counties which produced the greatest acreage of corn for the silo in 1917 were in the following order: Oxford, 34,202; Middlesex, 29,817; Carleton, 21,746; Lambton, 21,152; Perth, 19,923; Huron, 18,975; and Ontario, 18,471 acres. Under normal conditions the acreage used for silage corn in Ontario is likely to increase substantially from year to year.

No one variety of fodder corn is suitable for all parts of the Province. Owing to the importance of the crop in Ontario, especially for the production of fodder or of silage, extensive experiments have been conducted, the results of which might form a general guide for the farmers in different sections of the Province. A large number of varieties have been planted in duplicate tests in the experimental grounds in each of a number of years past. The results are reported in such a way that they should form available information to any one interested in corn growing in the Province of Ontario whether he be located in a southern, central or northern section. From the results presented he is able to glean information in regard to the total yield per acre, yield of ears, stage of maturity, etc. In the experimental work the corn has usually been planted during the last ten days of May and it has generally been harvested about the middle of September. Immediately after the corn has been cut the weight of the whole crop has been taken, after which the ears have been harvested, counted, weighed and examined. The stage of maturity of the corn has been indicated by the condition of the grain at the time it was cut. The seven terms which have been used to describe the corn in regard to its ripeness have been as follows: Water, Early Milk, Milk, Late Milk, Dough, Firm Dough and Ripe.

It is important to test not only the distinct varieties, but also to make a study of the sources of seed of the individual varieties as much as possible. The results presented in a general table give the record of the White Cap Yellow Dent corn obtained from several different sources in Ontario. These different lots of this variety had been selected by the individual farmers for a number of years, and it will be seen that the results of the different strains vary considerably. The following table gives the average results of duplicate tests in each of **ten years** for each of thirty-five varieties of corn:

Varieties.	Class of Corn and Color of Grain.	Average Results for Ten Years, 1909–1918.					
		Condition of Grain When Harvested.	Number of Days Until in Full Tassel.	Height of Plant (inches).	Weight per Ear (ozs.)	Yield per Acre.	
						Husked Ears (tons).	Total Green Crop (tons).
Eureka	Yellow Dent	Early Milk	99	107	6.26	2.61	**18.88**
Reid's Yellow Dent	"	"	97	105	5.96	2.63	**17.93**
Salzer's North Dakota	White Flint	Dough	86	88	5.73	3.42	**17.88**
Gold Nugget	Yellow Flint	Firm Dough	85	93	8.00	3.92	**17.72**
Compton's Early (U.S.)	"	"	87	94	7.09	3.61	**17.54**
Longfellow (U.S.)	"	"	88	91	5.45	2.93	**17.50**
Mammoth Southern Sweet	White Dent	Early Milk	98	99	5.60	2.38	**16.97**
Simmers' Mammoth Eight-rowed	Yellow Flint	Firm Dough	85	87	5.39	3.01	**16.41**
Genesee Valley	"	"	84	86	5.83	3.11	**16.40**
Stowell's Evergreen	Sweet	Milk	93	87	6.23	2.94	**16.21**
Compton's Early (Ontario)	Yellow Flint	Firm Dough	86	90	7.32	3.54	**16.16**
Improved Leaming (Vick)	Yellow Dent	Milk	92	101	7.46	3.31	**16.14**
Rennie's XXX. Early Sweet	Sweet	Late Milk	88	79	7.01	3.89	**16.07**
White Cap Yellow Dent (H. Smith)	Yellow Dent	"	90	99	8.55	3.51	**15.94**
Duke's Improved Sweet	Sweet	Milk	94	87	6.38	2.94	**15.69**
Wisconsin No. 7	White Dent	Late Milk	88	94	7.57	3.46	**15.63**
Sanford	White Flint	Firm Dough	85	89	6.59	3.22	**15.49**
Early Butler	Yellow Dent	Milk	88	98	7.23	3.45	**15.37**
Longfellow (Ontario)	Yellow Flint	Firm Dough	83	88	6.18	3.20	**15.32**
King Phillip (Ontario)	Colored Flint	"	83	89	6.15	3.12	**15.32**
White Cap Yellow Dent (E. M. Zavitz)	Yellow Dent	Dough	84	96	8.13	3.68	**15.03**
Australian Extra Early Eight-rowed White	White Flint	Firm Dough	83	86	6.92	3.63	**14.71**
Golden Glow or Wisconsin No. 12	Yellow Dent	Late Milk	84	92	7.92	3.82	**14.55**
Leaming (Ontario)	"	Milk	91	99	7.96	3.08	**14.55**
White Cap Yellow Dent (Dawson)	"	Late Milk	87	96	7.46	3.22	**14.47**
Red Blazed	Colored Flint	Firm Dough	82	87	6.51	3.04	**13.96**
Improved Early White Cap (J. O. Duke)	Yellow Dent	Dough	84	90	7.14	3.19	**13.84**
Sterling White Dent	White Dent	Dough	86	90	7.36	3.27	**13.68**
University No. 13	Yellow Dent	Firm Dough	83	90	7.42	3.59	**13.32**
Early California Flint	Yellow Flint	Ripe	82	83	7.32	3.59	**13.32**
White Cap Yellow Dent (Hammond)	Yellow Dent	Dough	82	89	7.24	3.39	**12.73**
Early Colorado Dent	"	Ripe	76	83	7.04	3.69	**12.14**
Pearce's Early Evergreen	Sweet	Late Milk	78	73	6.91	3.93	**11.71**
Mammoth White Cory	Sweet	Dough	76	64	5.53	3.51	**11.50**
Golden Bantam	Sweet	"	77	58	3.75	2.63	**8.80**

There is a general impression that dent corn yields more than flint corn. This is true only to a very limited extent. It will be seen that the Salzer's North Dakota White flint corn occupies third highest place and the Early Colorado yellow dent corn the fourth lowest place in average yield of green crop per acre per annum. It will be observed that as a general rule the late corns are heavy and the early corns are light yielders. There are, however, quite decided exceptions to this rule and it is the exceptions which are brought out by the results of the experiments, and which form the important part in the tests. The Salzer's North Dakota, for instance, with almost 18 tons of green crop per acre was in the dough stage, while under similar conditions the Improved Leaming gave about 16 tons per acre and only reached the milk stage. From general appearances of the growing crop a person is apt to be deceived, as the dent varieties, with single stalks, have a showy appearance, while the flint varieties, with shorter stalks and more leaves and suckers, generally yield higher than the appearance when growing would seem to indicate. Not many people realize, for instance, from the appearance of the growing corn, that the Salzer's North Dakota or the Compton's Early would likely produce, throughout the central part of Ontario, heavier crops of green material per acre than the White Cap Yellow Dent or the Wisconsin No. 7 varieties. The results here presented are worthy of careful study, as they represent the average of twenty separate tests of the thirty-five varieties included in the experiment.

It will be seen that the White Cap Yellow Dent varied from 15.9 tons to 12.7 tons in total yield of green crop per acre and that the stage of maturity varied from the late milk to the dough. It will also be seen that the Compton's Early produced 17.5 tons per acre from seed obtained in the United States and 16.2 tons per acre from seed which was secured in Ontario. In yield of ripened grain, however, the Ontario seed considerably surpassed the seed obtained from the United States in the case of both the Compton's Early and the Longfellow varieties. The Gold Nugget corn, although possessing ears which are not particularly attractive, is a variety of considerable promise, as it is a comparatively early variety, giving large yields of both ears and total crop. In growing corn for the silo it is important not only to have a knowledge of the different varieties but also to secure as much information as possible regarding the source of the seed.

Varieties of Sorghum for Fodder.

Under the term "Sorghum" is included a number of different classes of crops, such as sugar cane, broom corn, kaffir corn, milo maize, etc. Those varieties of sorghum spoken of as sugar cane in seedsmen's catalogues, but which are more correctly named sugar sorghum, are used for fodder purposes in Ontario more than any of the other classes of sorghums. These sugar sorghums are sometimes used for the production of sorghum molasses.

The best results from sorghums may be expected from rich sandy loam soils. As a rule the sorghums thrive well in comparatively dry seasons. The sorghums are usually sown in rows from two to three feet apart and cultivated in much the same way as corn.

Experiments have been conducted at Guelph in testing out different varieties of sorghums, not only for seed production but also from the standpoint of the production of green fodder. For the production of fodder, the crop is usually sown the latter part of May or very early in June. In 1918, eighteen varieties of sorghum were under experiment at the College for fodder production. The highest yields were produced by the Albaugh sugar cane, the Early Amber sugar cane, the Orange sugar cane, the Early Minnesota sugar cane, the White kaffir corn, and the California broom corn.

Seven varieties have been grown under similar conditions in each of nineteen years. Previous to 1912 the seed was planted in squares twenty-seven inches apart each way and three plants were allowed to remain in each place. The seed was planted to a depth of about three-quarters of an inch. In 1912 a change was made in the method of planting, the seed being placed in rows twenty-six inches apart and ten inches apart in the rows. One plant was allowed to remain in each place. In each year the sorghums received cultivation throughout as required. The experiment was conducted in duplicate in each season. The following table gives the average results of each of seven varieties for the past **nineteen years**:

Varieties.	Height. (ins.).	Yield per Acre.	
		Heads. (tons).	Total Crop. (tons.)
Early Minnesota Sugar Cane	103	.79	16.96
Orange Sugar Cane	89	.34	16.73
Early Amber Sugar Cane	94	.90	14.93
White Kaffir Corn	64	.54	11.46
Early Japanese Broom Corn	100	1.30	10.49
California Broom Corn	107	1.42	10.46
Improved Evergreen Broom Corn	103	1.30	9.50

The results here presented show that some of the sorghums can be grown in Ontario with a considerable amount of satisfaction, as three varieties have given practically fifteen or more tons of green crop per acre per annum for the past nineteen years. Although the Orange Sugar Cane gave the second highest yield per acre, it is not as early as either the Early Minnesota or the Early Amber. The Early Amber variety is the one which is grown more than all other varieties combined in Ontario. It will be seen that this variety has given a higher yield of green crop per acre than many of the varieties of corn. Sorghum is grown both for fodder and for seed production in some parts of Ontario, especially in the south-western portion. In normal years sorghum seed is frequently used in a mixture of oats, sorghum and clover as an annual pasture crop by using 51 pounds of oats, 30 pounds of sorghum and 7 pounds of Common Red Clover seed per acre. This mixture has given very good satisfaction, but, during the last three or four abnormally wet seasons, the sorghum has not been used as extensively, owing to the scarcity and the high price of the seed.

In each of several years important work has been under way in plant selection with the Early Amber variety of sorghum. When seed is taken from individual plants selected in a field of sorghum and these are tested out individually, quite decided differences are observed. By following this up over a series of years and by combining some of the most promising strains, it is hoped before long that an improved strain of the Early Amber sugar cane may be secured. The results so far are quite promising.

Varieties of Millet for the Production of Fodder.

In some seasons, millet is grown quite extensively and in other years to a very limited extent. It is looked upon largely as a supplementary crop and its cultivation depends mainly upon the success or the failure of other fodder crops. It can be sown comparatively late in the season on land on which corn or some of the other crops can not be planted at the proper time. It can also be sown at a season of the year after which time it is known whether or not the ordinary hay crop of the country will likely prove to be above or below the normal. Besides using millets as a supplementary crop, some people grow a small acreage regularly as an annual crop for the production of hay or of green fodder. As a rule, about twenty-five pounds of seed are used per acre on land which has been carefully cultivated and is in a moist condition to insure quick germination. If seeding takes place in May or about the first of June, a late variety may be sown, but, if the seeding does not take place until the latter part of June or in July, an early variety is likely to give the best satisfaction.

Sixteen varieties and strains of millet have been grown for fodder in each of **Five Years,** the average results for that period being as follows:

Varieties.	Height. (ins.).	Yield of Green Fodder. per Acre. (tons).	Yield of Hay per Acre. (tons).
Japanese Panicle	38	11.5	**4.32**
Siberian No. 92	31	9.6	**3.85**
Siberian No. 91	31	9.7	**3.78**
Japanese Panicle No. 91	40	9.9	**3.71**
Siberian No. 71	31	9.3	**3.66**
Steele Trust	31	8.9	**3.65**
Holy Terror Gold Mine	32	8.8	**3.57**
Siberian	30	9.1	**3.54**
Japanese Barnyard	40	9.5	**3.52**
Golden Wonder	29	8.4	**3.50**
Japanese Barnyard No. 91	40	9.2	**3.49**
Kursk	28	8.3	**3.41**
Hungarian Grass	31	7.9	**3.31**
German or Golden	32	7.4	**3.05**
Common	33	7.5	**2.98**
Japanese Barnyard (Minami)	35	8.0	**2.95**

The Japanese Panicle variety occupies highest place on the list in the production of both green fodder and hay. This variety has been grown in a test of seven varieties for a period of twenty-two years and also heads the list with an average of 10.6 tons of green crop per acre. The Japanese Panicle variety of millet was brought from Japan by Professor Brooks, of the Agricultural College, Amherst, Massachusetts. Professor Brooks occupied a position on the staff of an agricultural college in Japan for seven years previous to his return to the United States. He brought with him three varieties of millet, representing three types, viz.: Japanese Panicle, Japanese Barnyard and Japanese Common. The Japanese Panicle millet produces plants of an upright growth, a spreading head and a large leaf development. The crop usually stands up well and is highly productive. The seed of the Japanese Panicle millet is smooth, shiny and of a dark brownish color. In ordering seed of the Japanese Panicle millet from the seedsmen, great care should be taken to make the order very distinct, or it is quite probable the Japanese

Barnyard will be forwarded instead of the Japanese Panicle. In some of the seedsmen's catalogues, the mistake of describing the Japanese Barnyard and illustrating the Japanese Panicle has been made, when both of these have referred to the same millet. It is always wise to secure a sample of millet and then order according to sample if the seed is true to name. The Japanese Panicle and the Japanese Barnyard millets not only represent different varieties, but they actually represent different species.

Sowing Millets at Different Dates.

The Japanese Panicle and the Japanese Barnyard millets and the Hungarian Grass were sown on May 15th, June 1st, June 15th, July 1st, July 15th and August 1st, in each of six years. The average results for the six-year period show that the highest yields in tons of green crop per acre were obtained in the case of each of the three varieties from the seedings on June 1st. It might be mentioned, however, that for earlier seedings the Japanese Panicle and the Japanese Barnyard varieties are usually the most suitable, but for late seeding the Hungarian Grass, which requires a shorter season for growth, is frequently the most suitable variety to use.

Varieties of Rape, Kale, Cow Cabbage, Etc.

The rape plant resembles the Swede turnip in its leaf and the cabbage in its root. It is the leaf and the stem which furnish the valuable portion for feeding to live stock. Rape makes an excellent late summer and autumn crop for feeding cattle, sheep and lambs, for which purpose it has been used at the College extensively in past years. Lambs have always done exceptionally well when pastured on rape. Their health has been good and their increase in live weight has been rapid. Dairy animals do well when feeding on rape, but the crop taints the milk about the same as turnips.

In 1917, there were 37,732 acres of rape grown in Ontario. In 1916, the number of acres was 38,566 and in 1915, 40,613. The reduction in the acreage during the past three years has probably been due to the great scarcity of labor in growing this cultivated crop.

We have conducted a very interesting experiment at the College in which other crops than rape have been tested. This experiment has included kale, cow cabbage, sprouting Boroccoli and rape and furnishes some good information in the comparative results of these crops when grown in Ontario under similar conditions. In 1918, eleven varieties belonging to the rape class were under experiment. The crops were all sown in rows three and one-third links (26 2-5 inches) apart. Each plot was exactly 1-100th of an acre in size, consisting of three rows each four rods in length. The experiment was conducted in duplicate. The land between the rows was cultivated occasionally throughout the growing season. When the crops had reached their best condition for feeding each variety was cut with a scythe and weighed immediately. This description applies equally well to each of the years in which we have conducted this experiment. In England, where the cabbages are grown more extensively, they are frequently transplanted and a sufficient distance is allowed between the plants to enable the heads to be formed. In our experiments at Guelph, however, we have treated the different kinds of cow cabbage in exactly the same way as we have treated rape. The heads of the cabbage have been quite small, the growth being largely leaf and stem. The following table gives the average results in tons of green crop per acre in 1918 and for the average of **Nineteen Years:**

Varieties.	1918.	Average 19 Years.
Sutton's Earliest Drumhead Cabbage.	17.30	**23.26**
Thousand Headed Kale..............	13.37	**19.82**
Purple Sprouting Boroccoli	11.98	**19.07**
Dwarf Essex Rape..................	11.60	**18.14**

This shows the very high yielding properties of the Sutton's Earliest Drumhead cabbage.

Sutton's Earliest Drumhead Cabbage Grown for Stock Feed.

The following table gives the average results in height of crop and in yield of green crop per acre of each of eleven varieties for the past **Three Years:**

Varieties.	Height of Crop (inches).	Average Yield of Green Crop per Acre (tons.)
Sutton's Earliest Drumhead Cabbage.......	16	**20.41**
Carter's Monster Drumhead Cabbage	15	**18.91**
World Beater Cabbage	15	**18.25**
Swedish Giant Cabbage..................	15	**17.98**
Simmer's Matchless Flat Dutch Cabbage...	14	**16.58**
Thousand Headed Kale	25	**14.15**
Sutton's Purple Sprouting Boroccoli.......	23	**13.44**
Silver Beet............................	16	**13.07**
Dwarf Essex Rape	20	**12.64**
White Silver Swiss Chard	16	**12.09**
Spinach Beet	13	**11.59**

The Dwarf Essex variety of rape occupies ninth place in yield of green crop per acre in the average of the past three years. It was surpassed by the Sutton's Earliest Drumhead cabbage in yield per acre by over fifty per cent. It will be seen that each variety of cabbage under experiment gave a higher average yield per acre than any other crop under test. The three varieties of swiss chard under the names of Silver Beet, White Silver swiss chard and Spinach Beet give a comparatively low yield per acre in comparison with the cabbage but are about the same as the Dwarf Essex rape. It is noticed that when the swiss chard is harvested the crop quickly gives a second growth and in this respect is superior to any of the other classes of crop here reported in the foregoing table.

Thickness of Seeding Sutton's Earliest Drumhead Cabbage.

As the Sutton's Earliest Drumhead cabbage gave the highest yields per acre of all the different varieties of cabbage, rape, kale and similar crops under experiment when sown the same as rape, it was decided to conduct another experiment in using the cabbage at different thicknesses, having the plants at different distances apart in the rows. Consequently, an experiment was started in 1911 and has now been conducted in each of the past eight years in which the plants of the Sutton's Earliest Drumhead cabbage were allowed to remain at the following distances apart in the rows: one inch, two inches, three inches, eight inches, sixteen inches and twenty-four inches.

The following table gives the average results of this experiment in percentage of head and in yield of green crop per acre in the average of the **Eight Years** for each of the six thinnings:

Distance between Plants in the Rows.	Amount of Crop in form of Heads. (per cent.).	Yield of Green Crop per Acre. (tons).
1 inch	2	22.2
2 inches	4	21.3
3 "	7	22.4
8 "	15	21.5
16 "	27	20.3
24 "	32	17.1

It will be seen from the foregoing table that the greatest yield was produced when the plants were three inches apart in the rows and that the yield was fully two tons per acre more than when the plants were 16 inches and over five tons per acre more than when they were 24 inches apart in the rows. When thinned to an average of 3 inches apart, the plants were largely leaf and stem with only seven per cent. of the crop in the form of small fairly compact heads.

Miscellaneous Leguminous Crops for Green Fodder.

In 1918, twenty-one varieties of miscellaneous leguminous crops were grown in the Experimental Department with the object of securing information in regard to the production of green fodder. These included varieties of Soy beans and Cow peas. They were all planted in rows about 26 inches apart. The following gives the average height and the average yield of green crop per acre of fifteen varieties grown under similar conditions for a period of **Five Years:**

Varieties.	Height. (ins.).	Yield of Green Fodder per Acre. (tons).
O. A. C. No. 111 Soy Beans	27	7.76
Ito San Soy Beans	26	7.76
Habara Soy Beans (No. 20405 Wash.)	25	7.15
Quebec No. 537 Soy Beans	24	6.96
Medium Green Soy Beans	29	6.24
Early Yellow Soy Beans	24	5.98
O. A. C. No. 81 Soy Beans	22	5.94
Tsurunoko Soy Beans	25	5.69
Chernie Soy Beans (No. 18227 Wash.)	23	5.66
Brown Soy Beans	25	5.47
Buckshot Soy Beans (No. 17251 Wash.)	23	5.12
Quebec No. 92 Soy Beans	21	5.08
Wonderful Cow Peas	14	4.23
Whip-poor-will Cow Peas	13	3.22
Bruce's Early Soja Beans	27	2.79

The variety of soy beans which comes at the top of the list in yield of green fodder is one of our own selection. This was originated in connection with our plant breeding work with nursery plots. The two varieties of cow peas come comparatively low in the list.

The Early Yellow variety of soy beans has been under test at the College continuously since 1901. In the average of 17 years, it has given 6.4 tons of green fodder per acre per annum.

Sunflowers for Fodder.

Dr. J. W. Robertson, when Dairy Commissioner for the Dominion, strongly recommended the growing of sunflowers and Horse beans to mix with corn for silage. The production of Horse beans throughout Ontario is usually a failure, and the growing of sunflowers for use in the silo has never been practised to any great extent. In some instances, the sunflowers have been grown and the heads have been run through the cutting box along with corn when filling the silo.

Seven different varieties of sunflowers were tested in an experimental way at the College some years ago but all were dropped with the exception of three kinds which are still under experiment. Each of these three varieties have now been under test for **Nineteen Years,** with the following average results per annum:

Varieties.	16 Years.	19 Years.	
	Diameter of Heads (Ins.)	Yield per Acre.	
		Heads (tons).	Whole Crop. (tons).
Black Giant	7.2	6.4	22.0
Mammoth Russian	7.1	5.6	17.5
White Beauty	7.3	5.4	16.5

These results give the comparative amounts of head and of stalk. The stems become very woody in the autumn. It is understood that a few people use the whole crop for cutting and placing in the silo but, as the stems contain such a large amount of woody fibre, it scarcely seems reasonable that these, although kept in a somewhat succulent condition when mixed with corn in the silo, will furnish much feed of real service. There is, however, still room for investigational work regarding the value of sunflowers for mixing with corn in the silo.

Sunflowers are planted in about the same way as corn, and prove to be a hardy crop with little likelihood of a failure. In the last twenty-one years, we have never met with a failure in securing a crop of sunflowers.

Pasture Crops in Ontario.

A bulletin on "Hay and Pasture Crops—Grasses, Clovers, Etc." is almost completed and ready for the press. Information will be furnished in this bulletin regarding annual, temporary, and permanent pastures. As this important phase of Ontario's agriculture is discussed pretty fully in the bulletin, it is not necessary to present any details at this time. (See Bull. No. 269.)

Varieties of Alfalfa.

Alfalfas have obtained their varietal names from the countries in which they have been grown for a length of time, from the men who have been instrumental in their introduction or in their improvement, from the color of the flowers, etc. There are many of these so-called varieties of alfalfa. While some of these different kinds do not vary one from the other to any great extent from a botanical standpoint, there are some marked variations in character of growth, in hardiness and in productiveness. Information along these lines is of great importance in connection with alfalfa production in Ontario.

An experiment was started at the College in the spring of 1909 in which a number of varieties of alfalfa were sown on 71 plots at the rate of twenty pounds of seed per acre, with barley as a nurse crop. This experiment included some of the most noted varieties of alfalfa which were grown in Canada and in the United States, as well as others which were not so well known, except in an experimental way. As there were ten lots of Sand lucerne and nine lots of other variegated alfalfas from Europe, four lots of Common alfalfa from the central-western States, three lots of Grimm alfalfa from Minnesota and Nebraska, and two lots each of the Variegated alfalfa from Ontario and of Turkestan alfalfa from Asia, the results from these different lots of the separate varieties were averaged. These averages, as well as the results of other varieties taken separately, are presented for each of the past **Nine Years.** It is important to note that in the autumn of the first season of this experiment there was from 85 to 95 per cent. of a perfect stand of plants on each plot. The results have been affected principally by the comparative hardiness of the different varieties, and from this standpoint they are particularly interesting. The winter of 1917-18 was exceptionally severe on the old alfalfa plants, killing an unusually large number.

Varieties.	Color of Flowers.	No. of Tests.	Source of Seed.	Average Annual Yield of Hay per Acre (tons).									
				1910	1911	1912	1913	1914	1915	1916	1917	1918	Aver. 9 yrs.
Grimm	Variegated.	3	Minnesota... Nebraska ...	3.21	2.42	4.73	4.13	3.65	5.19	4.79	3.56	1.69	**3.71**
Ontario Variegated	Variegated.	2	Ontario	3.50	2.12	4.50	3.58	3.34	5.20	4.56	3.44	.48	**3.41**
Baltic	Variegated.	1	South Dakota.	3.10	2.52	4.08	3.36	3.52	5.36	4.00	3.24	.12	**3.37**
European Variegated	Variegated.	9	Europe	4.04	2.38	4.91	4.18	2.74	4.96	3.80	2.85	.40	**3.36**
Turkestan..	Violet	2	Asia	3.33	1.74	4.44	3.70	2.98	5.08	3.70	3.18	.48	**3.18**
Sand.......	Variegated.	10	Europe	3.04	2.28	4.45	3.61	2.64	4.77	3.85	2.87	.35	**3.10**
Mongolian...	Violet	1	Asia	3.20	2.12	4.92	2.72	2.36	4.84	2.80	2.64	1.84	**3.05**
Common	Violet	1	Ontario.......	3.20	.80	2.52	1.84	1.80	3.60	1.92	2.00	.04	**1.97**
		1	Montana (Chinook).......	2.35	.96	1.64	1.48	1.88	3.52	2.48	2.16	.13	**1.84**
		4	Utah. ...... Colorado .... Nebraska ... Kansas	2.31	.71	.95	.99	1.53	2.61	.85	1.11	.02	**1.23**
		1	Texas	2.05	.52	.76	.88	1.64	2.76	.53	.88	....	**1.11**
Peruvian ...	Violet	1	South America	2.60	.04	.72	.08	.09	.32	.05	....	....	**.43**
Arabian	Violet......	1	Asia..........	.90	.02	....	....	....	....	....	....	....	**.10**

Even in the cropping of alfalfa from year to year from the one seeding, the yields vary greatly. These differences are largely due to weather conditions. It will be noticed that practically all varieties produced larger yields of hay in 1912 than in 1911, and in 1915 than in the year previous. These crops were all produced from the one seeding which took place in the spring of 1909.

It will be seen that of these ten varieties of alfalfa five have variegated and five violet flowers. With only one slight exception, the variegated surpassed the violet-flowered varieties in average yield of hay per acre for the nine-year period. This points to hardiness of the variegated varieties and especially of the Grimm and the Ontario Variegated.

Growing Alfalfa in Ontario.

The number of acres of alfalfa in Ontario was 177,565 in 1916, 189,109 in 1917 and 144,010 in 1918. It will be seen that there was an increase in the acreage from 1916 to 1917 but a drop during the past year. This was undoubtedly due to the exceptionally severe winter which killed many fields of alfalfa in Ontario.

This crop is being recognized more and more as a most valuable farm crop for this Province. Its perennial character of growth, its power of making use of the free nitrogen of the atmosphere and of the fertilizing elements of the subsoil, and its capacity of producing large yields of exceptionally nutritious feed for farm stock, combine to place this crop as one of the most important which can be grown. It possesses a combination of characteristics which is not found in any other farm crop. Alfalfa starts its growth early in the spring and continues throughout the summer and even late into the autumn. Under favorable conditions it produces two or three crops per annum and thrives for several years without the necessity of re-seeding. The feed is relished by practically all kinds of farm stock. It can be fed in the green or in the dry condition, or can be converted into silage. In at least some localities over Ontario the second crop in the season is allowed to ripen for seed production to good advantage. Alfalfa is particularly suitable for use in a long rotation, and leaves the soil in an excellent condition for the growing of other farm crops. In order, however, to make alfalfa growing successful, it is important to sow the right kind of seed on suitable soil and to employ the best methods of culture.

Select land having a clean, mellow, fertile surface soil overlying a deeply drained, sweet subsoil. Use large plump seed of strong germinating power and of some hardy variety such as Grimm, Ontario Variegated or Baltic. The common alfalfa seed of the Western States, even though it has been northern grown, usually produces plants which are too tender to resist the climatic conditions of Ontario. Make use of seed which grades high according to the Seed Control Act. Inoculate the seed with the proper kind of bacteria, providing alfalfa has not been grown successfully on the land in recent years. Sow the alfalfa seed at the rate of about twenty pounds per acre. The seeding may be performed according to any one of the following methods:

1. Alfalfa seed may be sown on winter wheat in the early spring either on the old snow or on a fresh snow of one or two inches, and no harrowing or cultivation is necessary.

2. On a suitable seed bed and as soon as the land is sufficiently dry in the spring, alfalfa seed may be sown from the grass seed box placed in front of the tube drill. About one bushel of barley, wheat or rye per acre sown from the tubes of the drill makes a very good nurse crop. After the seed is sown the land should be harrowed lightly.

3. Alfalfa may be sown alone in the month of July on a summer fallow, providing there is sufficient moisture for good germination.

Alfalfa should never be pastured during the first year and seldom, if ever, afterwards, as pasturing very frequently destroys the plants. The crop should be cut for hay or for green fodder in the following year after the seeding takes place and as soon as the plants start to bloom. Care should be taken to retain as many of the leaves on the stems as possible and to protect the crop from rain. In many places in Ontario the alfalfa will produce three crops of hay per annum. The third cutting, however, may be used to advantage for mixing with corn when filling the silo as this forms an easy method of handling the green alfalfa in the autumn and also of improving the quality of the corn silage. In some localities hay may be obtained from the first crop and seed from the second crop in each season and for a period of several years.

If the directions here given are carefully followed, alfalfa may be expected to produce large and valuable crops for a number of years without re-seeding.

Alfalfa Seed Production.

Previous to the last four years of abnormally wet seasons, alfalfa seed production was becoming quite an industry in some parts of Ontario. As both a crop of hay and a crop of seed can be produced in the same season, if weather conditions are favorable, many of the alfalfa growers have found seed production quite profitable. From extensive enquiries made from farmers who had grown alfalfa seed in Ontario for at least five years, some very valuable information was obtained. We learned that alfalfa seed had been produced with success in at least thirteen counties in Ontario. In all cases where seed was produced it was taken from the second crop, the first crop of the season being converted into hay. The yield of alfalfa seed per acre varied considerably, the highest being seven bushels, and the average a little over two bushels per acre. The farmers determined the time for cutting the crop for seed production by the color of the pods, most of them stating that the crop should be cut when the pods were brown, although some of them left the crop until the pods were almost black. The majority of the farmers cut their seed crop with a mowing machine and a number mentioned having a table attachment to the machine. About twenty per cent. used the reaper and about twelve per cent. used the self-binder. As a rule the crop was cured in the windrow by those who used the mowing machine, and in the bunches by those who used the reaper, or the mowing machine with the table attachment. Those who used the self-binder cured the crop in shocks. The threshing was done mostly with a clover huller, and took place almost any time after the crop was harvested until midwinter. When the threshing is done in the autumn it is preferable to have dry weather, and when in the winter to have cold weather, in order to get the best results. Nearly all farmers reported obtaining good quality of seed in most years. The seed was sold chiefly to neighboring farmers and to local dealers. The greatest difficulties reported in alfalfa seed production in Ontario have been due to injuries caused by grasshoppers, wet weather, blighted plants, early frosts, and a few mentioned partial failures from thick seeding. The ideal condition appears to be a comparatively moist season for the production of the hay crop and a rather dry season after the hay has been removed from the land. The great majority of farmers stated that they considered seed production did not injure the plants. Nearly all were enthusiastic alfalfa growers from the standpoint of both hay and seed production.

Sweet Clover Experiments.

Sweet clover is a biennial leguminous plant, having an erect branching stemmy growth. The plant has a strong fragrant odor and a bitter taste. The growth is rather slow at first and not very large in the first year. In the second year, however, the growth is rapid and abundant. The stems become woody, the leaves easily drop from the plants on drying, and the seed matures unevenly and readily shatters on ripening, but generally yields well per acre. The seeds are formed singly on pods and closely resemble in shape, color and size those of alfalfa. The plants of sweet clover die after they produce seed at the end of from fifteen to eighteen months from the time the seed is sown.

Sweet clover thrives on a variety of soils, but seems to require an abundance of lime. It grows readily on roadsides and waste places, where the seeds reach the ground annually or biennially. Its eradication is rather difficult in uncultivated land, but not very difficult in cultivated fields. In past years seed has been harvested for market from the wild crops growing in waste places, and even at the present time seed offered for sale frequently contains many impurities. It is quite probable the seed obtainable will improve from year to year.

In an experimental way at the Ontario Agricultural College at different times within the past quarter of a century, the crop was grown for hay production in comparison with Common Red and other varieties of clover in the years 1892, 1895, 1897 and 1899. Sweet clover was compared with eight varieties of clover, sainfoin, and alfalfa from the standpoint of pasture production in the years 1902 and 1904. Various tests were made also in cutting the sweet clover at different stages of growth for feeding to different classes of farm animals, but in all instances the animals refused to eat the crop although, in some instances, it was cut when quite young and tender. The bitter flavor of the crop seemed distasteful to the animals and apparently they were not starved long enough to force them to develop the desired taste.

If sweet clover is to be used for hay production, it should be cut comparatively early, before any blooms appear. At this stage of development, the growth is not as abundant, but the plants are less woody and leaves are more easily saved than when the crop is cut at a later period. There seems to be rather more difficulty in curing hay from sweet clover than from red clover or from alfalfa.

In the spring of 1916, fifteen lots of sweet clover were sown in duplicate plots in our experimental grounds, making thirty plots in all. For this experiment, the white sweet clover seed was obtained from nine and the yellow sweet clover seed from six different sources. In 1917 the plots of each of one set were divided and the crop was cut at two different stages of maturity, allowing a few days to intervene between the two cuttings. The cuttings of each set gave some interesting results. The white varieties varied from 2.0 to 3.8 tons of hay and the yellow varieties from 1.1 to 2.3 tons of hay per acre. The average of the three cuttings of all of the varieties of sweet clover from the various sources gave the following yields of green fodder and of hay per acre in 1917:

Species of Type,	Average Yield per Acre.	
	Green Fodder (tons).	Hay (tons).
White Flowering Biennial Sweet Clover ..	10.42	2.55
Yellow Flowering Biennial Sweet Clover..	6.96	1.55

There were two lots of the biennial yellow-flowered sweet clover known under the name of "albotrea." The seed from one source gave an average of 1.28, and the seed from the other source, 1.31 tons of hay per acre. Of the six varieties of yellow biennial sweet clover under test, two gave higher and two gave lower yields than those obtained from the albotrea.

In each of two years the experiment was conducted at the College, comparing the amount of pasture crop produced by sweet clover, by alsike clover and by common red clover. The yields per acre were determined at each of six cuttings in each of the two years. Three weeks were allowed between each two cuttings. The results are very interesting in furnishing definite information regarding these three crops in the production of green clover which would correspond pretty closely to the relative amounts of pasture produced. The following table gives the average of the two years' experiments in tons per acre of pasture crop:

Periods of Cutting.	Variety of Clover, Tons of Pasture Crop per Acre.		
	Common Red.	Alsike.	Sweet.
First Cutting...............	13.5	11.0	11.0
Second "	1.4	.2	1.5
Third "	2.9	4.0	2.5
Fourth "	4.6	1.7	3.0
Fifth "	2.0	3.4	1.9
Sixth "	1.6	1.1	.9

Sweet clover is now being studied for pasture purposes, both alone and in combination with other crops.

As the plants of sweet clover vary so much in habits of growth, etc., a large amount of experimental work is being conducted at the College in securing seed from individual plants of different characteristics of growth. It is hoped that in the near future decided improvements will be obtained on the sweet clover which grows wild in waste places in different parts of the country, and that we may be able to secure a strain which retains the good features and has fewer of the objectionable characteristics of the average wild plants.

Summary Regarding Good Seed.

For the highest returns in crop production it is essential to have 1, good seed; 2, thorough cultivation; 3, fertile soil; 4, well-drained land, and 5, proper rotation of crops.

Good seed means not only large, plump, sound, well-matured seed of strong vitality and free from impurities, but also the *very best varieties* obtainable.

In order to know the best kinds, about 2,500 varieties of farm crops have been grown under test at the Ontario Agricultural College within the past twenty-

Agricultural Society Judges at practice work before starting out to judge Standing Field Crops throughout Ontario.

five years. Practically all varieties have been grown for five years in succession, after which the poorer kinds have been dropped, the better sorts have been continued, and new and promising kinds have been added to the test from time to time. Those varieties which have given the highest returns in the tests at the College have proven valuable, not only in themselves, but also as foundation stock from which to secure improved strains by selection, or new varieties by hybridization.

A few of the leading varieties obtained by introduction, by selection and by hybridization have been tested on thousands of farms throughout Ontario in the co-operative experiments conducted through the medium of the Experimental Union.

As the result of these lines of activity the following varieties have proven to be of special value for the farms of Ontario:

Oats.

O.A.C. No. 72.—Late, vigorous grower, good straw, spreading head, white grain with pinkish coloration, comparatively thin hull, high yielder of grain.

Banner.—Late, good straw, spreading head, white grain, medium hull, medium yielder.

O.A.C. No. 3.—Very early, good straw, spreading head, white grain, exceptionally thin in the hull, good yielder.

Barley.

O.A.C. No. 21.—Early, stiff straw, six-rowed head, grain bluish under the hull, good quality, heavy yielder.

Spring Wheat.

Marquis.—Early, good straw, beardless head, white chaff, red grain, excellent quality for bread production, good yielder.

Wild Goose.—Fairly early, tall straw of medium strength, compact bearded head, hard grain, particularly suitable for the manufacture of macaroni, high yielder.

Winter Wheat.

Dawson's Golden Chaff.—Stiff straw, beardless head, red chaff, white grain, medium quality, high yielder; the most popular variety of winter wheat in Ontario for many years.

Imperial Amber.—Tall straw of medium strength, bearded head, red chaff, red grain, good milling wheat, high yielder.

O.A.C. No. 104.—Stiff straw, beardless head, white chaff, white grain, of better quality for bread production than Dawson's Golden Chaff, high yielder.

Spring Rye.

O.A.C. No. 61.—Good straw of medium height, the highest yielder of all varieties of spring rye.

Winter Rye.

Petkus.—Very hardy, vigorous grower, highest yielder of all varieties of winter rye.

Mammoth White.—Very hardy, vigorous grower, the second highest yielder.

Field Peas.

Arthur.—Medium late, medium straw, white blossom, medium-sized white grain, large yielder.

Canadian Beauty.—Late, heavy straw, white blossom, large white grain, large yielder.

Potter.—Medium late, medium straw, white blossom, medium-sized white grain, large yielder.

Golden Vine.—Late, heavy straw, white blossom, small white grain, medium yielder.

Field Beans.

Common White Pea.—Medium early, medium straw, small white grain, good yielder.

Soy or Soja Beans.

O.A.C. No. 111.—Medium early, vigorous grower, yellow beans, heavy yielder of fodder.

O.A.C. No. 81.—Early, yellow beans, heavy yielder of grain.

Brown.—Very early, brown beans, heavy yielder of grain.

Vetches.

Hairy.—Can be sown alone in fall or spring, used for fodder, cover crop, green manure and to a limited extent for seed production. Autumn seeding usually gives best results. Seed very expensive at present.

Buckwheat.

Rough or Rye.—Early, medium yield of straw, grain with rough thick hull, very heavy yielder.

Silver Hull.—Medium early, heavy yield of straw, grain with smooth hull, fair yielder.

Flax.

Common.—Medium height, blue flowers, quantity of fibre and seed varying with care, soil and season.

Mixed Grains.

Grain Production.—O.A.C. No. 3 oats, 1 bushel per acre. O.A.C. No. 21 barley, 1 bushel per acre.

Green Fodder or Hay.—O.A.C. No. 72 oats, 2 bushels per acre. Multiplier peas, 1 bushel per acre.

Annual Pasture.—Joanette, O.A.C. No. 72 or Banner oats, 3 bushels per acre. Common Red clover seed, 7 pounds per acre.

Sweet Corn for Table Use.

Golden Bantam.—Early, yellow, eight-rowed ears, best of about fifty varieties for home use.

Flint Corn.

Compton's Early.—Early, medium yield of stalks, yellow twelve-rowed ears, good yielder of grain, suitable for silage in more northerly districts of older Ontario.

Salzer's North Dakota.—Medium early, heavy yielder of stalks, white eight-rowed ears, crop suitable for husking or for the silo in central Ontario.

Dent Corn.

White Cap Yellow Dent.—Medium early to medium late according to strain, grown for grain in southern Ontario and for fodder and silage in central Ontario.

Wisconsin No. 7.—Medium in earliness, usually matures in the extreme southerly parts of Ontario, suitable for the silo in the warmer parts of the Province.

Sorghum.

Early Amber Sugar Sorghum, usually called *Sugar Cane.*—Grows about eight feet tall and resmbles corn in appearance, but produces the seed on the top of the plants. Yields nearly equal to White Cap Yellow Dent corn, used for fodder and occasionally for syrup production.

Millet.

Japanese.—Late, heavy producer of green fodder and of hay, uncertain producer of seed, which is usually high in price.

Siberian.—Early, red seed, medium producer of both seed and fodder.

Hungarian Grass.—Early, light and dark seed, medium producer of both seed and fodder.

Rape.

Dwarf Essex.—Average yield more than corn, used as pasture or as green fodder, relished by cattle, sheep and hogs, very fattening, taints milk when fed to dairy cows.

Potatoes.

Irish Cobbler.—Early, white, good yielder, good quality.

Green Mountain.—Late, white, excellent shape, good yielder, good quality.

Mangels.

Yellow Leviathan.—Intermediate in length, good shape, high yielder, excellent quality.

Ideal.—Yellow, tankard shape, high yielder.

Sutton's Mammoth Long Red.—High yielder.

Sugar Mangels.

Giant White Feeding.—Intermediate in length, sugar content between mangels and sugar beets, yield of roots lower than mangels.

Royal Giant.—Pink skin, intermediate in length, sugar content between mangels and sugar beets, yield per acre lower than mangels.

Sugar Beets.

Dominion Sugar Company Selection.—Ontario grown seed, very high sugar content.

Kleinwanzlebener.—Imported seed, was used extensively in America for sugar production.

Swede Turnips.

Garton's Model.—Bronze top, high yielder, good quality.

Giant King.—Purple top, high yielder, good quality.

Perfect Model.—Purple top, high yielder, excellent quality.

Fall Turnips.

Red Top White Globe.—Very high yielder and excellent for early use in the fall.

Field Carrots.

Mammoth Short White.—Conical in form, good quality, high yielder. (All short white carrots offered by Ontario seedsmen are very similar.)

Grasses.

Timothy.—The popular variety for hay production, but not so suitable for pasture, especially in dry weather.

Orchard Grass.—A hardy perennial, used for hay when sown alone, but more suitable in a pasture mixture, starting growth early in the spring and continuing until late autumn.

Meadow Fescue.—A hardy perennial of good quality for hay or pasture, particularly suitable for use in a permanent pasture mixture.

Red Top.—A native perennial, particularly suitable for hay and pasture on low, damp land.

Clovers.

Common Red.—A biennial plant and the most valuable clover for Ontario, giving two crops per year.

Mammoth Red.—A late, coarse-growing clover, suitable for land which usually produces a light crop.

Alsike.—More suitable than Red clover for damp, shallow soil.

Alfalfa.

Grimm.—A perennial, deep-rooted legume, which is very hardy and which gives two or three crops annually for a series of years when well established under favorable conditions.

Ontario Variegated.—Very similar to the Grimm alfalfa and possessing about the same degree of hardiness.

CONTENTS

	PAGE.
Introduction	1
Field Experimental Work	2
Field Experiments by Farmers	4
Weather Conditions	4
Rotation of Crops	6
Standard Weights per Bushel and per Bag	7
Continuous Growing of Farm Crops without Change of Seed	8
Comparative Results from Different Classes of Farm Crops	10
Selection of Seed Grain	11
Influence of Root Seed Selection	13
New and Better Varieties originated at the College	14
The Stinking Smut of Wheat and the Loose Smut of Oats	17
Smut Resistance in Oats	20
Grains Grown in Combination	20
Sowing Spring Grains at Different Dates	21
Dates of Sowing Emmer and Spelt	22
Varieties of Oats	23
Two New Valuable Varieties of Oats	24
A Test of the Stooling of Oats	27
Percentage of Hull in Oats	28
Varieties of Spring Barley	29
Winter Barley	31
Varieties of Winter Wheat	32
New Winter Wheats Originated at the O.A.C.	35
Spring Wheat	36
Emmer, Spelt and Einkorn	38
Varieties of Winter Rye	39
Varieties of Spring Rye	40
Varieties of Buckwheat	40
Varieties of Field Peas	41
Varieties of Field Beans	42
Varieties of Soy or Soja Beans	43
Hairy Vetches and Spring Vetches for Seed	44
Grass Peas	45
Cow Peas	45
Varieties of Corn for Grain Production	46
Varieties of Sorghum for Seed	46
Sunflowers for Seed	47
Varieties of Flax for Seed and for Fibre	47
Different Quantities of Flax Seed per Acre	48
Flax Production and Soil Fertility	49
Varieties of Millet for Seed Production	50
Experiments with Potatoes	51
Root Crops in Ontario	52
Varieties of Mangels	53
Varieties of Sugar Beets and of Sugar Mangels	54
Varieties of Swede Turnips	57
Varieties of Fall Turnips	58
Varieties of Field Carrots	58
Varieties of Kohl Rabi	59
Varieties of Parsnips	60
The Production of Field Root Seed in Ontario	60
Varieties of Corn for Silage and for Fodder	62
Varieties of Sorghum for Fodder	64
Varieties of Millet for the Production of Fodder	66
Sowing Millets at Different Dates	67
Varieties of Rape, Kale, Cow Cabbage, etc.	67
Thickness of Seeding Sutton's Earliest Drumhead Cabbage	69
Miscellaneous Leguminous Crops for Green Fodder	69
Sunflowers for Fodder	70
Pasture Crops in Ontario	71
Varieties of Alfalfa	71
Growing Alfalfa in Ontario	72
Alfalfa Seed Production	73
Sweet Clover Experiments	74
Summary Regarding Good Seed	76

BULLETIN 269] [FEBRUARY, 1919

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

Hay and Pasture Crops Grasses, Clovers, etc.

By C. A. Zavitz and W. J. Squirrell

INTRODUCTION.

Pasture and hay crops occupy more than one-half of the farm lands of Ontario. The market value of the hay and clover of the Province has amounted to upwards of $40,000,000 annually for the past thirty-six years and the market value in each of the past three years has been almost double that of the average. No statistical information has been obtained for the Province regarding the value of the pasture crops but the areas used for pasture are slightly greater than those used for hay. The following table gives the average number of acres used for pasture, hay, small grain, corn, potatoes and roots in Ontario for the past thirty-five years in periods of five years each:

Periods of Five Years.	Pasture.	Hay.	Small Grain.	Potatoes.	Corn.	Roots.
1884-1888............	2,759,410	2,265,978	4,671,690	152,568	177,150	130,932
1889-1893............	2,623,111	2,536,092	4,837,700	150,486	247,613	156,092
1894-1898............	2,693,586	2,467,264	5,200,107	174,029	478,579	199,370
1899-1903............	2,824,080	2,603,804	5,205,050	153,960	541,684	220,300
1904-1908............	3,290,120	3,111,836	5,020,997	149,315	509,082	203,277
1909-1913............	3,132,015	3,234,497	4,846,164	163,831	653,962	171,169
1914-1918............	3,437,299	3,306,604	4,734,976	158,746	701,339	141,458

It will be seen that the maximum areas for pasture, hay and corn occurred in the five years from 1914 to 1918, for small grains and for roots in the five years from 1899 to 1903, and for potatoes in the five years from 1894 to 1898, inclusive. It will be observed that the greatest increases in the farm lands of Ontario in recent years have been with the coarse fodder crops such as pasture, hay and corn. While the pasture and hay crops have been increasing in area it is doubtful if there has been much improvement in the quality of these crops.

DESCRIPTIONS AND DRAWINGS OF HAY AND PASTURE PLANTS.

Twenty-six varieties of grasses, clovers and similar crops are given separately. Following these will be found the results of experiments conducted at the Ontario Agricultural College in the testing of various crops both singly and in combination for the production of hay and of pasture.

Timothy Grass (*Phleum pratense*).

Other common names: Meadow Catstail, Herd's Grass.

History.—Although this grass is a native of Europe, its agricultural value was first recognized in America. It was introduced from England into the State of Maryland by Timothy Hanson, from whom it takes its name, about 1720. In the New England States it is known as Herd's Grass because of its introduction into New Hampshire by John Herd.

Botanical Description.—Timothy is a hardy perennial grass possessing a short root stalk. The stems which are erect and smooth sometimes grow to a height of four feet. The leaves are short and flat. The inflorescence is in the form of a spike with the spikelets, which are one-flowered, arranged in a dense cylindrical form. The heads of timothy are distinguished from those of Meadow Foxtail by being larger and coarser and having no soft white hairs.

Habits of Growth.—Timothy is a slow growing grass, starting late in the spring and usually producing little second growth after being cut for hay. It produces flowers early in July and ripens seed about a month later.

Soil.—Timothy may be successfully grown on a variety of soils but is best adapted to clay loams which contain a good supply of moisture. Sour soils, sandy soils and those soils which dry out badly during the hot part of the summer are not so suitable for growing timothy.

Seed.—Timothy seed, for the best results, should be comparatively large in size, plump, of a bright silvery color, free from impurities and very little hulled. It is one of the best seed producers among grasses, and is ready to cut for this purpose when the spikes turn from green to yellow. Threshing is accomplished with the ordinary grain thresher, although the best seed on the market is flail-threshed. The legal weight per measured bushel is 48 pounds.

Seeding.—Owing to its weight and shape, timothy is easily sown. In Ontario, timothy is successfully sown with cereal crops both in the autumn and spring of the year. From 12 to 15 pounds is used per acre when this grass is not seeded in combination with clovers and other grasses.

Agricultural Value.

Timothy is the best known and the most widely grown of all the grasses in Ontario. It is essentially a hay grass producing a large amount of stems and a small amount of leaves. Its popularity is justly due to its many good qualities. (1) Its seed is comparatively cheap and readily obtainable. (2) The seed is less likely to contain weed seeds than most of the other grasses. (3) The crop is easily cut and cured. (4) There is less danger of the hay spoiling from being over-ripe before cutting than there is with other grasses. (5) It produces a large yield of hay of good quality. (6) On account of suitable digestibility, timothy is a favorite grass for work horses and for livery horses which are required to work immediately after feeding. For the best results in making hay, timothy should be cut when the plants are in bloom. It is one of the easiest of all the grasses to cure and wastes little in handling and in transportation. Because of its late start in the spring and its inability to stand the hot dry weather of the summer, timothy is only a fair pasture grass. This grass shows a great deal of variation in the individual plants and much improvement is possible by selection.

TIMOTHY GRASS.
(*Phleum pratense*).

Orchard Grass (*Dactylis glomerata*).

Other common names: Cocksfoot, Rough Cocksfoot.

History.—This grass is a native of Europe, its common name, "Orchard," being derived from the success attending its growth in shady places. It has been cultivated in America since about 1760. After Timothy and Kentucky blue grass, it is probably the most cultivated grass in Ontario.

Botanical Description.—Orchard grass is a long-lived perennial, having a very short root stalk. The heads are branching and the spikelets borne in dense clusters on the branches. The spikelets may contain from two to five flowers, each of which is enclosed within two strongly keeled and sharply pointed glumes. The stems grow erect and sometimes reach a height of three feet. The leaves are long, broad, flat, not as coarse in texture and more abundant than in timothy. This grass has a tendency to grow in close tufts, and forms one of the best examples among cultivated grasses of a "bunch" grass.

Habits of Growth.—Orchard is a quick growing grass, starting early in the spring, producing a large amount of growth during the summer and continuing to grow vigorously into the late autumn. It shoots up very quickly after being cut for hay. The flowering period is in the latter part of June and it reaches the hay condition about the same time as red clover.

Soil.—While Orchard grass is best suited for growing on a rich, well-drained, clay loam soil, it will succeed on soils with a lesser moisture supply than is required for timothy.

Seed.—Orchard grass seed is somewhat boat shaped, about one-quarter of an inch in length and possesses short awns. Good seed is of a bright straw color, free from weed seeds, other seeds and dirt. It is ready to cut for seed about three or four weeks after it has flowered and when the seeds are straw colored. The legal weight per bushel is 14 pounds.

Seeding.—On account of its light weight Orchard grass seed is more difficult to sow than timothy seed. It may be sown successfully either in the autumn or spring with cereal grains. From 25 to 30 pounds is sown per acre, when this grass is not seeded in combination with clovers and other grasses. The method of seeding is usually to sow it broadcast by hand.

Agricultural Value.

Orchard grass is grown both for hay and pasture but its chief value lies in its use for pasture. Close pasturing does not seem to injure Orchard grass and lessens its habit of growing in bunches. Grass and clover mixtures grown in Ontario with the object of producing pasture will nearly always be improved by the inclusion of Orchard grass. Orchard is one of the very best grasses in withstanding drought. The palatability of the grass is almost equal to that of timothy but it loses its palatability with age much more rapidly than this grass. When it is grown for hay, it should be cut early, not later than the commencement of bloom. After this period, it deteriorates in quality, soon becoming woody. Like timothy, Orchard grass is quite variable in its individual plants, showing great differences in height, coarseness of stem and leaf, leafiness, earliness, etc. There would appear to be almost as great a chance for improvement by selection with this grass as with timothy.

ORCHARD GRASS.
(*Dactylis glomerata*).

Tall Oat Grass (*Arrhenatherum elatius*).

Other common names: Meadow Oat Grass, Tall Meadow Oat Grass, Oat Grass, False Oat Grass.

History.—Like many of the most important economic grasses, Tall Oat is a native of Europe. It was first cultivated in Southern France. In Ontario up to the present time, it has been little grown. In experiments conducted at Guelph which have extended over a period of several years, it has proven to be one of the most promising grasses tested.

Botanical Description.—Tall Oat is a long-lived perennial with a short root stalk. The heads are in the form of a spreading panicle and somewhat resemble those of oats. The stems grow fairly erect but there is a greater tendency to droop in this grass than is found in either timothy or orchard. The leaves are long and broad, rather soft in texture, and of a yellowish-green color. This grass frequently grows in bunches or tufts but this peculiarity is less marked than in the case of Orchard grass.

Habits of Growth.—Tall Oat starts growth early in the spring and provides a large amount of green material throughout the summer and autumn. It flowers about the same time as Orchard grass and also reaches the hay condition at about the same period as this grass. In mixtures where Kentucky Blue and Canadian Blue grasses do not gain admission, Tall Oat will last for many years.

Soil.—The most suitable soils for Tall Oat are rich, moist loams with a good supply of lime. It will, however, give good results on other types of soil where there is a good supply of moisture, and is noted for its ability to give good returns on poor soils.

Seed.—The seed of this grass is straw-colored, about three-eighths of an inch in length, has long twisted awns, and in shape resembles hulless oats. The seed which shatters easily should be cut as soon as the panicles turn yellow. The weight per bushel is 12 pounds.

Seeding.—On account of its light weight and twisted awns, Tall Oat is a difficult grass to sow. This difficulty of seeding is one of the chief reasons why it is not more extensively grown. In order to obtain an even distribution of seed, it is often mixed and sown with the grain used as a nurse crop. From 30 to 35 pounds of seed is used per acre when this grass is not seeded in combination with clovers and other grasses.

Agricultural Value.

Tall Oat is both a good hay and pasture grass and gives its best returns when sown in mixtures. In its resistance to drought, Tall Oat is the equal, if not the superior, of Orchard grass. When grown for hay, it should be cut at the commencement of bloom. If left later than this stage it soon becomes woody and unpalatable. In Ontario this grass will frequently produce two good crops of hay in a season. This hay is not much more difficult to cure than timothy. Its earliness of growth and the large quantity produced, along with its ability to stand tramping, make it one of the most valuable of pasture grasses. Tall Oat grass is possessed of a certain bitterness of taste which animals do not at first like. When they become accustomed to it, however, they will eat the grass quite readily.

Tall Oat Grass.
(*Arrhenatherum elatius*).

Yellow Oat Grass (*Trisetum flavescens*).

Other common names: Golden Oat, Yellow False Oat.

History.—This grass which is also a native of Europe is only of secondary importance in the agriculture of that continent. In both England and France, it is used as a minor grass in permanent pasture mixtures. Its agricultural value is very little known in Ontario.

Botanical Description.—Yellow Oat is a perennial grass, possessing a short root stalk. The heads of this grass are smaller and finer than those of tall oat. From a green color in the immature grass the heads change to a golden yellow at the period of flowering. The stems which are short and fine in texture are covered with hairs. The leaves also, because of their covering of soft hairs, are fine in texture.

Habits of Growth.—Under suitable conditions of soil and climate, Yellow Oat grass quickly becomes established. It flowers at about the same period as does Orchard grass.

Soil.—A well drained clay loam soil is the best suited to its growth. Yellow Oat gives poor results on soils which dry out badly in the hot time of summer and on soils which contain excessive moisture.

Seed.—The seeds of Yellow Oat resemble those of Tall Oat but are much smaller in size. They are of a golden yellow color, about three-sixteenths of an inch in length, and have long and very fine awns. The seed is often very impure, usually being obtained from mixtures where Yellow Oat is one of the ingredients. The weight per bushel is about 6 pounds.

Seeding.—Because of its light weight, it is very difficult to obtain an even distribution in seeding this grass. When sown it is usually mixed with the seed of the grain used as a nurse crop and is even sometimes mixed with sand. From 20 to 25 pounds of seed is sown per acre when this grass is not seeded in combination with clovers and other grasses.

Agricultural Value.

The chief use of Yellow Oat grass is as a minor grass in permanent pasture mixtures and for growing in lawn mixtures. Where this grass has been included in permanent pasture mixtures tested at Guelph, it has proven to be one of the most persistent grasses used. The palatability of Yellow Oat grass is high. All classes of stock like it and cattle will eat it nearly as readily as Kentucky Blue grass. As a lawn grass, it possesses considerable value, forming a fine turf if kept closely cut.

YELLOW OAT GRASS.
(*Trisetum flavescens*).

Meadow Fescue Grass (*Festuca elatior*).

Other common names: English Blue Grass, Randall Grass, Evergreen Grass.

History.—Meadow Fescue is a native of Europe and is one of the most highly prized of English grasses. It is widely grown in some sections of the United States and Canada and is quite well known in some parts of Ontario.

Botanical Description.—Meadow Fescue is a perennial grass lasting many years. The heads are in the form of a spreading panicle and are distinctly nodding. The stems, which sometimes reach a height of three feet, are slender and smooth. The leaves are flat, broad and thick, and of a glossy dark green color.

Habits of Growth.—Meadow Fescue is a slower growing grass than either Orchard or Tall Oat. It is ready to cut for hay a few days later than Orchard grass and usually produces a good second growth.

Soil.—It gives its best results on rich moist soils and may be successfully grown on sandy soils where there is a sufficient supply of moisture available.

Seed.—The seed considerably resembles Orchard grass but is larger in size and not so pointed. It is awnless and of a light brown color. Meadow Fescue should be cut for seed as soon as the panicles of the head have turned brown. If left after this period, it shatters badly. It is a large yielder of seed and, under favorable conditions, has been known to produce seed crops for a period of three years. When it is grown for seed production, it is better not to pasture it in the spring. It may be successfully threshed with the ordinary grain thresher. The seed weighs about 25 pounds per measured bushel.

Seeding.—Meadow Fescue grass seed is comparatively easy to sow and is usually sown at the rate of from 35 to 40 pounds per acre when not seeded in combination with clovers and other grasses. When it is grown for seed production, 20 pounds of seed is enough to sow per acre.

Agricultural Value.

Meadow Fescue is a very hardy grass, being strongly resistant both against cold and drought. This grass is nearly always sown in mixtures and combines hay and pasture value better than most grasses. It is inferior to timothy in quality and in yield of hay, but is a much better pasture grass. It reaches its best hay condition just before full bloom. After flowering, the stems rapidly become hard and woody and lose much of their nutritive value. Because of its drought-resisting qualities, its ability to stand tramping and the large amount of pasture produced in summer and autumn, Ontario pasture mixtures could usually profitably include this grass.

Tall Fescue is very closely related, botanically, to Meadow Fescue. It shows the following physical differences:—greater height, somewhat coarser texture, later maturity, and a more vigorous second growth. The seeds of this grass can not be distinguished from those of Meadow Fescue.

MEADOW FESCUE GRASS.
(*Festuca elatior*).

Sheep's Fescue Grass (*Festuca ovina*).

History.—Sheep's Fescue is a native of the Old World and is found growing throughout the most of Europe and Asia and also Northern Africa. While it is also a native of Canada and the United States, many of the cultivated forms of this grass have been obtained by these countries from Europe.

Botanical Description.—Sheep's Fescue is a short-lived perennial which grows in dense tufts. The flowers are produced in a small one-sided panicle. The spikelets which contain three or four flowers are of a green color and have in addition a violet tint. Sheep's Fescue grass produces many slender stems which are somewhat angular in shape. The leaves are very narrow and of a pale green color.

Habits of Growth.—Sheep's Fescue produces little growth during the year in which it is sown and begins to go back after the third year. When once established, it commences growth early in the spring and continues to grow into the late autumn. It reaches maturity a few days earlier than Kentucky Blue grass.

Soil.—Sheep's Fescue is especially valuable for growing on poor, sandy, or stony soils, surpassing most other grasses under these conditions.

Seed.—The seed is about one-third of the size of Meadow Fescue grass seed. It is straw-colored and has short fine awns. Commercial seed is nearly all produced in Europe and is comparatively cheap. If over-ripe the seed shatters easily. The crop should be cut when the spikelets break up readily in the hand. The seed weighs about 10 pounds per measured bushel.

Seeding.—Good catches have been obtained where Sheep's Fescue has been sown in the spring with a nurse crop of barley or of spring wheat. Sheep's Fescue is usually sown in mixtures but, when not sown in combination with clovers or other grasses, from 20 to 25 pounds of seed is sown per acre.

Agricultural Value.

The chief agricultural value of Sheep's Fescue is for growing under those conditions not suitable for successfully growing other grasses. It usually makes a sheep pasture on poor soils where other and more valuable grasses cannot be grown. Opinions differ as to the ability of this grass to stand tramping and close grazing. Some writers claim that it is unsurpassed in its ability to support these conditions, while others hold almost the opposite opinion. In experiments conducted at Guelph extending over a period of years, it has produced less pasture than the average grasses tested and was inferior in its ability to stand tramping and close grazing to a number of the grasses included in the test. The hay produced from Sheep's Fescue is of fairly good quality but the yield is too small to warrant it being grown for this purpose. Sheep's Fescue and other closely related species are frequently included in lawn grass mixtures.

SHEEP'S FESCUE GRASS.
(*Festuca ovina*).

Kentucky Blue Grass (*Poa pratensis*).

Other common names: Blue Grass, June Grass, Spear Grass, Smooth Stalked Meadow Grass.

History.—Kentucky Blue is a native grass of North America, Europe and Asia. It is one of the most widely distributed and most valuable of the native American grasses. The name given is used to distinguish it from Canadian Blue grass, and also because of the famous blue grass regions of the State of Kentucky.

Botanical Description.—This grass is a long-lived perennial, having extensive creeping root stalks. Its root system and its hardiness make it one of the most persistent of grasses. The inflorescence is a panicle, pyramidal in shape and more widely spreading than Canadian Blue grass.

Habits of Growth.—Kentucky Blue becomes established after seeding comparatively slowly but, after establishment, is one of the earliest grasses in reaching maturity, being several days earlier than Orchard grass. Unlike Canadian Blue grass, which produces heads throughout the season, it heads only once. It produces a very thick uniform sod and is capable of crowding out most other grasses and even weeds. As an enemy to alfalfa, it is only surpassed among cultivated grasses by Canadian Blue grass.

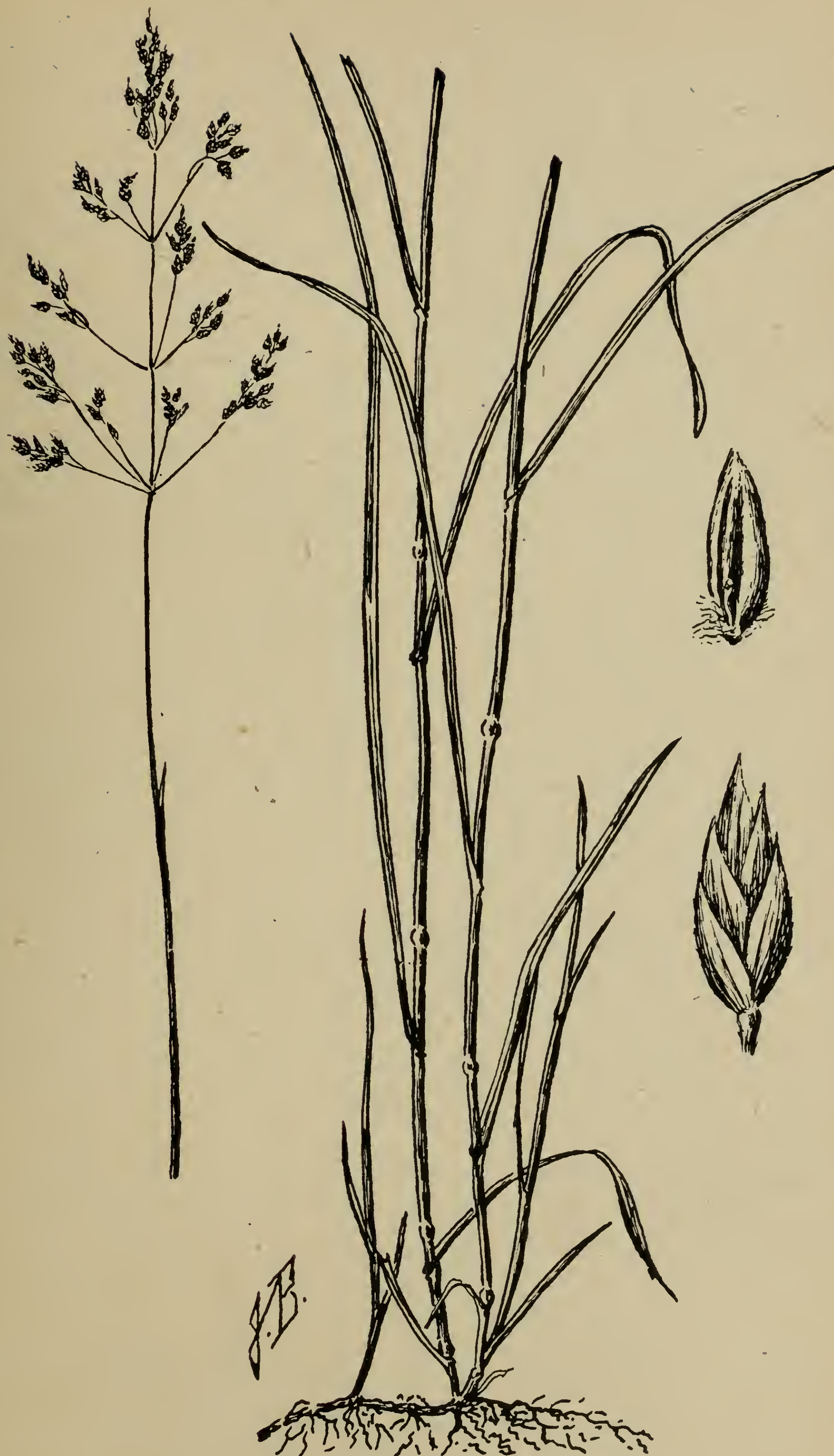
Soil.—Kentucky Blue gives good results on a wide range of soils. Rich clay loam soils, over limestone formations, which do not suffer from drought in summer are the most suitable. This grass gives only fair results on sandy and on heavy clay soils.

Seed.—The seed, which is harsh to the touch, is awnless and of a light brown color. In length it averages about one-eighth of an inch. The keel and the edges of the seed are covered with very fine silky hairs. Harvesting of seed should be commenced when the panicles have turned yellow in color. A large amount of the commercial seed is produced in the blue grass region of Kentucky. The weight per bushel is 14 pounds.

Seeding.—It frequently happens that the germination of the seed is injured by heating in the process of curing and emphasis should be put on the advisability of germinating the seed before sowing. About 25 pounds of seed is sown per acre when this grass is not seeded in combination with clovers and other grasses.

Agricultural Value.

This grass is grown both for hay and pasture and as an ingredient in lawn mixtures. It produces a small amount of hay of good quality. The feeding value and palatability of Kentucky Blue grass hay is equaled by few grasses. The best hay is produced if the grass is cut when in bloom. As a pasture grass it ranks high, its palatability for this purpose being unexcelled by few other cultivated grasses. Kentucky Blue grass starts growth early in the spring and gives a fairly large amount of pasture throughout seasons of sufficient rainfall. Its chief weakness as a pasture grass lies in its inability to stand hot, dry summers. It forms a close compact turf which enables it to stand a large amount of tramping and close grazing without injury. Kentucky Blue is used as a basic grass in lawn mixtures. The formation of a fine close turf, its ability to stand tramping and close cutting gives it a position for this purpose unrivalled by any other grass.



KENTUCKY BLUE GRASS.
(*Poa pratensis*).

Canadian Blue Grass (*Poa compressa*).

Other common names: Wire Grass, Flat Stemmed Meadow Grass, Canada Blue Grass, Virginia Blue Grass.

History.—Canadian Blue Grass is a native of Europe and Asia. It was first discovered in America, growing near Quebec, in 1792. It is now widely distributed throughout southern and central Ontario. and is common in many other parts of Canada.

Botanical Description.—Canadian Blue is a perennial grass with extensive underground creeping root stalks. The flowers are arranged in a panicle which is shorter and not so widely branched as that of Kentucky Blue. The stems, which seldom reach a height greater than two feet, are flattened in shape and knee bent at the joints. This flattened stem characteristic is one of the chief points of difference in distinguishing between this grass and Kentucky Blue. The leaves are few, varying from one to three inches in length and are wiry in texture. In color they are a bluish green.

Habits of Growth.—This grass reaches maturity several days later than Kentucky Blue. It will stand very unfavorable conditions of soil and climate without injury and is one of the most difficult of grasses to eradicate.

Soil.—While this grass is very commonly found growing on poor soils, especially gravelly loam soils, it gives good results on clay loams providing they are not too wet. Soils which are poor in quality and deficient in moisture. where most other grasses will not thrive, provide an economic place for Canadian Blue Grass.

Seed.—The seed very closely resembles Kentucky Blue-grass, and is often used to adulterate the seed of this grass. The chief points of difference between these two grass seeds are the presence of less prominent veins in the lemma of Canadian Blue grass seed and the slightly darker color of the seed. When grown for seed, it should be cut when the panicles are a deep yellow. The seed of this and of Kentucky Blue grass is threshed in the same way as Timothy. The weight per bushel is 14 pounds.

Seeding.—Canadian Blue grass usually appears in cultivation spontaneously. From 20 to 25 pounds of seed is sown per acre when this grass is not seeded in combination with clovers and other grasses.

Agricultural Value.

The chief use of Canadian Blue grass is under those conditions where Kentucky Blue does not thrive. It is very little grown for hay because of its light yield per acre. In permanent pasture mixtures, it produces pasture later in the season than Kentucky Blue and of only slightly inferior quality. Like Kentucky Blue grass, it is well able to stand tramping and close grazing, and in this condition is more palatable to stock. It is frequently sown in lawn mixtures, and for this purpose is especially valuable on gravelly and stiff clay soils.

CANADIAN BLUE GRASS.
(*Poa compressa*).

Red Top Grass (*Agrostis alba*).

Other common names: Fiorin Grass, Creeping Bent Grass.

History.—Red Top is a native of Europe and Asia and, it is thought, also of some of the countries of Northern Africa. In America it has been cultivated for nearly one hundred years. It is a well-known grass in many parts of Ontario.

Botanical Description.—It is a hardy perennial grass with smooth erect growing stems, which sometimes reach a height of four feet. The root system is shallower than that of Timothy. In general appearance Red Top resembles Kentucky Blue, but may be distinguished from this grass by the purple color of the panicles, their wider branching and also by the fact that in Red Top the spikelets are one flowered, while in Kentucky Blue there are from three to five flowers in a spikelet.

Habits of Growth.—Red Top commences growth late in the spring but continues to grow until late autumn. It is several days later in blooming than Timothy, and is not at its best when included in a mixture with Timothy and other grasses for hay. Red Top usually provides a good second growth. It is quite resistant to cold.

Soil.—This grass is adapted to a wide range of soil and climate. It thrives best in moist or even wet soils. The moisture content of the soil seems to be a greater deciding factor in the successful growing of this grass than the type of soil on which it is grown.

Seed.—Red Top grass seed is one of the smallest of cultivated grass seeds. It is from 1-32 to 1-16 of an inch in length and somewhat boat shaped. In color it is a glossy light red and is without awns. Commercial seed usually contains considerable chaff, which lessens its weight per bushel. The seed should be cut when it shells easily in the hand. It may be readily threshed in the same manner as Timothy seed. Seed weighs 14 pounds per measured bushel.

Seeding.—Red Top may be seeded in the spring of the year with good results, using a nurse crop of cereal grain. Twenty pounds of good seed is sufficient to sow an acre when this grass is not seeded in combination with clovers and other grasses.

Agricultural Value.

This grass is grown for hay and pasture and also as an ingredient in lawn mixtures. Red Top hay, which weighs heavy for its bulk, is inferior in quality to Timothy. On wet soils, Red Top will outyield most of the other cultivated grasses for hay. On clay loam soils with a good supply of moisture, it is an excellent bottom grass in hay mixtures. Red Top makes sod quickly and nearly equal in quality to that of Kentucky Blue grass. Pasture mixtures, both temporary and permanent, when sown on low wet lands, should always include Red Top as one of the grasses sown. It gives its best results in lawns when it is sown thickly and is closely mowed. The individual plants of Red Top show almost as much variation in characteristics as those of Orchard grass, and much improvement is possible by selection.

RED TOP GRASS.
(*Agrostis alba*).

Perennial Rye Grass (*Lolium perenne*).

Other common names: English Rye Grass, Common Darnel.

HISTORY.—Perennial Rye was the first of the perennial grasses to be cultivated as a pure culture. There are records which show that this grass was cultivated in England as early as 1677, which date is many years earlier than we have any record of the cultivation of Timothy. In European countries, Perennial Rye is considered to be one of the most valuable grasses and is widely grown in short rotation mixtures. In Ontario, this grass has not usually been found a profitable one to grow.

BOTANICAL DESCRIPTION.—Perennial Rye is a low growing grass lasting only a few years. It has indications of creeping root stalks and the plants often grow in spreading tufts. The inflorescence is in the form of a spike, with the spikelets set edgewise on the stem. These stems, which in Ontario seldom reach a height greater than two feet, grow erect and are slender and smooth. The leaves are dark green in color and are folded together when in the bud.

HABITS OF GROWTH.—Perennial Rye produces a low strong growth the first year, and its maximum growth during the second year. Even under the most favorable conditions, it is not likely to last more than three or four years. It reaches maturity about the same time as Kentucky Blue grass.

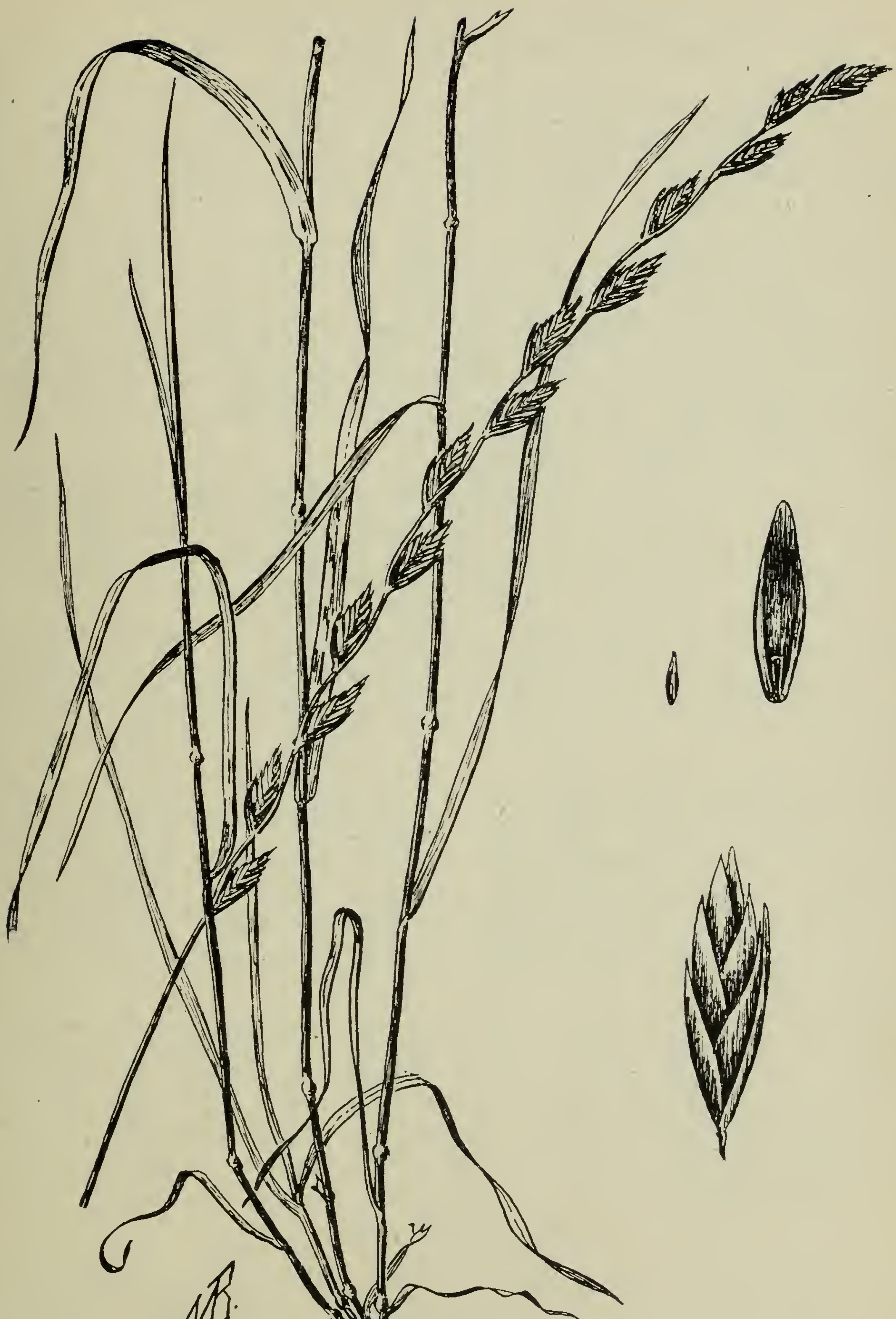
SOIL.—Rich moist loams and clay loam soils and comparatively mild climates are best suited to the growth of Perennial Rye grass. Soils with excessive moisture and poor sandy soils are not well suited for growing this grass.

SEED.—The seed of Perennial Rye is of a light brown color and shows more lustre than is usually found in the seeds of Meadow Fescue. In size and shape and in being awnless these two seeds resemble each other, but Perennial Rye seed is flatter and blunter at the ends. Perennial Rye is one of the largest seed producers among grasses. The seed is taken from the second crop when it becomes tough and leathery, which period is usually about one month after flowering. Good seed weighs about 25 pounds per bushel.

SEEDING.—Where the winters are mild enough, Perennial Rye is sown in the autumn to insure a crop the next season. Spring sown seed rarely produces a crop worth cutting the same year as sown. The seed is almost as easy to sow as that of Timothy. From 25 to 30 pounds of seed is sown per acre when this grass is not seeded in combination with clovers and other grasses.

Agricultural Value.

In Europe and those sections of America where Perennial Rye is grown, it is used for both hay and pasture. Its chief value, however, is as a pasture grass. When grown for hay it should be cut when in full bloom, and is cured in the same manner as Timothy. On account of the rapidity with which it becomes established, it is used in temporary pastures, permanent pastures and even in lawns. In permanent pastures it provides pasture during the period when the other and more valuable grasses are becoming established. It stands tramping and close cutting without injury. Its feeding value is inferior to that of Timothy.



Perennial Rye Grass.
(*Lolium perenne*).

Italian Rye Grass (*Lolium multiflorum*).

History.—This grass is said to have been first cultivated in Northern Italy. It has been grown in France and England for nearly one hundred years and is considered of more value in these countries than elsewhere in Europe. In Ontario and other parts of Canada, it has been little grown in cultivation.

Botanical Description.—Italian Rye is a short-lived perennial which considerably resembles Perennial Rye grass. The inflorescence is in the form of a spike with the spikelets set edgewise on the stems. These spikelets contain a greater number of flowers than do those of Perennial Rye grass. The stems are more slender, usually grow taller, and have the upper part more roughened than those of Perennial Rye. The leaves, which are of a bright green color, are comparatively broad and soft in texture.

Habits of Growth.—Italian Rye grass is even shorter-lived than Perennial Rye, few plants living after the second year. This grass starts growth early in the spring, reaches maturity early, and, where conditions are favorable, may be cut three or four times in a season.

Soil.—Italian Rye gives good results on rich sandy loam and rich clay loam soils. A good supply of lime in the soil favors its growth. It is not suited for growing on poor soils and on soils where water remains stagnant for any length of time.

Seed.—The seed much resembles that of Perennial Rye, but may be distinguished from the latter by its long slender awn, and its blunter and flatter appearance. It is also somewhat lighter in color and has less lustre than the seed of this grass. Italian Rye grass seed is usually cut in the late dough stage, as it shatters badly if over-ripe. Like Perennial Rye, it is a large seed yielder and is just as easily harvested and threshed. Seed weighs from 20 to 25 pounds per measured bushel.

Seeding.—In mild climates fall seeding is usually considered to give the best results with Italian Rye grass. In Ontario fair results have been obtained where the grass has been seeded in the spring of the year along with a nurse crop of barley or of spring wheat. It is more often sown alone than in mixtures, when as much as 35 pounds of seed is sown per acre.

Agricultural Value.

The chief value of Italian Rye grass lies in its rapid growth and in the quickness with which it recovers after being cut for hay. Where the grass has been irrigated and where liquid manures have been applied, it has produced large yields. Experiments have shown, however, that, under the average conditions of Ontario, it is decidedly less valuable than such grasses as Timothy or Orchard. It produces a fair amount of pasture early in the spring and a medium amount of hay of about the same quality as Perennial Rye. The hay should be cut when the plants are in full bloom and may be cured in much the same way as Timothy.

Italian Rye Grass.
(*Lolium multiflorum*).

Meadow Foxtail Grass (*Alopecurus pratensis*).

History.—Meadow Foxtail is a native grass of Europe, Asia and Africa. It is one of the oldest and most commonly cultivated grasses in Great Britain and in other European countries having a moist climate. It is considerably grown in the Eastern United States and in some parts of Central and Eastern Canada.

Botanical Description.—Meadow Foxtail is a long-lived perennial which grows in loose tufts and produces many basal leaves. The inflorescence is in the form of a spike which much resembles Timothy. The spikelets are covered with long soft hairs which give to the spike a softness to the touch not possessed by Timothy. The stems, which grow erect and are smooth, usually do not reach as great a height as Timothy. The leaves are smaller and finer than those of Timothy.

Habits of Growth.—This grass is the earliest of the cultivated grasses in reaching maturity and is frequently in full head before the first of June. It recovers quickly after being cut for hay and usually produces a good second growth.

Soil.—Rich clay and clay loam soils with a plentiful supply of moisture suit its growth the best. It is not partial to dry weather nor to soils where the water lies stagnant the greater part of the time.

Seed.—The seed is straw-colored, comparatively short, soft, fluffy and possesses fine medium-length awns. It ripens early but rather unevenly, which makes it difficult to harvest and to cure. The unevenness in maturing seed seems to be the explanation of the lack of vitality in much of the seed. Seed weighs about 5 pounds per measured bushel.

Seeding.—Meadow Foxtail is one of the most difficult grasses to sow and obtain an even distribution of seed. Successful seeding is only possible where the grass seed is mixed with the grain sown as a nurse crop or with sand or other soil. From 20 to 25 pounds of seed is sown per acre when this grass is not seeded in combination with clovers and other grasses.

Agricultural Value.

Meadow Foxtail produces hay of a quality nearly equal to Timothy, but is a much smaller yielder per acre. Owing to the fact that it requires from two to three years to become established it is very seldom sown in short rotation mixtures. It is cut for hay when in bloom. Its chief value lies in its use in permanent pasture mixtures. For this purpose its earliness gives it a value possessed by no other cultivated grass, as it provides considerable pasture at a period when stock have little to graze upon.

Meadow Foxtail Grass.
(*Alopecurus pratensis*).

Awnless Brome Grass (*Bromus inermis*).

Other common names: Brome Grass, Smooth Brome Grass, Hungarian Brome Grass, Austrian Brome Grass, Russian Brome Grass.

History.—Awnless Brome, which is a native of Europe and western Asia, has been cultivated in Europe for about one hundred and fifty years. It was introduced into America about 1882 by the California Experiment Station and into Canada shortly after this date. It is now widely distributed throughout Canada and especially in the Prairie Provinces.

Botanical Description.—This grass is a very long-lived perennial, and is one of the hardiest of the cultivated grasses. Its extensive system of creeping root stalks forms a firm deep sod which is difficult to break up. The panicle, which is large, spreading and drooping, becomes contracted after flowering. The spikelets, which are often nearly an inch long, turn a brownish red color with maturity. The stems are stout and smooth. The leaves, which are quite numerous, are long, broad and smooth.

Habits of Growth.—Awnless Brome grass grows slowly the first year and does not reach its full growth until the third year. After becoming established, it produces a fairly large amount of material early in the spring, during the summer and into late autumn. It is such an extensive stooler that the soil has been known to become sod bound, necessitating reseeding to maintain the yield. It matures a few days earlier than Timothy.

Soil.—It seems best adapted to dry and rather poor soils, and is especially suited to those regions where the climate is cold and the rainfall light during the summer.

Seed.—The seed is light brown in color, about three-eighths to one-half of an inch in length, and in shape resembles that of Meadow Fescue. It differs from this grass, however, in being larger, flatter, and having blunter ends. Commercial seed is grown chiefly in the north-western States, Manitoba and Saskatchewan. This seed usually contains considerable quantities of chaff and broken stems. When grown for seed, Awnless Brome should be cut when the spikes have turned brown. The seed is less likely to shatter through being over ripe than that of most other grasses. It is harvested and cured in much the same manner as cereal grains. Good seed weighs 14 pounds per measured bushel.

Seeding.—Spring seeding, using a nurse crop of cereal grain, gives good results with Awnless Brome grass. This method of seeding is especially suitable where it follows dry autumns and winters with a small amount of snowfall. Fifteen pounds of good seed is sufficient to sow an acre when this grass is not seeded in combination with clovers and other grasses.

Agricultural Value.

Awnless Brome grass is grown for both hay and pasture. It is resistant against both cold and drought. When grown for hay, it should be cut just as soon as it reaches full bloom. The quality of hay produced is not equal to that of Timothy and, owing to greater leaf growth, it is more difficult to cure and is more easily injured by unfavorable weather conditions than the hay of this grass. It is of greater value for pasture than for hay. The pasture is readily eaten by stock and it stands close tramping well. Its extensive root system enables it to give fair returns for pasture.

Awnless Brome Grass.
(*Bromus inermis*).

Fringed Brome Grass (*Bromus ciliatus*).

History.—Fringed Brome is a native of the North American continent, but has been very little grown in cultivation. In experiments conducted at Guelph, extending over a period of six years, this grass has given promising results, standing third in yield of hay among fourteen varieties of grasses tested, and giving returns above the average for pasture.

Botanical Description.—It is a long-lived perennial having short root stalks and growing in loose tufts. The panicle is broad, spreading and drooping. The spikelets, which are nearly all carried at the end of the panicles, are long and from five to nine flowered. The stems are tall, rather slender and covered with stiff hairs on the lower parts. The leaves are broad and soft in texture, being covered on both sides with soft short hairs. In color the grass is a decidedly light green.

Habits of Growth.—This grass is less hardy than Awnless Brome and greater difficulty is experienced in obtaining a good stand. When once established, however, it maintains itself almost as well as Awnless Brome. It commences growth slowly in the spring and recovers slowly after being cut for hay. Fringed Brome is one of the latest grasses in reaching maturity and is ready to cut for hay about three weeks later than Timothy.

Soil.—It gives the best results on rich moist soils and is well adapted to growing in shady places.

Seed.—With the exception that it is hairy, it much resembles Awnless Brome seed in appearance and weighs about the same per measured bushel.

Seeding.—Good results have been obtained when Fringed Brome has been sown in the spring with a nurse crop of barley or other cereal grain. Fifteen pounds of good seed is sufficient to sow an acre when it is not seeded in combination with clovers and other grasses.

Agricultural Value.

The value of Fringed Brome as a cultivated grass is very little known in Ontario. Experiments, conducted at Guelph, indicate that it is worthy of more attention than has hitherto been given to it. In these tests, it surpassed Timothy in yield of hay per acre. The hay, however, was more difficult to cure and was coarser and less palatable than that of Timothy. Fringed Brome, in order to make its best quality of hay, should be cut when it reaches the period of full bloom. In tests conducted at Guelph, where it was grown for pasture, it produced slightly more per acre than Awnless Brome grass and stood tramping equally well. The quality and palatability of the grass, however, was inferior to that of Awnless Brome.

Fringed Brome Grass.
(*Bromus ciliatus*).

Western Rye Grass (*Agropyron tenerum*).

Other common names: Slender Wheat Grass, Bald Wheat Grass.

History.—Western Rye is a native American grass which is widely distributed throughout Canada and the Pacific coast states. Although Western Rye has been cultivated less than forty years, it is already highly esteemed in many parts of western Canada. It combines hay and pasture value better than most grasses which have been under test at Guelph.

Botanical Description.—This grass is a long-lived perennial with somewhat of a branching habit of growth. The roots are long and fibrous and have not the extensive, creeping, underground system of Couch grass. The inflorescence is in the form of long narrow spikes, and much resembles that of Couch grass. The spikelets, which have awn pointed glumes, differ from those of Perennial Rye by being attached flatwise to the stems. The stems grow tall and erect and are more slender than those of Couch grass. The leaves are long and softer in texture than those of this grass.

Habits of Growth.—After seeding, this grass quickly becomes established, and in favorable seasons will often produce heads in the autumn of the year. It reaches its maximum growth the third year after sowing. Western Rye matures hay ten to twelve days later than Timothy and usually produces a good second growth.

Soil.—Western Rye grass does best on rather dry soils and in climates where there is a comparatively limited rainfall. Its deep root system enables it to stand prolonged drought without serious injury. It produces poor results on flooded land areas.

Seed.—The seed, which is of a bright straw color, is from three-eighths to one-half of an inch long and somewhat resembles small oat grain. These seeds have short straight awns. Western Rye, which is one of the easiest of the grasses to harvest and thresh for seed, should be cut when the spikelets become straw colored. The seed weighs about 20 pounds per measured bushel.

Seeding.—It is one of the easiest grasses to sow, and usually gives good results when sown in the spring with a nurse crop of cereal grain. An even distribution of seed may be obtained by seeding broadcast by hand or with the grass seeder attachment on the grain drill. Fifteen pounds of good seed is sufficient to sow an acre when this grass is not seeded in combination with clovers and other grasses.

Agricultural Value.

Western Rye is one of the best grasses cultivated in its resistance to cold and drought. It produces good results for both hay and pasture when sown alone or in mixtures with clovers and other grasses. In variety tests, which were conducted at Guelph over a period of six years, it stood first in average yield of hay per acre and was third in pasture value. It makes its best quality of hay if cut just when the heads are fully out of the sheath. The quality of hay produced is not quite the equal of Awnless Brome. This grass, like Timothy and Orchard, is quite variable in its individual plants, showing great differences in height, in stooling qualities, in vigor of growth, and in color. Systematic plant selection would much improve Western Rye grass.

WESTERN RYE GRASS.
(*Agropyron tenerum*).

Bearded Wheat Grass (*Agropyron caninum*).

Other common name: Awned Wheat Grass.

History.—This grass, which is a native of Europe, is now quite common in the Prairie Provinces of Canada. In experiments conducted at Guelph it has given only fair results for hay and pasture.

Botanical Description.—Bearded Wheat in general appearance resembles Western Rye, but is coarser in texture and may be distinguished from this grass by the long awn of its flowering glumes and the arrangement of the flowers in a one-sided spike. It often grows in tufts, sometimes reaches a height of three feet, and droops at maturity.

Habits of Growth.—Bearded Wheat commences growth slowly in the spring of the year and reaches its maximum growth the third year after sowing. It is late in maturing, reaching the hay condition two or three weeks later than Timothy. It usually produces a fairly good second growth.

Soil.—Unlike Western Rye grass, it is not partial to dry soils, but prefers rich moist loam soil.

Seed.—The seed resembles Western Rye grass seed, but is not quite so long and has slightly greater width. One of the chief points of distinction between this seed and Western Rye lies in the long stiff-awned characteristic of Bearded Wheat. This grass is seldom listed by seedsmen, but seed is sometimes obtainable in small quantities through the experiment stations of Western Canada. The seed weighs about 7 pounds per measured bushel.

Seeding.—Because of its light weight and long stiff awns, Bearded Wheat is a very difficult grass to seed successfully. This is only possible by mixing the grass seed with the grain sown as a nurse crop or by mixing it with sand. About 15 pounds of good seed per acre is the amount used when the grass is not seeded in combination with clovers and other grasses.

Agricultural Value.

Bearded Wheat is a very hardy grass, standing cold as well as Western Rye grass, but being more susceptible to injury from drought. Although it has given fair yields of hay and fair results for pasture in experiments conducted at Guelph, it is unlikely, on account of the difficulty of seeding it evenly, its lack of palatability and its general coarseness, that it will ever be much cultivated in Ontario.

BEARDED WHEAT GRASS.
(*Agropyron caninum*).

Virginia Lyme Grass (*Elymus virginicus*).

Other common names: Lyme Grass, Terrell Grass.

History.—Virginia Lyme is a native of the North American continent and is found throughout Canada from Nova Scotia to the Rocky Mountains. It is more common in the Maritime Provinces than in any other part of Canada. Very little attention has so far been given to the cultivation of this grass.

Botanical Description.—It is a long-lived perennial grass with a tendency to grow in dense tufts. The flowers are produced in a spike-like inflorescence which is nearly as large as the spike of wheat. The stems, which sometimes grow to a height of four feet, have a purplish tinge, are smooth, rather slender and leafy to the top of the plant. The leaves are quite broad and abundant, the lower ones usually being dead at flowering time.

Habits of Growth.—Virginia Lyme starts growth slowly in the spring and usually does not produce much of a second crop after being cut for hay. It reaches the hay condition at a period intermediate between Western Rye and Fringed Brome grasses and is at least two weeks later in maturing than Timothy.

Soil.—Virginia Lyme is quite adaptable in its soil requirements. It gives good results on moist loam soils and has been successfully grown on light dry soils where other grasses do not thrive.

Seed.—Virginia Lyme grass seed is one of the largest of the cultivated grass seeds, often reaching a length of one-half inch or more. It is very broad, with wide projecting smooth glumes, which have very short awns. The seed weighs about 12 pounds per measured bushel.

Seeding.—It is not a difficult grass to sow. It may be seeded successfully in the spring of the year with a nurse crop of barley or other cereal grain or sown broadcast by hand. About 15 pounds of seed is sown per acre when this grass is not seeded in combination with clovers and other grasses.

Agricultural Value.

Virginia Lyme produces a large amount of hay, the quality of which, because of its coarseness and lack of palatability, is poor. It makes its best hay if cut when the heads are just out of the sheath. If left later than this period, it soon becomes woody and unpalatable. If used for pasture, it is usually not cut for hay. The best pasture results are obtained when the grass is pastured closely.

VIRGINIA LYME GRASS.
(*Elymus virginicus*).

Canadian Lyme Grass (*Elymus canadensis*).

Other common names: Nodding Wild Rye, Common Wild Rye.

History.—Canadian Lyme grass, which is a native of Canada and the United States, is common in some parts of the Canadian West, but, so far, has been little grown in cultivation in Ontario.

Botanical Description.—It is a leafy perennial, with deep fibrous roots, and shows a decided tendency to droop as the grass approaches maturity. The spike is long and densely flowered, the spikelets having long bent awns. The stems are stouter than those of Virginia Lyme, but do not grow to as great a height. The leaves are short, broad and somewhat coarse in texture.

Habits of Growth.—Canadian Lyme grass starts growth slowly in the spring and does not reach its full growth until the third year. Under favorable conditions, it produces a better second growth than does Virginia Lyme grass. It reaches the hay condition about the same time as this grass.

Soil.—It is best suited to growing on sandy loam soils and is less adaptable to different soil types than is Virginia Lyme grass.

Seed.—The seed of Canadian Lyme grass, while about the same length, is more slender than the seed of Virginia Lyme. Its color varies from straw to a light brown. The glumes of the seed are hairy and the awns are long and bent. Seed is usually not obtainable through commercial sources. Small amounts, however, may sometimes be had from experiment stations. The seed weighs about seven pounds per measured bushel.

Seeding.—Owing to its light weight and to the awn characteristic of the seed, it is difficult to sow the seed evenly. The most even stands are obtained when the grass is seeded with the grain used as a nurse crop or when mixed with sand. At Guelph, the best results have been obtained from spring sowing and the use of a nurse crop of barley or of spring wheat. About 15 pounds of seed is sown per acre when this grass is not seeded in combination with clovers or other grasses.

Agricultural Value.

Owing to the scarcity of seed, its low vitality and the difficulty of obtaining an even distribution of the seed in sowing, it is doubtful if this grass will ever be of much agricultural importance in Ontario. In the experiments which have been conducted at Guelph, over a period of six years, Canadian Lyme grass has given better results for pasture but less hay per acre than Virginia Lyme. The hay produced was of inferior quality to that furnished by Virginia Lyme grass. The best quality of hay of Canadian Lyme is obtained when the grass is cut early, soon after the heads are out of the sheath. The best pasture results are obtained when the grass is pastured at an early stage of growth.

CANADIAN LYME GRASS.
(*Elymus canadensis*).

Common Red Clover (*Trifolium pratense*).

Other common names: June Clover, Meadow Clover, Broad-Leafed Clover, Meadow Trefoil.

History. Red Clover is a native of Europe, northern Africa, Siberia, and south-western Asia. The history of its cultivation is much older than that of any of the grasses. There are records of its use as a cultivated plant at least two thousand years old.

Botanical Description. Red Clover is mainly a biennial, a few plants being short-lived perennials. It has deep branching tap roots, which enable it to withstand drought and which have an excellent mechanical effect on the soil. The inflorescence is in the form of a dense head, which is, when fully grown, nearly an inch in diameter, and may be bright red, or purple, in color. The flowers are cross-fertilized chiefly through the agency of bumble bees. The stems grow erect and vary much in height. The leaflets, which are larger than those of Alsike or White Clover, have distinct V-shaped white markings.

Habits of Growth. In the year in which it is seeded, Red Clover produces little more than its root system and sufficient growth to protect itself over winter. In the second season, it reaches the hay condition from ten days to two weeks earlier than Timothy and usually produces a good second growth after being cut for hay.

Soil. Red Clover is adapted to growing on various types of soil, the most suitable soils being well-drained clay loams with a fair amount of lime and plenty of humus. Red Clover does not grow successfully on poor or water-logged soils. An open subsoil is almost as necessary for successfully growing Red Clover as is the required surface soil.

Seed. Red Clover seed is about one-sixteenth of an inch long and varies in color from a yellow to a dark violet or purple. The presence of deadish brown shrunken seeds indicates immature seed and seed of low vitality. Seed is usually obtained from the second crop, which is cut when the heads turn brown and when the stems are drying up. The legal weight is 60 pounds per measured bushel.

Seeding. Red Clover seed may be successfully sown in the spring with a nurse crop of barley or other cereal grain. Good results are also obtained by seeding Red Clover on winter wheat in the early spring on a fresh fall of snow. About 10 to 12 pounds of seed is sown per acre when this clover is not sown in combination with grasses or other clovers.

Agricultural Value.

Red Clover is one of the most important fodder plants grown. It has a high feeding value, especially for young growing animals and milk cows. It is one of the best improvers of the mechanical condition of the soil and is highly valuable as a green manuring crop. Besides its use for hay and pasture and as a green manure, it is also grown for soiling and as a silage crop. Red Clover should be cut for hay when just past full bloom and when the heads are beginning to turn brown. The leaves are the most valuable part of the hay crop and the method of curing adopted should insure the saving of the highest percentage possible of this part of the plant. Red Clover is sometimes pastured the first autumn, but care should be taken that it is not pastured too closely, or too late. Mammoth Red is an important strain of Red Clover. It is larger, coarser, and several days later in maturing than Common Red Clover. Unlike Common Red Clover, it only produces one good cutting of hay in a season.

Red Clover.
(*Trifolium pratense*).

Alsike Clover (*Trifolium hybridum*).

Other common name: Swedish Clover.

History. Alsike Clover, which was first cultivated in Sweden, about one hundred and fifty years ago, takes its common name from a parish in that country. In the last fifty years, it has been extensively grown throughout Europe. In Canada, its growth is largely confined to the eastern provinces and chiefly to Ontario. The city of Toronto is one of the principal Alsike Clover seed markets of the world.

Botanical Description. Alsike is a perennial which, on good soils, frequently lasts from four to six years. Its root system is less deep and more branching than that of Red Clover. The heads are smaller and grow on longer stalks than those of Red Clover. In color they vary from a white to a pinkish rose. The flowers are cross-fertilized chiefly through the agency of honey and bumble bees. The stems, which are smooth, grow erect and usually do not reach a height greater than two feet. The leaflets are smooth, and are shorter and comparatively broader than those of Red Clover. They have no V-shaped white markings.

Habits of Growth. Alsike commences growth later in the spring than Red Clover. It blossoms later than this clover and does not reach the hay condition until just before Timothy. Alsike produces less second growth than Red Clover.

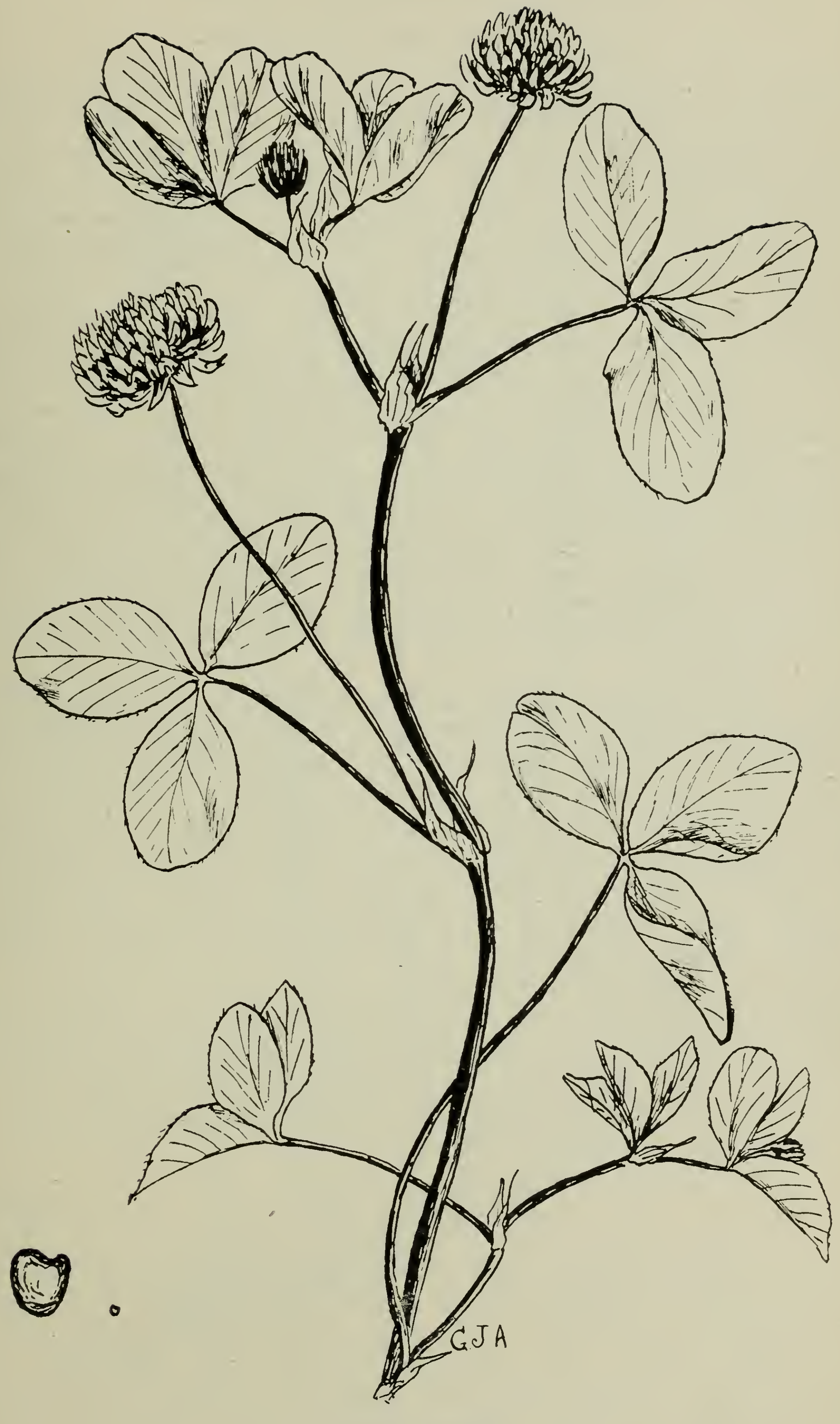
Soil. The most suitable soils for Alsike are moist clay and clay loams, although it gives good results on other types of soil where there is a good moisture supply. Alsike may be successfully grown on soils which are too wet for Red Clover.

Seed. Alsike seed is about one-half the size of Red Clover and is heart-shaped. It varies in color from a light green to almost a black. The seed is obtained from the first crop, which is often pastured for a time in the spring. Plants should be cut for seed when the heads have turned brown. The seed shells easily and, to prevent loss, the plants are often cut in the early morning when they are wet with dew. The legal weight per measured bushel is 60 pounds.

Seeding. Alsike may be successfully sown in the spring of the year with a nurse crop of barley or other cereal grain. Good results are also obtained when it is sown on winter wheat in the early spring on a fresh fall of snow. From 6 to 8 pounds of seed is sown per acre when this clover is not sown in combination with grasses or other clovers.

Agricultural Value.

In total value, Alsike is not the equal of Red Clover. It, however, surpasses this clover in being more perennial in character, in being a better pasture clover under most conditions, and in being a better hay plant on soils too wet to successfully grow Red Clover. It should be cut for hay when the plants are in full bloom or a small percentage of the heads have turned brown. It remains green and succulent longer than Common Red and is not injured as much when cut over-ripe for hay as is this clover. Alsike seldom produces more than one crop of hay in a season. The hay is cut and cured in the same manner as Red Clover. Alsike is a valuable clover in permanent pasture mixtures, especially on low land. It is one of the most valuable of honey plants. There is less variation in the individual plants of Alsike than is found in Common Red and there are no recognized varieties or strains.



ALSIKE CLOVER.
(*Trifolium hybridum*).

White Clover (*Trifolium repens*).

Other common name: Dutch Clover.

History. This clover is a native plant of Europe, Russia in Asia, and northern Africa. Although widely distributed in both the United States and Canada, it is not thought to be a native of either of these countries. It was first cultivated in Holland, which fact gave rise to the common name "Dutch Clover."

Botanical Description. White Clover, which is a low growing, creeping plant, is one of the most perennial of the clovers. It is shallow rooted and differs from Alsike in that the solid stems creep on the ground and easily take root. This characteristic enables it to stand much mowing and rather close grazing. The heads, which are white in color, are produced from the lower part of the stem and are smaller in size than those of Alsike. The flowers are cross-fertilized chiefly through the influence of honey bees. The stems are smooth. These are so close to the ground that when they are cut for hay, the crop is nearly all flower-stalks and leaves. The leaves are smaller and more nearly rounded than those of Alsike. They have white markings, smaller but otherwise similar to those on Red Clover.

Habits of Growth. When sown in the spring, the plants often produce blossoms in the autumn. When White Clover becomes well established, its creeping stems enable it to spread over the ground rapidly. The seed which reaches the ground retains its vitality for a long period and aids in the persistency of this clover.

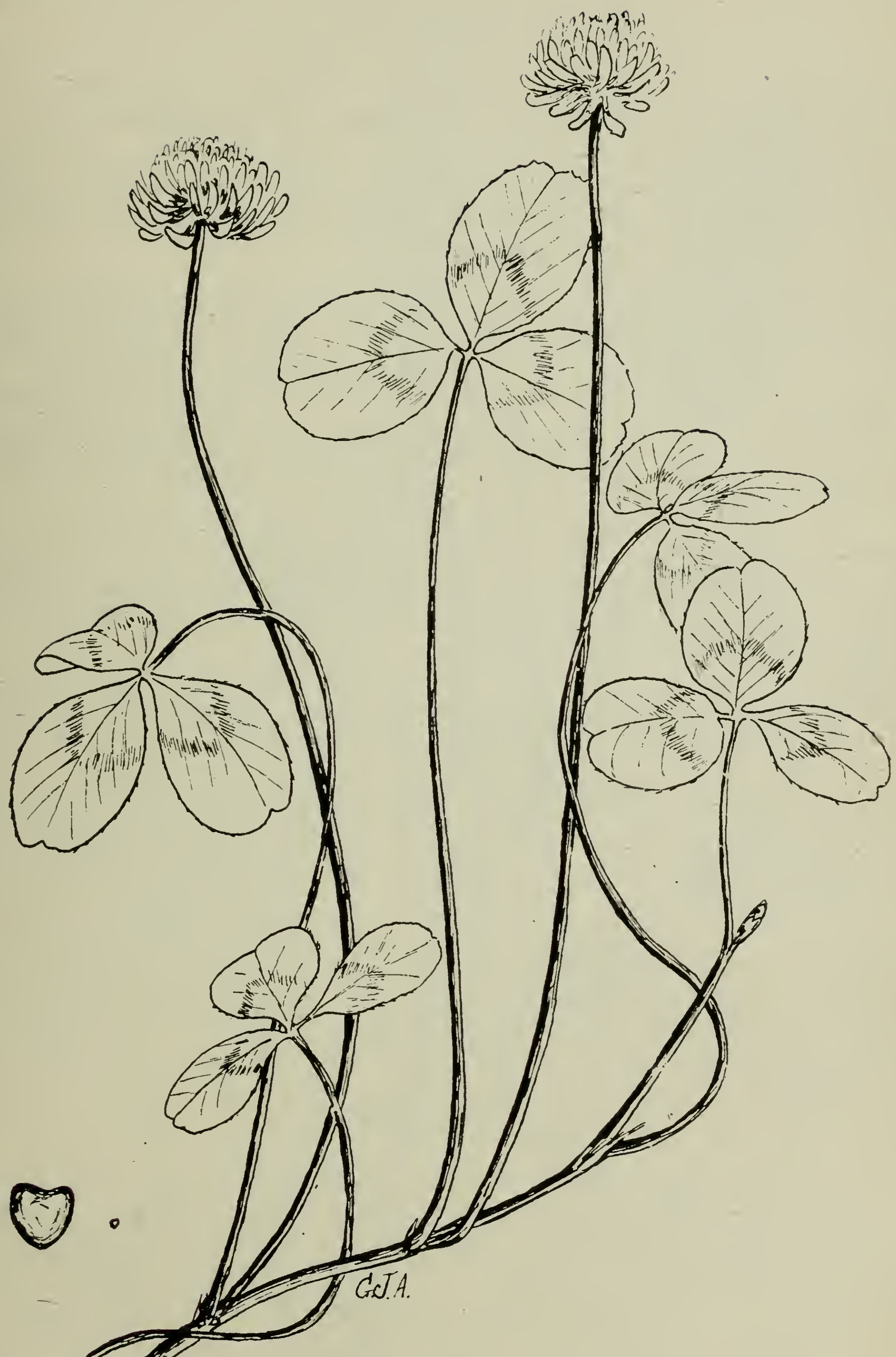
Soil. White Clover may be grown successfully on a variety of soils, but prefers a rich moist loam, well-drained, and which contains considerable lime. White Clover is not suitable for growing on poor or on wet soils.

Seed. The seed is much the same shape as that of Alsike, but is slightly smaller in size. In color it varies from a yellow to an orange red. It is usually obtained from the first crop which, like Alsike, is often pastured for a time in the spring. Seed is ready to cut when the heads have turned a dark brown. The seed shatters easily and requires the greatest care in harvesting. White clover will naturally reproduce itself from seed if not too closely pastured. The legal weight per measured bushel is 60 pounds.

Seeding. White Clover may be successfully sown in the spring of the year with a nurse crop of barley or other cereal grain. Good results are also obtained when it is sown on winter wheat in the early spring on a fresh fall of snow. From 6 to 8 pounds of seed is sown per acre when this clover is not sown in combination with grasses or other clovers.

Agricultural Value.

The chief value of White Clover consists in its use as a lawn clover, its use in permanent pasture mixtures, and its use as a honey plant. As a lawn clover, it is unequalled among clovers, withstanding considerable tramping and mowing without serious injury. Its perennial character, and its ability to stand tramping and close grazing make it one of the most valuable of clovers for use in permanent pasture mixtures. Here, its chief function is that of a bottom grass. With suitable soil and moisture requirements, it provides pasture much relished by all classes of stock and lasting from early spring until late summer. It produces a good quality of hay but an amount so small as to prohibit its general growth for this purpose.



White Clover.
(*Trifolium repens*).

Crimson Clover (*Trifolium incarnatum*).

Other common names: Italian Clover, German Clover, French Clover, Scarlet Clover.

History. Crimson Clover is a native of southern Europe and attains its greatest perfection in the countries of this region. In the United States, it has been successfully grown in the middle and south Atlantic States. In Ontario, it has so far been but little cultivated, due largely to unfavorable climatic conditions. The small amount of this clover grown is confined almost entirely to the Niagara Peninsula and to south western Ontario.

Botanical Description. Crimson Clover is a short, erect growing annual or winter annual, with strong branching tap roots. The flowers are in a spikelike head which is longer, narrower and more pointed than that of Red Clover. These cone-shaped heads are scarlet or crimson in color. The stems, which sometimes reach a height of three feet, are soft in texture and covered with soft hairs. The leaflets are shorter and broader than those of Red Clover and, like the stems, are covered with soft hairs.

Habits of Growth. Where the climate is favorable, Crimson Clover will, if sown in the spring, often produce seed in the autumn. Where it is fall sown, if it survives the winter, it will produce a hay crop earlier in the following season than any other clover grown in Ontario.

Soil. It is best suited to rich sandy soils and gives good returns on lighter soil types than those which best suit the growth of Red Clover.

Seed. The seed is somewhat egg-shaped and almost twice the size of Red Clover seed. Good seed has a uniform pinkish color. Old seed is of a brownish color and generally shrunken. In harvesting, the seed easily shatters if over-ripe and care should be taken to see that the crop is cut in the early morning when the plants are wet with dew. The legal weight per measured bushel is 60 pounds.

Seeding. In climates which are well suited to its growth, Crimson clover is usually sown in the early autumn. In Ontario it is usually spring sown and makes such rapid growth that a nurse crop is seldom used with it. About 15 pounds of seed is sown per acre when this clover is not sown in combination with grasses or other clovers.

Agricultural Value.

Crimson Clover is grown for hay and pasture, as a cover crop in orchards, and for its use as a soiling crop. It is cut for hay when the lower leaves of the most matured plants have faded. The stiff hairs on the plants in their later stages of development are known to have caused injury to stock and Crimson Clover, therefore, should not be cut for hay later than the commencement of bloom. In Ontario, Crimson Clover is occasionally used as a hog pasture, sometimes alone and sometimes in combination with other crops. As a cover crop, it possesses value because of its rapid growth and the early period in the spring at which it may be ploughed under. In numerous experiments conducted at the Ontario Agricultural College, Crimson Clover from autumn seeding has winter killed badly and from spring seeding has not equalled Common Red Clover when sown under similar conditions for pasture or for hay.

Crimson Clover.
(*Trifolium incarnatum*).

White Sweet Clover (*Melilotus alba*).

Other common names: Bokhara Clover, Melilot, Sweet Melilot, Melilotus.

History. This plant, which is a native of Europe and also of Asia, was first cultivated in western Asia. It was introduced into the United States by the early settlers and is now widely distributed throughout that country and also throughout Canada.

Botanical Description. White Sweet Clover is a biennial plant, having a deep tap root system and producing a very strong vigorous growth. The flowers, which grow in long racemes, are white in color and ripen seed very unevenly. The stems, which frequently grow to a height of five feet or even more, are much branched and spreading. The leaves resemble those of alfalfa but are less numerous. The characteristic fragrance of this plant is responsible for the name, "Sweet Clover."

Habits of Growth. It grows slowly the first year and does not bloom or produce seed. In the second season, its growth is rapid and it reaches the hay condition several days earlier than alfalfa. The second year's growth of White Sweet Clover is less leafy and more stemmy than that of the first year.

Soil. It is adapted to growing on many types of soil and gives especially good results on rather poor and on wet soils. A plentiful supply of lime in the soil favors its growth. In order to grow it successfully the presence of the proper bacteria is as necessary as for the successful growing of alfalfa. These bacteria are thought to be identical with those of alfalfa.

Seed. The seed is shorter, usually slightly smaller and less kidney-shaped than that of alfalfa. In color it is a darker yellow and has less lustre than this seed. White Sweet Clover seed may be distinguished from the yellow seed of Red Clover by a more distinct notching near the end of the seed and by its characteristic odor. The seed weighs 60 pounds per measured bushel.

Seeding. The ease with which Sweet Clover establishes itself on roadsides and in waste places has led to the mistaken belief that it is very easy to get a good catch of this crop. Experiments have shown that it is almost as difficult to secure a good stand of White Sweet Clover as it is to obtain a good stand of alfalfa. The seed may be successfully sown in the early spring, using barley or some other cereal grain as a nurse crop. Good results have also been obtained where the seed has been sown on winter wheat in the early spring after a fresh fall of snow. Sweet Clover seed often contains a considerable percentage of "hard seeds," the germability of which is poor. The percentage of germination of these seeds may be increased by scarifying the seed. About 20 pounds of seed is usually sown per acre when this legume is not sown in combination with grasses or other legumes.

Agricultural Value.

Its chief importance in agriculture lies in its suitability for growing on those soils where alfalfa does not thrive, in its value as a soil renovator, and in its ability to improve the mechanical condition of the soil. When grown for hay. it should be cut just before blossoming. After the most suitable period for cutting hay is past, it quickly becomes woody and unpalatable. In cutting, care should be taken to cut the first crop sufficiently high above the ground so as not to injure the second growth. Its peculiar "odor" is generally distasteful to stock. On poor soils and on poorly drained land, it produces more pasture than alfalfa. As a bee plant it possesses considerable value. The individual plants of White Sweet Clover differ much in height, in percentage of leaf to stem, and in coarseness of leaf and stem. Much improvement, therefore, is possible by selection.

White Sweet Clover.
(*Melilotus alba*).

Yellow Sweet Clover (*Melilotus officinalis*).

Other common name: Melilot.

History. This plant is a native of Central Asia and has been cultivated in this region for many centuries. In Ontario it is much less common than White Sweet and its agricultural value is but little known.

Botanical Description. Yellow Sweet Clover is a biennial with a smaller tap root system than that possessed by White Sweet Clover. The flowers resemble those of this plant but are smaller and yellow in color. The stems do not grow so tall and are finer in texture than those of White Sweet. The leaves resemble those of this legume but are somewhat deeper notched and more numerous.

Habits of Growth. The plants of Yellow Sweet are smaller and are more decumbent the first year than those of White Sweet. The second season this legume grows very rapidly and is ready to cut for hay several days earlier than White Sweet Clover. It maintains itself on roadsides and in waste places chiefly through its habit of reseeding itself.

Soil. It grows successfully on different types of soil and will produce good results on poor soils. A plentiful supply of lime in the soil favors its growth. Inoculation of the seed with the proper bacteria in soils lacking in these organisms materially assists its growth.

Seed. The seeds in shape, size and color much resemble those of White Sweet and usually cannot be distinguished from those of this species. Occasionally, however, they are slightly mottled with purple, when they may be identified. The seed weighs 60 pounds per measured bushel.

Seeding. Yellow Sweet Clover may be successfully sown in the early spring of the year, using barley or some other cereal grain as a nurse crop. Success has also been attained where this seed has been sown on winter wheat in the early spring after a fresh fall of snow. Twenty pounds of seed is sufficient to sow an acre when this legume is not sown in combination with grasses or other legumes.

Agricultural Value.

Yellow Sweet Clover produces less hay per acre than White Sweet Clover, and its value as a soil improver is less because of its smaller root system and its generally smaller growth. Some farmers, however, prefer it to White Sweet on account of its production of a finer quality of hay and because of its greater palatability. It should be cut for hay just before blossoming. If left later than this period, it soon becomes woody and fibrous, although this condition is reached less quickly than with White Sweet. It apparently stands pasturing as well as White Sweet Clover and the pasture seems to be more relished by stock. Yellow Sweet Clover has considerable value as a bee plant and, in some sections, is sown especially for this purpose.

Yellow Sweet Clover.
(*Melilotus officinalis*).

Alfalfa (*Medicago sativa*).

Other common name: Lucerne.

History. Alfalfa is one of the oldest of fodder plants and has been cultivated in Europe and Asia for nearly twenty-five hundred years. It has been cultivated in Ontario for about sixty years. For years after its introduction into this province, its cultivation was confined largely to a few individual farmers in the counties of Haldimand, Welland and Lincoln. In the last few years, its merits have been more generally recognized and the area devoted to growing it has been largely increased.

Botanical Description. It is a long-lived, deep-rooted perennial legume with a typical tap root. The part of the tap root showing above ground is known as the crown. The flowers of Alfalfa are produced in clusters and are usually purplish in color. The stems are generally smooth and are less branched than those of Sweet Clover. The leaves consist of three leaflets which are narrow and sharply toothed in the upper part.

Habits of Growth. Alfalfa usually does not produce sufficient growth in the year in which it is seeded to provide a crop of hay or pasture. In the second year, it commences growth early in the season and is ready to cut for hay several days before Red Clover.

Soil. Alfalfa is very particular in its soil requirements, and failures to secure good stands are often due to unsuitable soil conditions. Definite soil types seem less necessary to success in growing this crop than does the presence of the other proper conditions. The best results are obtained where the sub-soil is open, where the drainage is good, where a good seed bed has been provided, where the proper bacteria are present in the soil, and where a plentiful supply of lime exists.

Seed. Alfalfa seed is kidney-shaped, about one-third larger than Red Clover seed and is yellow in color. The presence of many deadish brown seeds indicates seed of low vitality. Seed is usually obtained from the second crop. Alfalfa should be cut for seed when about one-half of the pods have turned brown. The legal weight per measured bushel is 60 pounds.

Seeding. The following methods have given good results in seeding Alfalfa: 1. Sowing on winter wheat in the early spring on a fresh fall of snow; 2. Sowing in the early spring with a nurse crop of barley or other cereal grain; 3. Sowing alone about July 15th on well prepared land where a good supply of moisture exists. About 20 pounds of seed is sown per acre when Alfalfa is not sown in combination with grasses or other legumes.

Agricultural Value.

Alfalfa is chiefly valuable as a hay crop, but is also grown for pasture, as a soiling crop, for silage, and for its use as a green manure. When grown for hay it should be cut at the commencement of bloom or at the beginning of the second growth. It makes hay of excellent quality but the greatest care is necessary to preserve the leaves of the plants. In average seasons in most parts of Ontario, three cuttings of hay are produced. Alfalfa is only a fair pasture plant and should never be pastured too closely, too early in the spring, or too late in the autumn. Many failures in growing Alfalfa have been due to the sowing of tender strains. The most suitable strains of Alfalfa for growing in Ontario are Grimm, Ontario Variegated and Baltic.

ALFALFA.
(*Medicago sativa*).

Sainfoin (*Onobrychis sativa*).

Other common name: Esparsette.

History. This plant is said to have been first cultivated in France more than four hundred years ago. Since that date it has been extensively grown in other countries of Europe, notably England. In Europe it added an important fodder crop asset because of its ability to grow on dry barren calcarious soils. It was first introduced into America about one hundred years ago, but has never attained any great agricultural prominence. It is not to be compared with alfalfa in fodder value.

Botanical Description. Sainfoin is a long-lived perennial plant with a deep, woody, much branched tap root system. The flowers, which are rose-colored, are contained in a spikelike inflorescence. The stems grow erect and seldom reach a height greater than two feet. The leaves are compound and consist of many leaflets. The seed pods are one-seeded and are brown in color.

Habits of Growth. Sainfoin commences growth early in the spring and reaches the hay condition about the same time as alfalfa. When once well established on suitable soil, it lasts for many years.

Soil. The most suitable soils are friable clay loams with a plentiful supply of lime.

Seed. On account of low vitality of commercial seed, it is often difficult to obtain a good stand of Sainfoin. It is sold both as shelled and unshelled seed. The unshelled seed is cheaper and occurs in much greater quantity in commerce than shelled seed. The unshelled seed or seed-pods are flattened and somewhat bean-shaped, the surface being covered with a fine, mesh-like netting. The outer edge of the seed pod has strong sharp teeth. Shelled seed is kidney-shaped, about three-sixteenths of an inch long, and of an olive brown color. Shelled seed weighs 60 pounds per measured bushel.

Seeding. Sainfoin may be successfully seeded in the early spring of the year with a nurse crop of barley or other cereal grain; or in the early spring on winter wheat on a fresh fall of snow. From 50 to 60 pounds of shelled seed is sown per acre when this legume is not sown in combination with grasses or other legumes.

Agricultural Value.

Sainfoin excels alfalfa in agricultural value only in its ability to grow on poor soils and to stand close pasturing. It should be cut for hay when the plants are about one-third in bloom. After this period it rapidly becomes woody and loses much of its feeding value. In favorable seasons, it will produce two crops in the one year. It is ready to pasture fully as early in the spring as alfalfa and will stand pasturing by sheep better than this plant. It is considered a valuable bee plant.

SAINFOIN.
(*Onobrychis sativa*).

VARIETIES OF GRASSES FOR HAY PRODUCTION.

Comprehensive and numerous experiments have been conducted at the Ontario Agricultural College in comparative tests of different varieties of grasses for hay production. The different experiments have varied somewhat in the varieties used. It has been found very difficult to get a perfect stand of all varieties under similar conditions and, at the same time, to have all kinds growing pure in the plots without mixtures of other grasses, clovers, or certain weeds. Some varieties give one and some varieties two cuttings in the same season. This adds to the difficulty in getting accurate results of cured hay from a large number of varieties and in different years. The following table gives the comparative results of sixteen varieties of grasses grown under similar conditions in each of six years:—

Varieties of Grasses.	Date When in Full Head (Average 4 Years).	Average Results for 6 Years.	
		Height of Crop (ins.).	Total Yield of Hay per Acre per Annum (tons).
Western Rye	July 13th	30	3.98
Virginia Lyme..........	July 21st	31	3.65
Fringed Brome	August 2nd	33	3.39
Timothy	July 5th	34	2.84
Bearded Wheat........	July 21st	32	2.83
Canadian Lyme........	July 22nd	28	2.76
Tall Oat	June 21st	42	2.75
Orchard..............	June 23rd	33	2.16
Awnless Brome........	July 2nd	22	1.82
Canadian Blue.........	June 22nd	18	1.71
Meadow Fescue........	June 26th	30	1.53
Meadow Foxtail........	June 6th	30	1.42
Red Top..............	July 13th	20	1.23
Kentucky Blue	June 17th	23	1.20
Yellow Oat............	June 27th	27	1.19
Perennial Rye	June 18th	19	.76

A few varieties of grasses, showing the comparative average height. From the left: Tall Oat, Timothy, Orchard, Meadow Fescue, Western Rye, Meadow Foxtail, Kentucky Blue, Awnless Brome, Red Top, Perennial Rye, and Canadian Blue.

Five out of the six of the highest yielding grasses are all native of Canada, and especially of the Western Provinces. Timothy occupies a relatively higher place when used for hay than it does when used for pasture. The Tall Oat and the Orchard grass are suitable for either hay or pasture production. The Awnless Brome grass, which was strongly advertised a few years ago, has not given very satisfactory results in Ontario. Of the varieties under test, Meadow Foxtail is the earliest and Fringed Brome the latest. All of the sixteen varieties are comparatively hardy. The results here presented should furnish some good information as a basis for making certain selections and combinations when it is desirable to grow different grasses in mixtures.

VARIETIES OF TIMOTHY.

There is no variety of grass which is used so extensively in Ontario for hay and for pasture as Timothy. As a pasture crop, however, it gives very poor results in a hot, dry time in the summer, when pasture is needed the most. Such crops as Orchard grass, Tall Oat grass, Meadow Fescue, Tall Fescue and Meadow Foxtail will usually give a fairly good green growth in a time of drought when the timothy makes practically no growth.

Several years ago, Dr. Hopkins, formerly of the Agricultural Experiment Station at Morgantown, West Virginia, carried on some extensive work in starting new strains of timothy from selected plants. From the very large number of selections which Dr. Hopkins made, he finally chose three of the very best for fulfilling certain requirements. Some of the seed of each of these special strains was obtained. The different strains were sown in comparison with the Common timothy on a duplicate set of plots. After they became established the first season, they were cropped in each of four successive years, the following being the average results in yield of hay per acre:—

Varieties.	Tons of Hay per Acre. Average 4 years.
Common Timothy	1.35
Early Timothy	1.50
Stewart's Mammoth Timothy	1.34
Pasture Timothy	1.63

It will be seen from the results here presented that two of the selected strains of timothy gave greater yields of hay than the Common timothy of Ontario.

In the spring of 1915, seed of each of ten strains of specially selected timothy was obtained from Cornell University, Ithaca, N.Y. These selected strains resulted from a large amount of investigational work extending over a series of years. As the result of three years' testing, an average annual return varying from 2.65 to 3.32 tons per acre was obtained. The highest return resulted from the strain No. 1777 of Cornell University. Unfortunately, no common timothy was included in this test as a basis of comparison.

VARIETIES OF CLOVER FOR HAY PRODUCTION.

A number of varieties of clover have been under test for the production of hay but it has been difficult to get the results of a large number of varieties of clover under uniform conditions for a series of years. The following table gives the yield per acre, in tons of hay per annum, for each of three varieties of clover in each of seven years:—

Varieties.	1892.	1897.	1898.	1900.	1902.	1907.	1916.	Average 7 Years.
Mammoth Red..........	2.81	1.36	2.84	3.20	2.55	2.95	4.88	2.94
Alsike	2.31	2.24	2.64	3.00	2.85	1.90	4.80	2.82
Common Red...........	1.89	3.08	2.92	3.10	2.05	2.25	4.25	2.79

Mammoth Red gave the highest yield of hay per acre in each of four years, Common Red in each of two years, and Alsike in one year. Although the Alsike gave a slightly higher average yield of hay per acre than the Common Red, it will be seen that the latter surpassed the former in hay production in each of four out of the seven years. In the seven-year period, there were two cuttings of Red clover in each of four years, of Mammoth clover in each of two years and of Alsike clover in one year.

In each of three years comparative results were obtained from alfalfa, White or Dutch clover and Yellow Trefoil, in addition to the three clovers previously reported. The following table gives the number of tons of hay per acre per annum for each of these six varieties of crops in each of three years:—

Varieties.	1900.	1907.	1916.	Average 3 Years
Alfalfa	4.60	4.00	4.15	4.25
Mammoth Red............................	3.20	2.95	4.88	3.68
Alsike....................................	3.00	1.90	4.80	3.23
Common Red.............................	3.10	2.25	4.25	3.20
Yellow Trefoil...........................	1.40	1.63	3.95	2.33
White or Dutch..........................	1.80	1.06	2.70	1.85

It should be understood that alfalfa does not receive its full development until the third year, and under favorable conditions should produce crops for many years in succession. The alfalfa does not even reach its maximum returns by the time that the life of most of the clovers has passed.

Weighing grasses grown on the experimental plots.

An eleven-acre field of Ontario Variegated Alfalfa grown on the College farm.

Loading Alfalfa in a thirty-acre field on the College farm.

ALFALFA FOR HAY.

In each of the past twenty-three years, experiments were conducted on growing alfalfa in the experimental grounds at Guelph. The results for 1899 and for 1905 were not recorded in sufficient detail to permit of their being reported. For the other years, however, accurate determinations were made. A number of different seedings are represented. Each seeding took place in the spring of the year by sowing from 18 to 20 pounds of alfalfa seed per acre which was usually sown in combination with a grain crop, such as barley, at the rate of one bushel per acre. The following table gives the yields per acre of the different cuttings of green alfalfa and of cured hay produced in each of twenty-one years:—

Years.	Green Crop.					Hay.				
	First Cutting.	Second Cutting.	Third Cutting.	Fourth Cutting.	Total.	First Cutting.	Second Cutting.	Third Cutting.	Fourth Cutting.	Total.
1896....	9.96	6.47	4.06	2.06	22.55	3.08	1.91	1.29	.65	6.93
1897....	12.04	5.61	4.42	....	22.08	3.59	1.56	1.23	....	6.38
1898....	9.71	5.85	2.64	....	18.20	2.30	1.75	.63	....	4.68
1900....	11.93	6.00	1.60	....	19.53	2.33	1.47	.80	....	4.60
1901....	9.70	2.20	7.49	....	19.39	2.03	1.00	1.50	....	4.53
1902....	13.35	8.69	2.96	....	25.00	2.50	2.02	.54	....	5.06
1903....	13.10	8.53	2.75	....	24.38	2.50	2.09	.67	....	5.25
1904....	12.45	9.35	4.00	....	25.80	3.40	2.50	1.08	....	6.98
1906....	9.78	6.60	4.85	....	21.23	2.55	1.13	.58	....	4.26
1907....	14.55	3.95	....	....	18.50	2.95	1.05	....	....	4.00
1908....	9.70	6.75	3.73	....	20.18	2.50	1.15	.75	....	4.40
1909....	8.68	4.56	.84	....	14.08	2.52	1.40	.14	....	4.06
1910....	15.08	3.88	4.76	....	23.72	2.94	.80	1.32	....	5.06
1911....	8.00	1.80	1.36	....	11.16	1.76	.34	.30	....	2.40
1912....	9.48	4.68	4.72	....	18.88	2.08	.99	.56	....	3.63
1913....	9.00	2.96	2.33	....	14.29	2.66	.88	.68	....	4.22
1914....	7.64	1.61	4.28	....	13.53	2.32	.54	1.02	....	3.88
1915....	10.63	6.06	6.92	....	23.61	3.07	1.31	1.53	....	5.91
1916....	13.29	6.86	2.40	....	22.55	3.10	1.60	.83	....	5.53
1917....	12.04	5.54	2.60	....	20.18	2.40	1.50	.90	....	4.80
1918....	2.38	1.98	2.00	....	6.36	.64	.60	.66	....	1.90
Average 21 Years.	10.59	5.23	3.37	.10	19.30	2.53	1.31	.81	.03	4.69

In each of nineteen years, the alfalfa gave three cuttings per annum. In 1907, two cuttings, and in 1896, four cuttings were produced in the one season. The spring of 1896 opened up very early and that of 1907 very late.

The yield of alfalfa hay per acre amounted to over six tons in each of three years, between five and six tons in each of five years, between four and five tons in each of nine years and less than four tons in each of four years.

The results show that, on the average, the first crop of the season was about double the yield of the second crop and that the second was nearly double that of the third crop. In some years the yields of alfalfa per acre were more than twice as much as those of other years. The average annual production of alfalfa for the twenty-one year period was nearly twenty tons of green crop and nearly five tons of hay per acre. The green alfalfa furnished on an average 24.3 per cent. of its weight as dried hay. The average dates of cutting for the twenty-one years were June 22nd for the first, July 30th for the second and September 17th for the third.

MIXTURES OF GRASSES, ALFALFA, AND CLOVERS FOR HAY PRODUCTION.

Six separate yearly tests have been obtained from growing, under uniform conditions, sixteen mixtures of grasses and clovers for hay production. Alfalfa, Common Red clover, Mammoth Red clover, and Alsike clover were used in combination with Timothy, Orchard grass, Tall Oat grass, and Tall Fescue grass. Each mixture consisted of a grass and a legume. The mixtures produced either two or three cuttings each season, the third cutting resulting from the mixture containing alfalfa. Seed mixtures were sown with a grain crop in every case. No crop was obtained in the same year in which the seed was sown. The cuttings were made, in every instance, from the second and the third years after seeding took place. Two or three separate weighings were made of the hay from each plot in order to make accurate determinations. The following table gives the average annual yield of green crop and of hay per acre per annum for the six separate tests of each of sixteen mixtures:—

Mixtures.	Green Crop.	Hay.
Tall Oat and Alfalfa	18.17	5.20
Orchard and Alfalfa	18.56	4.85
Timothy and Alfalfa	17.24	4.64
Tall Fescue and Alfalfa	18.81	4.57
Tall Oat and Mammoth Red	12.90	4.08
Tall Oat and Common Red	12.18	4.02
Timothy and Mammoth Red	13.41	3.91
Tall Fescue and Mammoth Red	13.77	3.86
Orchard and Mammoth Red	12.57	3.75
Tall Fescue and Common Red	12.88	3.47
Orchard and Common Red	11.17	3.46
Tall Oat and Alsike	10.22	3.41
Timothy and Common Red	12.02	3.40
Orchard and Alsike	9.52	2.98
Tall Fescue and Alsike	9.70	2.86
Timothy and Alsike	9.02	2.64

It will be seen, that in high production, the dominating influence resulted from the alfalfa of the legumes, and from Tall Oat of the grasses. The Timothy and the Alsike clover seemed to exert greatest influence towards low production. It is interesting to note that the Tall Oat grass and the alfalfa are both very hardy, start early in the spring, are ready to cut at about the same time, withstand hot dry weather in the summer, and form good growth in the autumn. It is a mixture which not only gives a large yield of hay, but should form excellent pasture, providing the alfalfa is not eaten down closely so that the animals would destroy the crowns of the roots and thus kill the plants.

GRASSES, ALFALFA AND CLOVERS SOWN IN THE FALL AND IN THE SPRING WITH AND WITHOUT NURSE CROPS.

On three different occasions an experiment was conducted in the experimental grounds in sowing three varieties of grasses, two varieties of clover and one variety of alfalfa in the autumn with winter wheat and without winter wheat, and in the spring with oats and without oats. The cropping took place in 1898, in 1901 and in 1906. The fact of having this experiment conducted in three separate periods covering different seasons adds value to the results. The same quantities of seed were used for the three different seedings. The crops, when in the proper stage, were cut and weighed in the green condition and then carefully cured into hay and were weighed three times, leaving several hours between each two weighings in order to secure accurate and reliable information.

The tabulated results here given represent the average yield of hay in tons per acre for each crop sown under each of the conditions of the experiment. The figures in every case represent the average of three distinct experiments:—

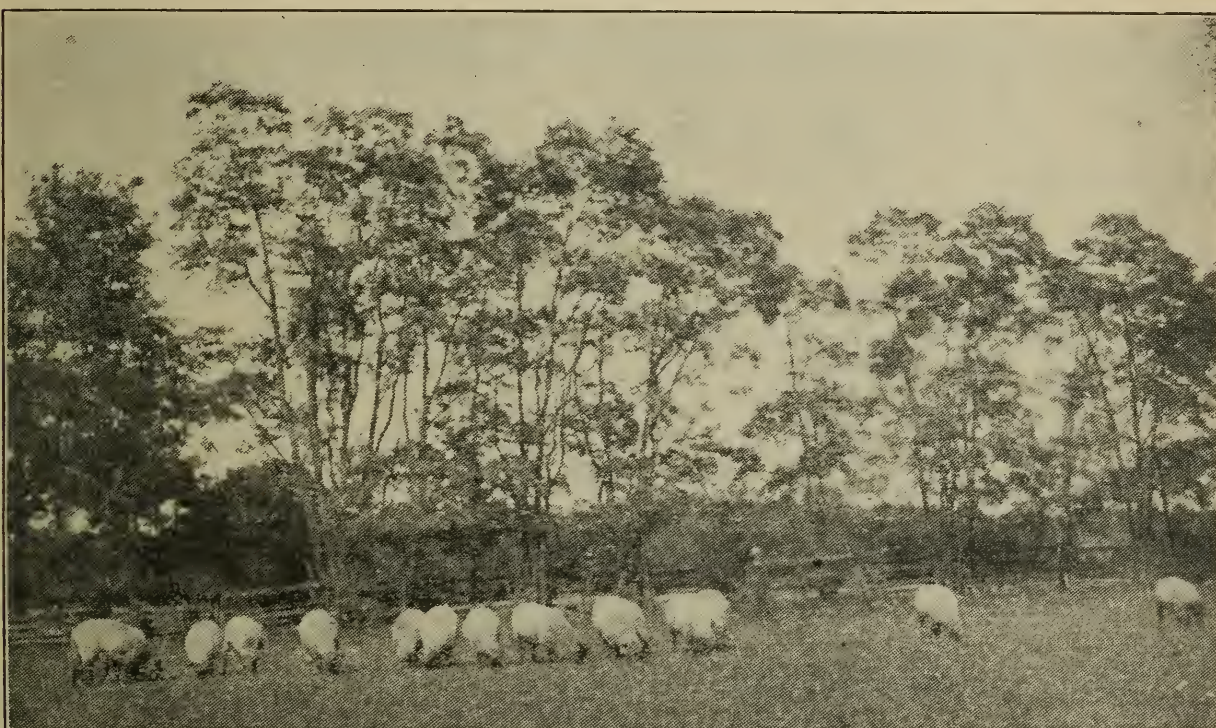
Crops.	Autumn Sowing.		Spring Sowing.	
	Winter Wheat as Nurse Crop.	No Nurse Crop.	Oats as Nurse Crop.	No Nurse Crop.
Orchard Grass	3.26	3.60	4.05	3.13
Meadow Fescue	2.44	2.36	3.52	2.94
Timothy	3.26	3.18	3.68	3.63
Common Red Clover	2.86	1.16	3.32	3.35
Alsike Clover	2.51	.90	2.57	2.39
Alfalfa or Lucerne	3.56	1.24	4.11	3.97
Average 3 Grasses	2.99	3.05	3.75	3.24
Average 3 Legumes	2.98	1.10	3.35	3.24

It will be seen that the figures given in the tabulated results represent the yields per acre for only one year which was the second summer after the seeding took place. In the first experiment the Orchard grass, the Meadow Fescue and the Timothy, which were sown in the autumn without a grain crop, produced hay in the next summer as follows:—Orchard grass, 3 tons per acre; Meadow Fescue, 4.6 tons per acre; and Timothy, 4.6 tons per acre. In the second experiment these same three grasses which were sown in the autumn without winter wheat also produced hay the following year, the yields being as follows: Orchard grass, 1 ton per acre; Meadow Fescue, 1.1 tons per acre; and Timothy, 2.1 tons per acre. Each of the grasses and the clovers sown in the first experiment without a grain crop in the spring of the year produced the following yields of hay per acre in the first summer after the seed was sown: Orchard grass, 2.2 tons; Meadow Fescue, 3.2 tons; Timothy, 1.7 tons; Common red clover, 1.9 tons; Alsike clover, 2.1 tons; and Alfalfa, 1.5 tons. These were the only crops which were of sufficient quantity to cut and weigh in the first summer after sowing.

It will be observed from the figures given in the table here presented that the amount of hay produced from sowing the clover and the alfalfa in the autumn of the year without any grain crop was very small. In both the first and the third experiments the alfalfa and clovers which were sown alone in the autumn made a good growth before the winter started, but were badly winter killed before spring. Although the clovers and alfalfa which were sown alone in the autumn in the second experiment did not fare as badly as those of the first and the third experiments, still the results were poor in comparison with those of other seedings. The grasses, the clovers and the alfalfa gave good results when sown in the spring, either with or without a grain crop. The grasses also gave fairly good results when sown in the autumn either alone or with winter wheat. In studying these results, it must be remembered that where the grass and clover seed has been sown with either winter wheat or with oats, there is a great advantage in having the grain crop which is likely to be more valuable, in most instances, than the increase in the yield of the grasses or the clovers when sown by themselves.

GRASSES GROWN SINGLY FOR PASTURE.

It is, indeed, a difficult matter to make an exact determination of the amount of pasture produced from a number of different kinds of grasses when pastured by farm stock. In the experiments conducted in connection with the Royal Agricultural Society at Woburn, England, as well as at other places, it was found unwise to attempt to compare different grass lands by having the crops pastured by sheep unless at least three acres were used in each plot. If cattle were used, even larger plots than these would be necessary. It will, therefore, be seen that if it is desirable to make a comparison of fifteen or twenty kinds of grasses by pasturing them separately with sheep or cattle, a very large amount of land would be required. It was thought, however, that some valuable information might be obtained by using smaller plots of land and by cutting, weighing and removing the crops from the land instead of pasturing them with farm stock. An experiment was conducted, therefore, for four years in succession by cutting, weighing and



Sheep do wonderfully well on pasture lands, and are very effectual in eradicating weeds.

removing the crop produced from each of sixteen varieties of grasses at that time in the spring when the earliest varieties were ready for pasturing, and then by repeating this process at each time during the summer when the more vigorous varieties had produced a sufficient growth for furnishing a good pasture crop. In the average of the four years, the crops were cut on the six dates as follows: May 28th, June 18th, July 9th, July 30th, August 20th and September 16th. It will be seen that the growth was somewhat slower between the last two dates than in the earlier periods.

In one year during which an experiment was conducted there were two sets of grass plots containing sixteen varieties each. These two sets were fenced separately. They were pastured three times during the summer, one by a herd of cattle and one by a flock of sheep. The sheep were turned on the pasture on May 19th, July 3rd and September 14th and the cattle on May 27th, July 13th and September 22nd. In each instance the animals were on the pasture about one week.

Careful notes were taken of the amount of pasture removed from each plot at the end of the first and of the last day of each period. This experiment was conducted in order to glean information regarding the palatability of the different grasses as pasture for cattle and for sheep.

The following table gives the average yields of the four years' results of each of sixteen varieties of grasses at each of six different cuttings, as well as the total number of tons of pasture material per acre per annum, and the comparative palatability of the different grasses:—

Varieties of Grasses.	Percentage Palatability as determined by pasturing cattle and sheep. 12 determinations		Tons of Green Pasture per Acre per Annum from each of Six Cuttings. (Ave. 4 years).						
	Cattle.	Sheep.	1st.	2nd.	3rd.	4th.	5th.	6th.	Total 6 Cuttings
Tall Oat	77	100	5.93	.83	1.59	1.23	1.33	.87	11.70
Orchard	100	80	4.34	1.71	.92	1.30	1.05	1.40	10.72
Western Rye	37	26	4.82	1.28	.93	1.58	.89	.64	10.14
Canadian Lyme	67	72	3.67	1.81	1.01	1.82	1.01	.73	10.05
Bearded Wheat	41	48	3.18	1.78	1.03	1.89	1.11	.79	9.78
Meadow Fescue	68	53	4.60	1.72	.69	1.09	.84	.61	9.55
Virginia Lyme	43	49	4.13	1.32	.87	1.65	.86	.62	9.45
Tall Fescue	55	55	4.70	1.75	.78	.87	.74	.59	9.43
Timothy	87	92	4.87	1.71	.58	1.11	.62	.49	9.38
Fringed Brome	59	58	4.27	.80	1.09	1.55	.98	.58	9.27
Awnless Brome	81	80	4.53	.96	1.04	1.26	.63	.62	9.04
Perennial Rye	40	42	4.10	1.49	.61	.78	.90	.80	8.68
Meadow Foxtail	88	75	3.81	1.32	.72	.95	.53	.37	7.70
Kentucky Blue	69	87	3.76	1.04	.73	.78	.58	.58	7.47
Rhode Island Bent	59	66	3.17	1.17	.66	.91	.52	.40	6.83
Red Top	63	68	2.71	1.03	.62	.67	.44	.37	5.84

It will be seen that the Tall Oat grass produced the largest amount of pasture crop per acre, the average for the four years being nearly twelve tons per annum. It gave decidedly the largest yield at the first cutting, held out well in the middle of the summer and furnished a fairly large amount of pasture crop in the autumn of the year. The Orchard grass was especially strong in the autumn, producing the greatest quantity of pasture crop at the last cutting of any of the sixteen varieties of grasses under experiment. Although the Western Rye, Canadian Lyme and Bearded Wheat have all given comparatively high results in yield of pasture crop per acre, a study of the experiment shows that when these crops are cut six times during the summer the plant vitality becomes greatly exhausted and the crops are apt to be quite inferior in the following season. In the case of Tall Oat, Orchard Grass, Meadow Fescue and Tall Fescue, however, the vitality of the plants does not seem to be injured to any great extent by frequent cutting. The results of this experiment are very suggestive and furnish some valuable information regarding the special characteristics of different varieties of grasses when grown with the object of pasture. The results of the individual tests help to form a basis for procuring different mixtures of grasses to be sown for the production of pasture.

CLOVERS AND SIMILAR CROPS GROWN SINGLY FOR PASTURE.

An experiment was conducted for three years by cutting each of eight varieties of clover and somewhat similar crops at six different times during the growing season, in order to ascertain the amount of pasture crop produced by each variety throughout the summer. The first cutting was made as soon as the earliest varieties had furnished sufficient growth to afford a good pasture. Each of the other five cuttings were made at such times as the most vigorous growing varieties had produced sufficient growth for pasture purposes. As each cutting was made, the crop was weighed immediately in order to ascertain the exact yield of pasture crop produced by each variety.

In order to glean information regarding the palatability of the different varieties, each of two sets of plots was enclosed with a hurdle fence. When the majority of varieties were in the best condition for pasture, a herd of cattle was turned on one set and a flock of sheep on the other set. The animals were allowed to roam over the plots. Careful notes were taken on the evening of the first and on the evening of the last day of the pasture period, which lasted nearly a week. This process was repeated three times during the season. The average amount of pasture crop removed from the plots in the six observations for each class of farm stock, when worked out in the form of percentages, furnishes information regarding the comparative palatability of the different varieties when pastured by cattle and by sheep.

The following table gives the average results for three years of each of six cuttings per annum of each variety, and also the palatability of the different varieties of pasture crops, as determined from six observations made in the one season when cattle and sheep were allowed to pasture on the plots:

Varieties.	Percentage Palatability as determined by pasturing cattle and sheep. 12 Determinations.		Average of Three Years' Results in Yield of Green Pasture Crop per Acre from each of Six different cuttings (tons).						
	Cattle.	Sheep.	1st.	2nd.	3rd.	4th.	5th.	6th.	Total 6 Cuttings
Alfalfa	93	83	8.73	3.06	2.70	3.62	1.56	1.27	20.94
Common Red	99	88	10.88	1.10	2.37	3.39	1.52	1.15	20.41
Mammoth Red	100	100	10.55	1.02	1.99	2.83	1.19	1.19	18.77
White or Dutch	86	93	7.35	2.35	1.95	1.91	2.08	1.63	17.27
Alsike	98	96	8.22	.28	3.06	1.41	2.56	.93	16.46
Yellow Trefoil	..	..	5.07	.19	2.59	2.18	2.10	1.02	13.15
Sainfoin	88	74	4.64	.67	1.78	2.73	1.19	.79	11.80
Burnet	88	69	2.64	1.39	1.05	1.52	.59	.41	7.60

The foregoing tabulated results show that those crops which were the least relished as pasture were Sainfoin and Burnet, by sheep, and White or Dutch clover, Sainfoin and Burnet, by cattle. The Mammoth Red clover proved to be very palatable to both classes of farm stock.

It will be seen that upwards of twenty tons per annum of green pasture crop per acre were produced by Alfalfa and by Common Red clover. Alfalfa produces a large amount of pasture material, but unfortunately animals in tramping over a field composed entirely of Alfalfa often destroy the plants by eating off the crowns of the roots. This is particularly true if any heaving has taken place. The White or Dutch clover has also made a high return. Although the plants do not grow to a great height, the crop is apt to be very compact and generally yields more than its appearance would indicate. The results which are here presented should be considered in connection with the figures previously reported for the grasses grown singly for pasture.

Sainfoin to the left and Alfalfa to the right.

In each of two years an experiment was conducted at the College in comparing the amount of pasture crop produced by sweet clover, by Alsike clover and by Common red clover. The yields per acre were determined at each of six cuttings in each of the two years. Three weeks were allowed between each two cuttings. The results are very interesting in furnishing definite information regarding these three crops in the production of green clover, which would correspond pretty closely to the relative amounts of pasture produced. The following table gives the average of the two years' experiments in tons per acre of green pasture crop:

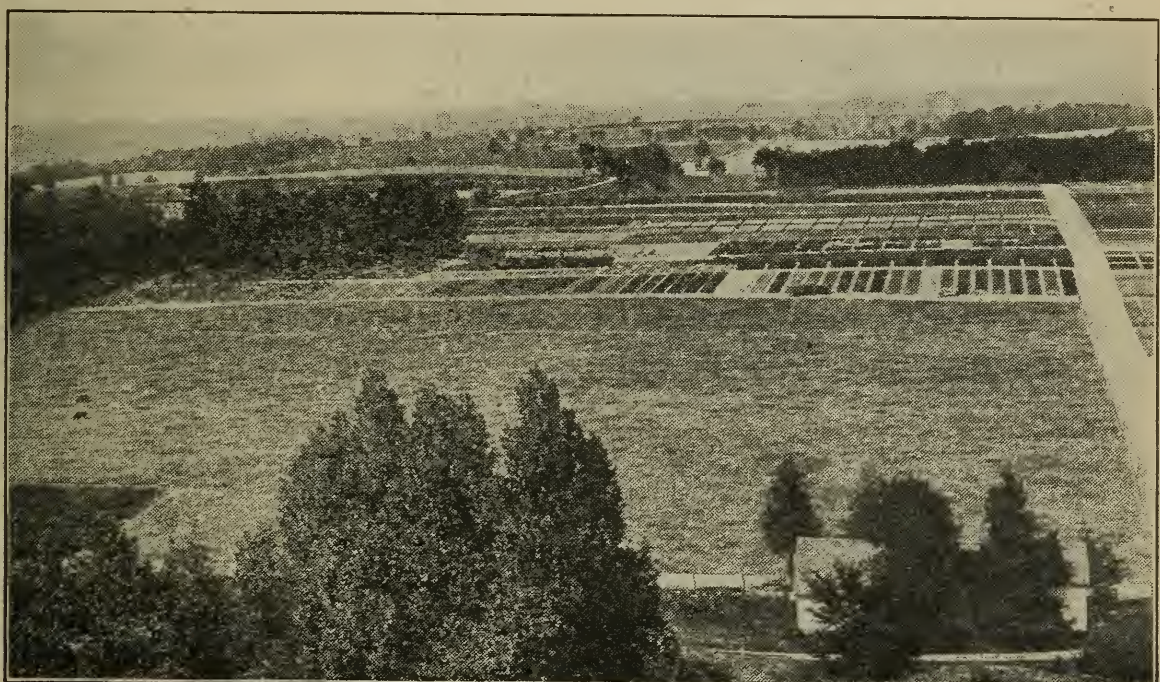
Varieties.	1st.	2nd.	3rd.	4th.	5th.	6th.	Total 6 Cuttings.
Common Red Clover.....	13.3	1.4	2.9	4.6	2.0	1.6	26.0
Alsike Clover...........	11.0	.2	4.0	1.7	3.4	1.1	21.4
White Sweet Clover.....	11.0	1.5	2.5	3.0	1.9	.9	20.8

The results show that, with one exception, in the average of the two years the Common red surpassed the sweet clover in yield of pasture crop per acre at each of the cuttings. In the total amount of pasture per acre per annum the Common red clover surpassed the sweet clover by fully five tons or by about twenty-five per cent., and the Alsike surpassed the sweet clover by about one-half ton.

MIXTURES FOR ANNUAL PASTURES.

Owing to various circumstances, stock farmers sometimes realize in the spring of the year that the amount of pasture for the season is likely to be deficient for maintaining the farm stock throughout the coming summer. Experiments were started at the Agricultural College with the object of gleaning information regarding the most suitable varieties of crops to sow in the spring, either separately or in combination, to produce pasture satisfactorily in the same season in which the crops are sown. Fourteen different crops were selected, and after some preliminary work definite experiments were planned. These crops were sown on twenty-eight plots, which were uniform in size and shape. One set of fourteen plots was used for determining the comparative earliness, drought resistance, quick and persistent growth and yields of the different crops, and the other for determining the palatability of the crops when being pastured by farm stock.

It was decided to cut each crop in one set at the end of six, nine, twelve, fifteen and eighteen weeks after the seed was sown, thus making five cuttings for each crop. By weighing the green material obtained in each instance, immediately on its being cut, information could be gleaned regarding the approximate amount of green pasture material from each crop throughout the season. The experiment was repeated in each of five years.



A section of the experimental grounds showing, in the foreground, a field of Annual Pasture Mixture on which cattle are grazing, and some grass plots beyond.

The other set was sown in exactly the same way as the one already described, but the crops were pastured by a small herd of cattle instead of being cut and weighed every three weeks. When the crops were in their best condition for pasture, the cattle were turned on and allowed to roam freely over the plots. Notes were carefully taken of the approximate amount of pasture eaten from each plot at the end of the first day and of the last day of the pasture period, which lasted about a week. This was repeated from two to three times each season in each of three years and furnished some valuable information regarding the palatability of the crops for pasture purposes.

The following table gives the average percentage of palatability as determined by pasturing cattle and also the production of pasture material obtained from the different cuttings of each of fourteen crops:

Varieties.	Percentage Palatability as determined by pasturing Cattle 3 years. 16 Determinations.	Average of Five Years' Results in Yield of Green Pasture per Acre from each of five different Cuttings (tons).					
		1st.	2nd.	3rd.	4th.	5th.	Total 5 Cuttings.
Oats	100	3.61	2.73	1.16	.72	.51	8.73
Red Clover	67	.05	2.15	2.70	1.97	1.73	8.60
Hairy Vetches	67	1.04	3.85	1.17	1.30	.89	8.25
Sorghum or Sugar Cane	82	.11	2.00	3.20	1.43	.94	7.68
Pasture Rape	90	.61	3.98	1.08	.97	1.01	7.65
Crimson Clover	66	.04	2.49	2.48	1.05	1.57	7.63
Spring Rye	22	5.54	.71	.37	.51	.28	7.41
Barley	89	3.91	1.55	.58	.33	.43	6.80
Hungarian Grass	58	1.01	2.98	1.24	.97	.33	6.53
Common Vetches	62	1.54	2.31	1.01	.92	.66	6.44
Grass Peas	63	1.56	2.78	.77	.38	.24	5.73
Flint Corn	96	.77	2.31	1.72	.64	.01	5.45
Goose Wheat	74	2.18	1.62	.78	.27	.33	5.18
Soy Beans	52	.64	1.26	1.05	.69	.41	4.05

Those varieties of pasture crops which were eaten most readily by the animals were in the following order: oats, flint corn, pasture rape, barley, sorghum and goose wheat. Other crops which held an intermediate position in palatability were red clover, hairy vetches, crimson clover, grass peas and common vetches. The Hungarian grass, soy beans and spring rye were the least relished as pasture crops. The spring rye grew rapidly and soon became unpalatable.

In total amount of pasture per acre per annum the oat crop heads the list with 8.73 tons. It furnished its largest crop early in the season. In comparison with this, red clover furnished a larger amount of pasture material than any other crop at both the 4th and the 5th cuttings. The hairy vetches and pasture rape gave the highest yields of pasture crop at the 2nd cutting, and the sorghum or sugar cane furnished the largest amount of pasture material at the 3rd cutting. Sorghum stools considerably when pastured down and thrives comparatively well in the time of drought. Barley gave considerably less pasture material than oats. If any of the barley plants come into head, they are objectionable for pasture purposes, owing to the presence of beards. Goose wheat is comparatively low in both yield and palatability and the seed is expensive.

In the fourth year of the experiment, emmer was added to the list of crops. In total production and in palatability of pasture it is almost identical with Hungarian grass. In distribution of pasture material throughout the season, however, it corresponded more closely with barley.

Realizing that for pasture purposes greater satisfaction would probably result from the annual crops grown in mixtures rather than grown separately, an experiment was conducted by using six different combinations of three crops each. These six mixtures were tested in duplicate in each of five years. Each mixture was cut at the end of six, nine, twelve, fifteen and eighteen weeks after the seed was sown, thus making five cuttings of each crop in the season. The following table gives the amount of pasture material obtained from the different cuttings of each of the six mixtures:

Mixtures.	Average of Five Years' Results in Tons of Green Pasture per Acre from each of five different Cuttings. (10 tests).					
	1st.	2nd.	3rd.	4th.	5th.	Total 5 Cuttings
1. Oats, Sorghum, Hairy Vetches	2.95	3.73	1.84	1.14	1.01	10.67
2. Oats, Hairy Vetches, Crimson Clover	2.92	3.54	1.74	1.21	1.00	10.41
3. Oats, Sorghum, Red Clover	2.78	3.13	1.18	1.18	.85	9.12
4. Emmer, Hungarian Grass, Red Clover	2.46	2.28	1.06	1.10	.66	7.56
5. Emmer, Sorghum, Red Clover	2.30	2.09	1.14	1.12	.72	7.37
6. Spring Rye, Emmer, Hungarian Grass	4.43	1.06	1.06	.55	.22	7.32

In selecting the mixtures in each case the aim was to have a natural succession of crops and a continuous supply of pasture in the autumn and in the hot, dry summer, as well as in the earlier part of the season. Any one of the first three mixtures has produced a good yield of pasture material, which has been well relished by the animals.

As a result of testing the different crops, both singly and in combination, it was decided to make use in a more extensive way of a mixture of oats, sorghum and red clover as an annual pasture. For this purpose, the following quantities were used:

Oats	51	pounds	per acre.
Sorghum	30	"	"
Red Clover	7	"	"
Total	88	"	"

The oats and the sorghum were mixed together and were sown from the grain box of the seed drill, and the clover seed was sown from the grass seed box placed in front of the tubes of the drill.

Fully eight acres sown with this mixture have been used for pasture purposes in the Department of Field Husbandry in each of eleven years. The seeding has generally taken place about the end of the first week in May and the crop has usually been ready for pasturing from the 15th to the 20th of June. The crop was pastured with milch cows for three years, with heifers for three years, and with steers for five years. When steers were used they were weighed once a month and were removed from the pasture at no other time. In the average of five years in which careful records were kept, it was found that on the average one steer would require four-fifths of an acre, or five steers would require four acres for the season. The increase in live weight of the animals was 2.6 pounds per head per day. The annual pasture crop was not supplemented by any other kind of feed. In no instance was there any trouble from bloating, and the animals kept in excellent health and in fine condition when on the pasture. The tramping did not injure the soil to any appreciable degree and all three crops in the mixture withstood the tramping of the animals satisfactorily. In ten out of the eleven years, there was a good catch of clover, while in the other season the clover crop was only fair. The clover, when sown in this way, forms a good matting over the ground in the autumn and is in a satisfactory condition to be left over winter to furnish hay, pasture or seed in the following season if desired.

As the seed of the Early Amber Sugar Cane was scarce and expensive in 1917, the mixture was composed of one bushel each by weight of oats, barley and wheat, and seven pounds of red clover seed per acre, and in 1918 the mixture consisted of two bushels by weight of oats, one bushel of barley, and seven pounds of red clover

Cows pasturing on the Annual Pasture mixture.

per acre. In all our results up to date we have not obtained as good satisfaction from either wheat or barley as we have from oats.

In each of the past two years an experiment has been conducted in testing different quantities of different varieties of oats with red clover as an annual pasture. The results so far indicate good returns from eight to ten or twelve pecks of a good stooling oat in combination with seven pounds of Common red clover, providing there is not a drought in July or August. Such crops as Early Amber Sugar Cane and Hairy vetches, however, help the pasture greatly in a hot, dry summer.

In the experiments of the past two years winter wheat, winter rye, winter emmer and winter barley, when sown in the spring, have not given very satisfactory results as pasture crops.

MIXTURES FOR TEMPORARY PASTURES

Grasses and clovers may be used singly or in combination for the production of hay or pasture to meet the requirements of the individual farms. In some instances Common red clover, Mammoth clover or sweet clover may be sown with a grain crop, with the object of producing either hay or pasture in the following year, after which the land is again brought into cultivation. A legume of this kind is suitable for a three years' rotation such, for instance, as a cultivated crop, a grain crop and a hay or pasture crop. In the majority of cases, however, farmers sow a mixture of one or more varieties of grasses and one or more varieties of clover. The mixtures are usually used according to the length of time that the farmers intend to leave the land in sod. A mixture of timothy and Common red clover is probably used more extensively than any other combination and is generally suitable for two years of hay and pasture. Unfortunately, however, in recent years when labor has been scarce many farmers seed their grain with timothy and Common red clover, and after taking off one crop of hay use the land for pasture for a number of years. The clover soon disappears and the timothy forms a comparatively poor pasture, especially in dry seasons. If it is the intention to use the crop for pasture for a series of years, it is frequently wise to add to the mixture a quantity of some of the hardier grasses which usually give a fairly good green

Grass and Clover plots, showing a mixture of Tall Oat grass and Alfalfa in the foreground.

growth, even in a summer when the season is comparatively hot and dry. The following are suggested combinations of grasses and clovers suitable for shorter or longer rotations in which the amount of seed per acre of each variety is indicated:

Common Red Clover	8	12 pounds of seed per acre.
Timothy	4	

Common Red Clover	6	12 pounds of seed per acre.
Alsike	2	
Timothy	4	

Common Red Clover	6	18 pounds of seed per acre.
Alsike	3	
Timothy	3	
Orchard Grass	3	
Meadow Fescue	3	

Alfalfa	4	25 pounds of seed per acre.
White or Dutch Clover	1	
Timothy	4	
Orchard Grass	8	
Meadow Fescue	8	

Each of the first two mixtures would be suitable for two years, the third mixture for a longer period, and the fifth mixture would even be suitable, in some instances, as a permanent pasture.

If the land is low and comparatively wet such varieties as Red Top, Blue Joint and Alsike can often be used to advantage.

A nurse crop of grain may be used satisfactorily with any one of the foregoing mixtures. The seed, in all cases, should be sown in front of the tube drill. The clover and the timothy can be sown from the grass seed box and the Orchard grass and the Meadow Fescue by hand. The crop could be used for hay in the following year and for either hay or pasture afterwards.

MIXTURES FOR PERMANENT PASTURES.

Land which can be spared from the regular rotation of the farm can often be seeded with a permanent pasture mixture to excellent advantage. Fields lying remote from the buildings and which are inconvenient for cultivation, or fields which are unsuitable for some of the other crops, can frequently be converted into permanent pasture, especially for the use of cattle, sheep, or growing stock. It is also convenient to have some small sections of permanent pasture near the farm buildings and which are suitable for turning on the milch cows.

A large amount of experimental work has been done in testing varieties of grasses and clovers, both singly and in combination, within the past thirty years. The grasses and the clovers have been carefully seeded and much information has been gleaned regarding their value for permanent pasture. In the earlier days of the College it was found that some of the grasses, such as Sweet-scented Vernal, Crested Dog's Tail, and Italian Rye grass, proved to be unsuited for Ontario's conditions. After about twenty grasses had been sown on two or three occasions and their characteristics and hardiness studied, a permanent pasture mixture was recommended in 1885 by the late Prof. Wm. Brown. In 1893, after eight years of additional experimental work, during which time the writer was closely connected with the operations of the Experimental Department, another mixture was recommended, containing a lesser number of varieties and containing a smaller amount of seed per acre. The grasses and clovers recommended in 1893 have proven themselves to be particularly valuable in the formation of a permanent pasture mixture. They are all hardy varieties and, when grown together, furnish a large amount of pasture. A definite experiment was started by sowing a plot of the mixture which was recommended in 1885 and a plot of the mixture which was recommended in 1893. It was impracticable to use farm stock for pasturing the crops. It was also desirable to glean information in regard to the relative productiveness of the two mixtures. Each crop was, therefore, cut and weighed from two to three times each year and, in a period of eleven years during which this experiment was conducted, no less than twenty-six cuttings were obtained. The relative yields were reckoned as freshly cut green material, and the average annual returns for the eleven-year period are as follows:

Class of Crop.	Varieties in Mixture.	Amount of Seed Sown per Acre. Pounds Single Varieties.	Amount of Seed Sown per Acre. Pounds Total Mixture.	Average tons of Green Pasture Crop per acre per annum 11 years. (26 Cuttings).
1885.				
Grass	Meadow Fescue.....	6		
"	Meadow Foxtail.....	3		
"	English Rye	2		
"	Timothy............	3		
"	Canadian Blue	4		
"	Orchard	3		
"	Red Top............	2	35	12.9
"	Yellow Oat	2		
Alfalfa	Alfalfa	4		
Clover.................	White or Dutch	2		
"	Alsike..............	2		
"	Red................	1		
Legume	Yellow Trefoil	1		
1893.				
Grass	Orchard	4		
"	Meadow Fescue	4		
"	Tall Oat............	3		
"	Timothy............	2		
"	Meadow Foxtail.....	2	24	15.7
Alfalfa	Alfalfa	5		
Clover.................	Alsike..............	2		
"	White or Dutch......	1		
Legume	Yellow Trefoil	1		

The foregoing table shows that the mixture of 24 pounds of the hardy and vigorous growing grassses and clovers gave a higher average yield of material per acre than the other mixture composed of 35 pounds and containing a few of the smaller-growing varieties.

In the eleventh year after the permanent pasture plots were seeded they were carefully examined, and it was found that 88 per cent. of the larger and 90 per cent. of the smaller mixture was composed of the original grasses. In the larger mixture, the English Rye grass, the White or Dutch clover and the Alsike clover had entirely disappeared, and in the smaller mixture there was not even a trace of the Alsike or the White or Dutch clover. Those varieties which proved to be the hardiest were the Tall Oat grass, the Yellow Oat grass and the Orchard grass.

These two mixtures of permanent pasture should have been kept for a number of years longer but, unfortunately, they were ploughed by mistake.

It is now considered unwise to use Yellow Trefoil in a permanent pasture mixture in Ontario.

The seed of a permanent pasture mixture can be sown in the early spring, either with or without a grain crop. It is better to follow some cultivated crop which has been carefully looked after during the previous season. If the seed is sown alone, the tops of the plants should be cut occasionally during the summer and allowed to lie on the ground as a mulch. If a nurse crop is used, about one bushel of barley or of wheat per acre is recommended. As a rule, oats do not form a good nurse crop for a permanent pasture mixture. If, however, they are used they should be sown thinly. The seed for the permanent pasture should be sown in front and not behind the tube drill. Some of the finer seeds can be sown from the grass seed box and the others by hand.

The most desirable combination of hardy grasses and clovers, when once well established on suitable land, should produce a good pasture, appetizing to the animals, excellent in quality, abundant in growth and permanent in character.

CONTENTS

	Page
Introduction	1
Descriptions and Drawings of Hay and Pasture Plants	1
Timothy Grass (*Phleum pratense*)	2
Orchard Grass (*Dactylis glomerata*)	4
Tall Oat Grass (*Arrhenatherum elatius*)	6
Yellow Oat Grass (*Trisetum flavescens*)	8
Meadow Fescue Grass (*Festuca elatior*)	10
Sheep's Fescue Grass (*Festuca ovina*)	12
Kentucky Blue Grass (*Poa pratensis*)	14
Canadian Blue Grass (*Poa compressa*)	16
Red Top Grass (*Agrostis alba*)	18
Perennial Rye Grass (*Lolium perenne*)	20
Italian Rye Grass (*Lolium multiflorum*)	22
Meadow Foxtail Grass (*Alopecurus pratensis*)	24
Awnless Brome Grass (*Bromus inermis*)	26
Fringed Brome Grass (*Bromus ciliatus*)	28
Western Rye Grass (*Agropyron tenerum*)	30
Bearded Wheat Grass (*Agropyron caninum*)	32
Virginia Lyme Grass (*Elymus virginicus*)	34
Canadian Lyme Grass (*Elymus canadensis*)	36
Common Red Clover (*Trifolium pratense*)	38
Alsike Clover (*Trifolium hybridum*)	40
White Clover (*Trifolium repens*)	42
Crimson Clover (*Trifolium incarnatum*)	44
White Sweet Clover (*Melilotus alba*)	46
Yellow Sweet Clover (*Melilotus officinalis*)	48
Alfalfa (*Medicago sativa*)	50
Sainfoin (*Onobrychis sativa*)	52
Varieties of Grasses for Hay Production	54
Varieties of Timothy	55
Varieties of Clover for Hay Production	56
Alfalfa for Hay	58
Mixtures of Grasses, Alfalfa and Clovers for Hay Production	59
Grasses, Alfalfa and Clovers sown in the Fall and in the Spring with and without Nurse Crops	59
Grasses grown singly for Pasture	61
Clovers and Similar Crops grown singly for Pasture	63
Mixtures for Annual Pastures	64
Mixtures for Temporary Pastures	69
Mixtures for Permanent Pastures	70

Ontario Department of Agriculture

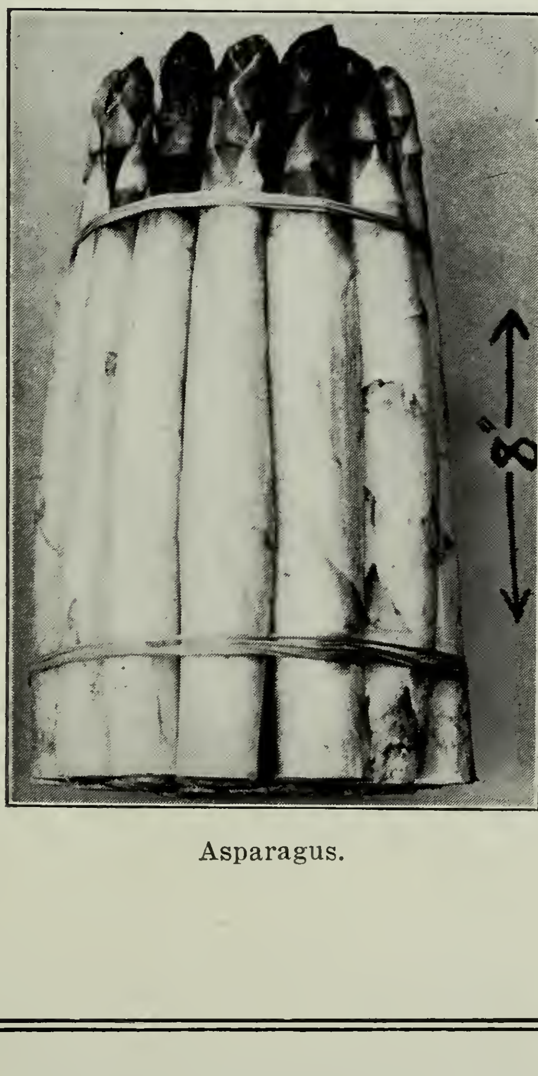
BULLETIN 270

JUDGING VEGETABLES

By

A. H. McLENNAN, B.S.A.

Vegetable Specialist



Asparagus.

TORONTO, ONTARIO, MAY, 1919

BULLETIN 270] [MAY, 1919

Ontario Department of Agriculture

JUDGING VEGETABLES

A. H. McLENNAN

STANDARDS FOR JUDGING VEGETABLES.

For some time it has been felt that a more definite idea of the type of each vegetable should be published in order that judges may be enabled the more easily to give their decision.

Uniformity of exhibit is necessary always. Each specimen exhibited should be similar in size and shape, and smooth. Too many exhibitors fail owing to lack of uniformity in their entry.

The size certain vegetables should be, to obtain first place, has been a much debated point. Many individuals give preference to size rather than quality. As this latter is somewhat difficult to explain it may be stated as what a good cook chooses when she selects the vegetables for table use. Medium size in most cases indicates this.

Each specimen should be fresh, firm, free from blemish and correctly named; nothing soft, spongy or decayed should be entered or considered for a prize.

Weight must be considered in judging cabbage, melons, squash, pumpkins, onions, egg plant and citrons. While coarseness is always to be avoided, the heavier specimens should be awarded the prize.

Asparagus.

Shoots should be thick, of medium length (6 to 8 inches) and uniform in thickness, tender, and free from rust and insect injury. Should show no signs of branching and no more than 1½ inches of white at bottom. Bundles from half lb. to 2 lbs. in weight.

Beans.

Broad Beans: Straight, broad, well-formed pods filled with large tender beans. Free from disease.

String Beans: Pods should be long, straight, moderately broad, fresh, brittle, uniform and free from disease. Seeds well developed but tender. Colour according to variety.

Beets.

Long: Not more than 2½ inches in diameter, smooth and free from side roots, straight, gradually tapering from crown to tip, firm, free from cracking or signs of disease. Top small and compact. Roots uniform; showing little of scaling or sunburn, colour judged by outer indication and by slight abrasion on side.

Turnip: Not over 3 inches in diameter, firm, with smooth round shape and fine terminal root; no side roots. As dark red a colour as possible to variety. Roots uniform, typical of variety and showing as little scaling or sunburn as possible. Free from cracks or signs of disease.

Brussels Sprouts.

Stems straight; densely covered with medium-sized, firm sprouts.

Cabbage.

Early: Generally round or pointed, typical of variety if named, should be of medium size, 4-6 lbs. in weight, fresh, hard and free from insect injury or disease.

Later: Heads round or flat with two layers of green outer leaves. Specimens should be fresh, uniform, hard but not excessive in size. Free from disease or insect injury.

Red: Slightly conical or round in shape. Dark red colour, solid, heavy.

Savoy: Round or flattened, firm and heavy. Dark green colour with close curl in leaf.

Carrots.

Roots should be long, straight and smooth; showing no green at the crown, free from side roots, and gradually tapering from crown to tip. Core small with a large outer ring. Roots uniform in size and shape. Free from disease, discoloration or cracks.

Medium: Medium in length and size, straight, free from side roots and without green top or split roots, gradually tapering or blunt tip according to variety. Skin smooth, colour clear and bright with a small core and large outer ring. Roots uniform in size and shape. Free from disease.

Cauliflower.

Head: Large in size, of a well-formed curve, with a dense formation of flower, showing no tendency to open; pure white in colour and without small leaves in the head. Free from all blemishes. A few of the lower leaves attached. Specimens uniform.

Celery.

Heads large, stems long, well-blanched except in winter varieties, firm, medium thickness, none hollow, free from rust and rot, showing no flower stems. Roots trimmed short or to pyramid shape. Heart large and carried well up. Ribs not prominent. Uniform in shape, true to type of variety.

Citron.

Large, well-rounded, heavy specimens, finely mottled and well-coloured throughout. Must be firm and of good weight.

Cucumber.

Indoor: Should be of the length of the variety, smooth, uniform with size and shape well-carried out towards the ends. Dark green in colour; not large enough to show tendency toward too great seed development.

Outdoor: Specimens should be smooth in form, uniform, straight, not over 8 inches long and 1¾ inches diameter which is well-carried out towards the ends; of a dark green colour.

Pickling cucumbers must not be over $4\frac{1}{2}$ inches in length and $1\frac{1}{4}$ inches in diameter, smooth, of even diameter from end to end. Gherkins not over $2\frac{1}{2}$ inches long and $\frac{3}{4}$ inch in diameter.

Egg Plant.
Colour should be dark purple all over, specimens even in size, large, smooth and solid. Free from any signs of decay.

Garden Herbs.
True to name, should be either green or well dried. Bunches medium in size.

Kale.
Specimens in pots generally, should have a close, even curl on all leaves. Size according to particular variety.

Lettuce.
Cabbage: Heads should be large, well-rounded, firm, free from any blemishes. Fresh, no flower stems.

Cos. Conical in shape with straight, upright growing leaves, well-bleached and crisp, and with a firm heart. Fresh, no flower stems.

Leaf: Heads of crisp, well-crinkled leaves, showing medium green, without any blemish. No flower stems. Leaves forming dense mass.

Melons.
Musk: Medium to large according to variety, firm, evenly ribbed and closely netted. When fit for use melon pulls easily from stem and flower end is somewhat soft and yielding to the finger. Readiness for eating is the first requirement. This is indicated largely by the smell. Closeness of the netting denotes the quality.

Water: Medium to large according to variety, firm, smooth. Melon must be tapped to get quality.

Onions.
Large: Shape, globe or flat and of colour of variety. Clean but not peeled, uniform, of good weight and have a small well-ripened neck, firm, especially at the base of the neck. Showing no sections. Thorough ripening essential. Should be separate classes for seed, transplanted, and sets.

Pickling: Should range from $\frac{1}{2}$ inch to $\frac{3}{4}$ inch in diameter, uniform in size and shape, clean, firm and white in colour. Thoroughly dried.

Parsley.
Head, large and bushy with numerous, finely curled, dark green leaves. Crisp and free from any discoloration.

Parsnip.
Roots straight, of good length, broadly shouldered, not less than 3 inches, crown well hollowed, free from side roots, gradually tapering from crown to tip, clean, smooth and free from discoloration or disease, firm with a small core.

Peas.
Pods long and straight, dark green in colour and well-filled with medium, sweet-flavoured, tender peas. Pods uniform in size and colour with no signs of ripening.

Peppers.

Either red or green. Should be smooth, firm and typical of variety. Free from disease and injury.

Potatoes.

Specimens uniform in size, 10 to 14 ozs. in weight, smooth, with eyes as shallow as possible for the variety, firm, white inside colour, clean and free from disease of any kind.

Pumpkins.

Round or oblong in shape, symmetrical, medium size, thin-skinned, closely ribbed, firm, heavy; deep yellow or creamy yellow colour all over.

Radish.

Summer and Winter: Medium size, according to variety; clean, smooth, even form; free from insect or disease injury, cracking and side roots; crisp, firm, not spongy, uniform in size, no stem, leaves close to fleshy root.

Rhubarb.

Stalks, medium in diameter, long, straight, fresh and tender. Well-coloured over all the stem.

Salsify.

From 1½ inches to 2 inches at top, smooth and straight, gradually tapering to tip, free from side roots, firm, fresh and clean, skin white in colour. Core small.

Spinach.

Specimens should be large with close heavy foliage: fresh and free from all coarse, outer leaves; broad, dark green, tender leaves, typical of the variety, free from disease and insect injury.

Squash.

Summer: Medium size and weight, colour and shape of variety, firm but with rind soft enough to admit thumb nail readily.

Winter: Should be large, heavy and firm, of colour and shape according to variety. Hubbard should be heavily warted.

Tomatoes.

Medium in size, uniform, with an even, well-rounded shape, smooth, skin even-coloured all over, firm, fresh, good weight and a small eye. Free from diseases or insect injury. Not over-ripe. Blossom end small, colour varies according to variety—pink, bright red, or yellow.

Turnips.

Medium size with smooth, symmetrical form, small tap root and free from side roots, firm and heavy. Small core, as free as possible from splitting or sunburn, showing no insect or disease injury. Colour varies from white to light yellow, according to variety.

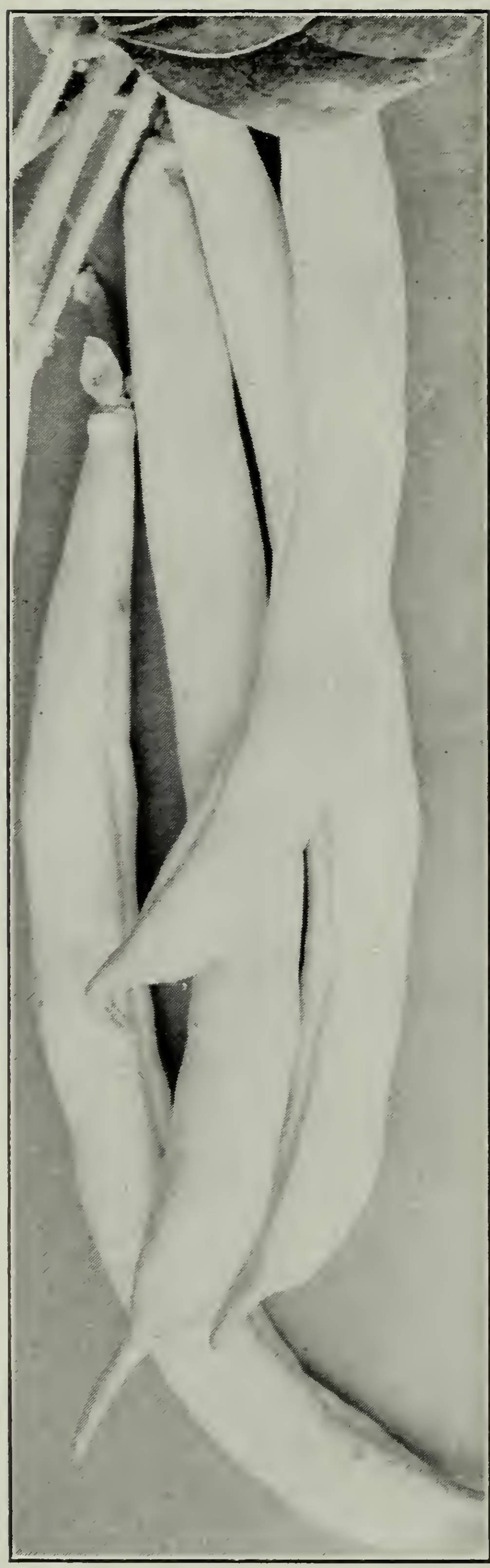
Vegetable Marrow.

Medium size, oblong in form, smooth and even, with uniform thickness and good weight. Fresh, firm but with a rind soft enough to readily admit thumb nail. Colour varies from a cream yellow to a mottled green.

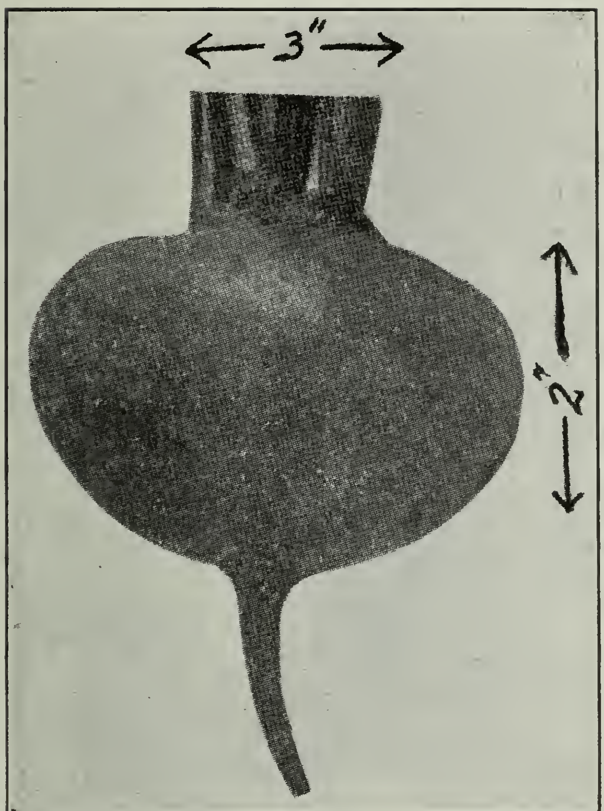
NUMBER OR QUANTITY IN AN EXHIBIT OF VEGETABLES FOR JUDGING.

Artichokes	6	specimens.
Asparagus	2½	lb. bunches.
Beets (Long)	6	specimens.
Beets (Turnip)		"
Beans (Yellow)	12	pods.
Beans (Green)	12	pods.
Brussels Sprouts	1	quart.
Cabbages (Flat)	3	specimens.
Cabbages (Round)	3	"
Cabbages (Pointed)	3	"
Cabbages (Savoy)	3	"
Cabbages (Red)	3	"
Cauliflower	3	"
Carrots (Long)	6	"
Carrots (Intermediate)	6	"
Carrots (Stump-rooted)	6	"
Celery (White)	6	"
Celery (Golden)	6	"
Celery (Green)	6	"
Citrons	2	"
Corn (Sweet White)	6	"
Corn (Sweet Golden)	6	"
Cucumbers (Slicing)	6	"
Cucumbers (Pickling)	12	"
Cucumbers (Gherkins)	1	quart.
Egg Plant	2	"
Garden Herbs	4	varieties.
Kale	3	specimens.
Lettuce	3	"
Muskmelons (Green flesh)	2	"
Muskmelons (Salmon flesh)	2	"
Watermelons	2	"
Onions from seed (White)	12	"
Onions from seed (Yellow)	12	"
Onions from seed (Red)	12	"
Onions from Dutch Sets	12	"
Onions Transplanted (White)	12	"
Onions Transplanted (Yellow)	12	"
Onions, pickling	1	quart.
Parsnips	6	specimens.
Peas	12	pods.
Peppers (Red)	6	specimens.
Peppers (Green)	6	"
Peppers (Cayenne)	6	"
Potatoes	½	peck.
Pumpkins	2	specimens.
Radishes (Summer)	12	"
Radishes (Winter)	12	"
Rhubarb	12	stalks.
Salsify	12	specimens.
Spinach	3	"
Squash (Summer)	2	"
Squash (Winter)	2	"
Tomatoes (Red)	12	"
Tomatoes (Pink)	12	"
Tomatoes (Yellow)	12	"
Turnips (White)	6	"
Turnips (Yellow)	6	"
Vegetable Marrows	2	"

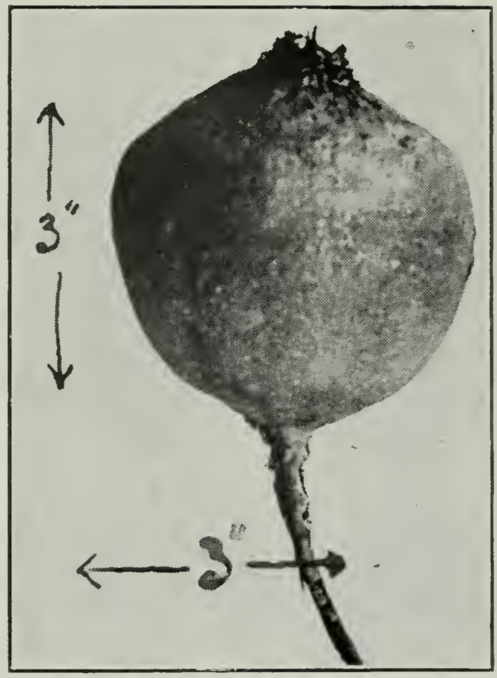
Display of collection of vegetables, 20 varieties, two specimens of each, tastefully arranged.



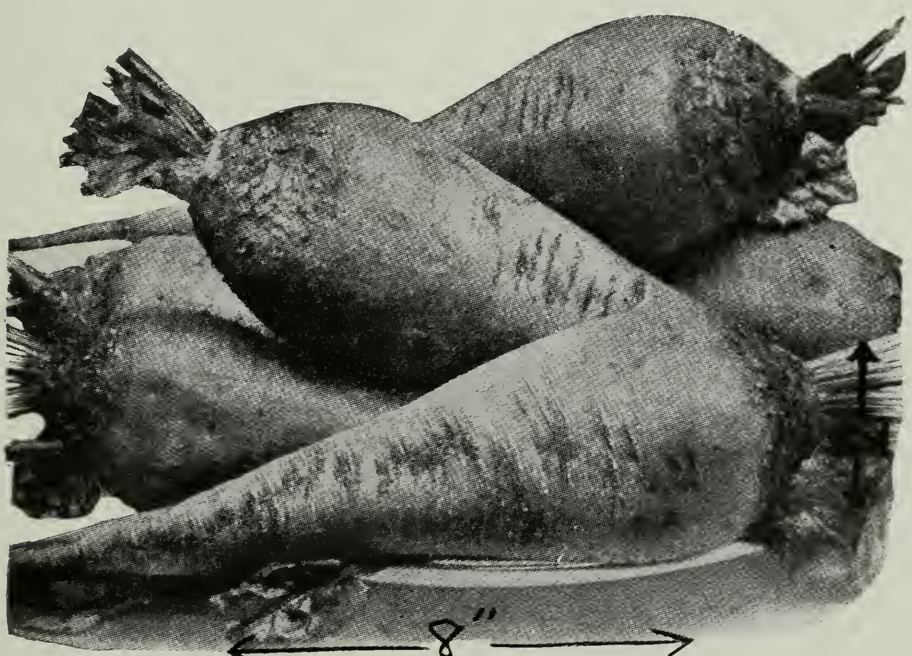
Beans.



Beet, Egyptian.

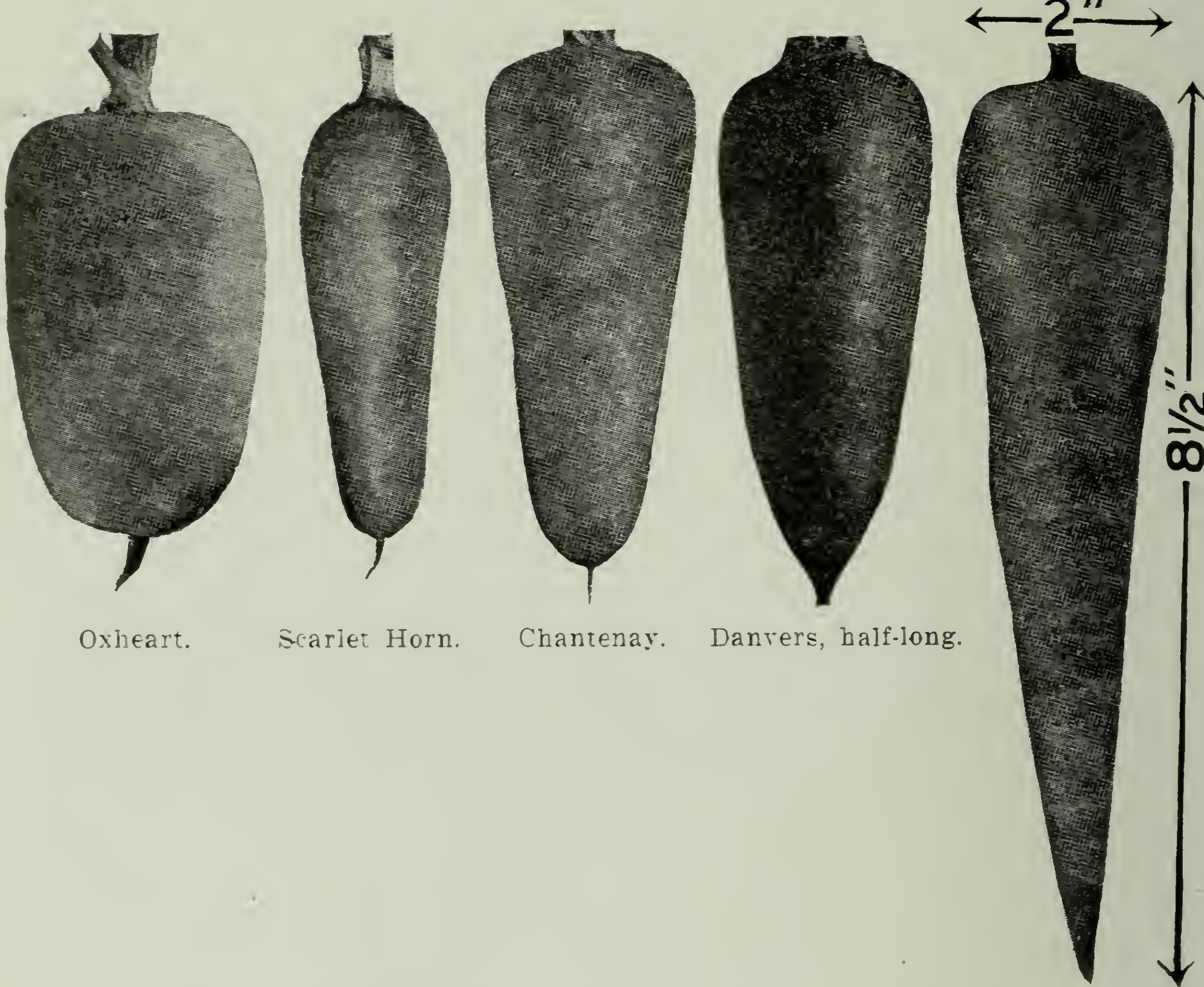


Detroit Dark Red Beet.



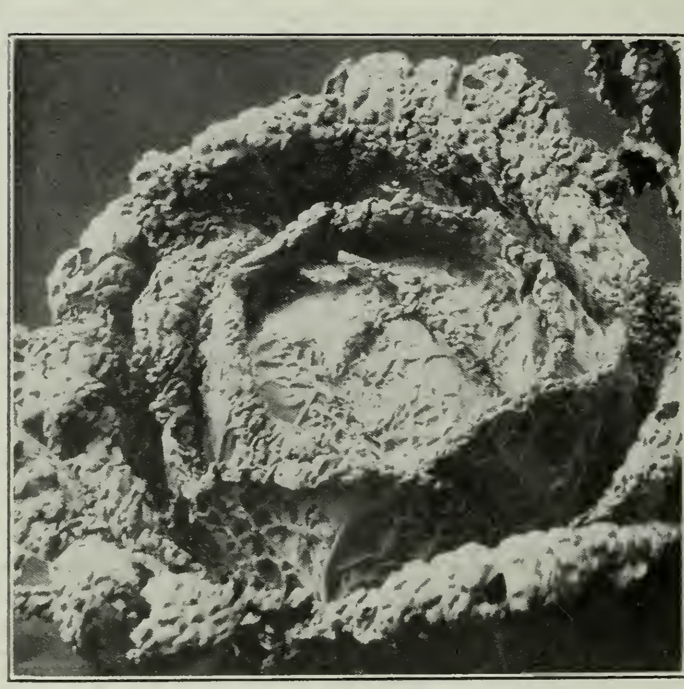
Long Beets.

CARROTS.



Oxheart. Scarlet Horn. Chantenay. Danvers, half-long.

Long Orange.



Savoy Cabbage.

Jersey Wakefield Cabbage.

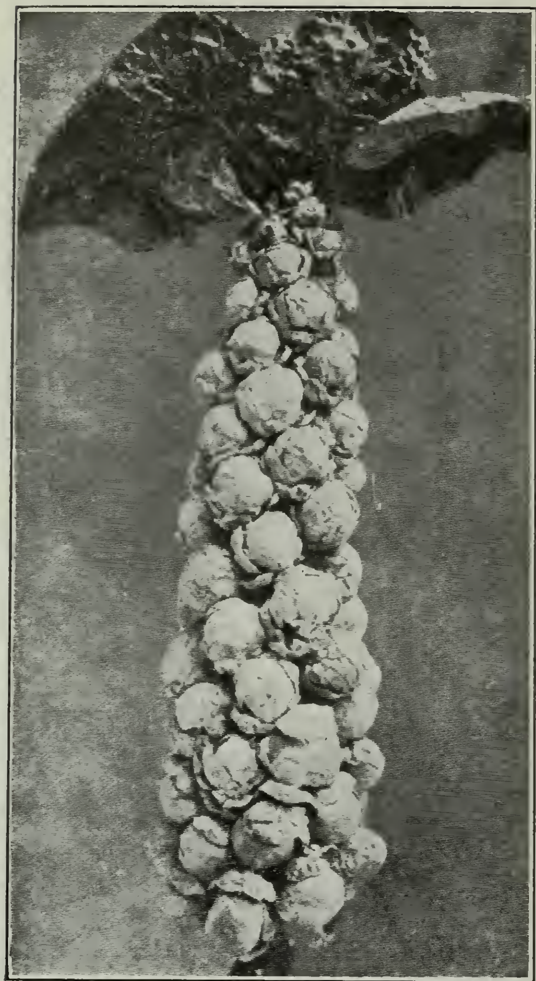
Copenhagen Market Cabbage.

Danish Ball Head Cabbage.

Glory of Enkhinzen Cabbage.

Red Danish Stonehead Cabbage.

Extra Curled Scotch Kale.



Brussels Sprouts.

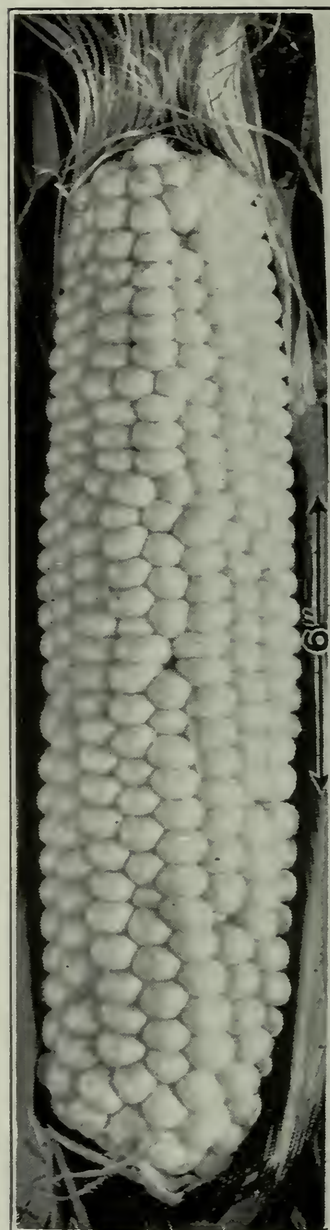
Swiss Chard.

Cauliflower.

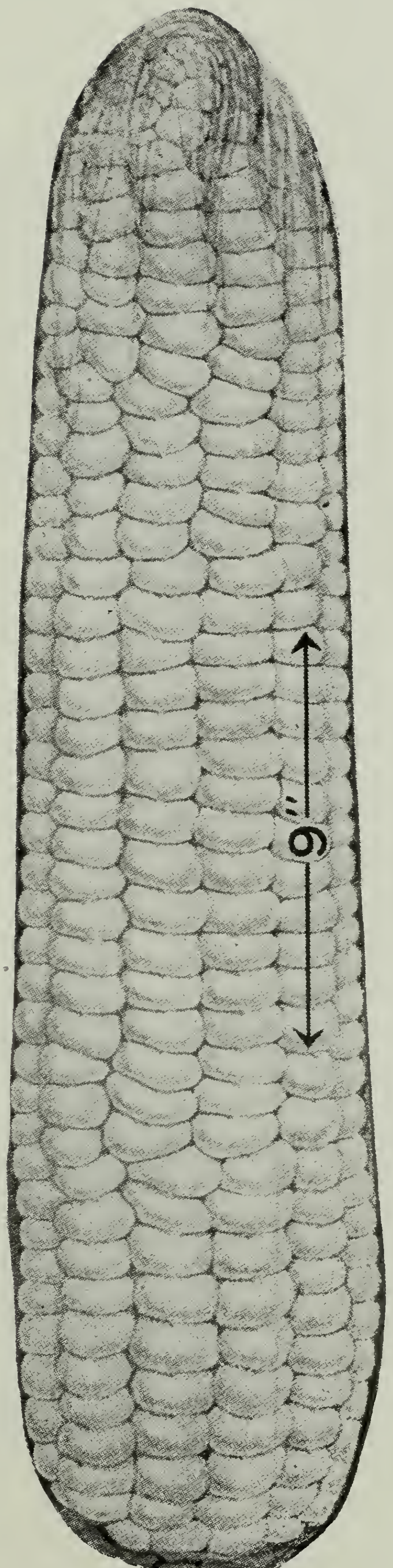
Late White Celery.

Golden Self-Blanching Celery, 18 inches of white.

Golden Bantam Corn. 7 inches to tip.

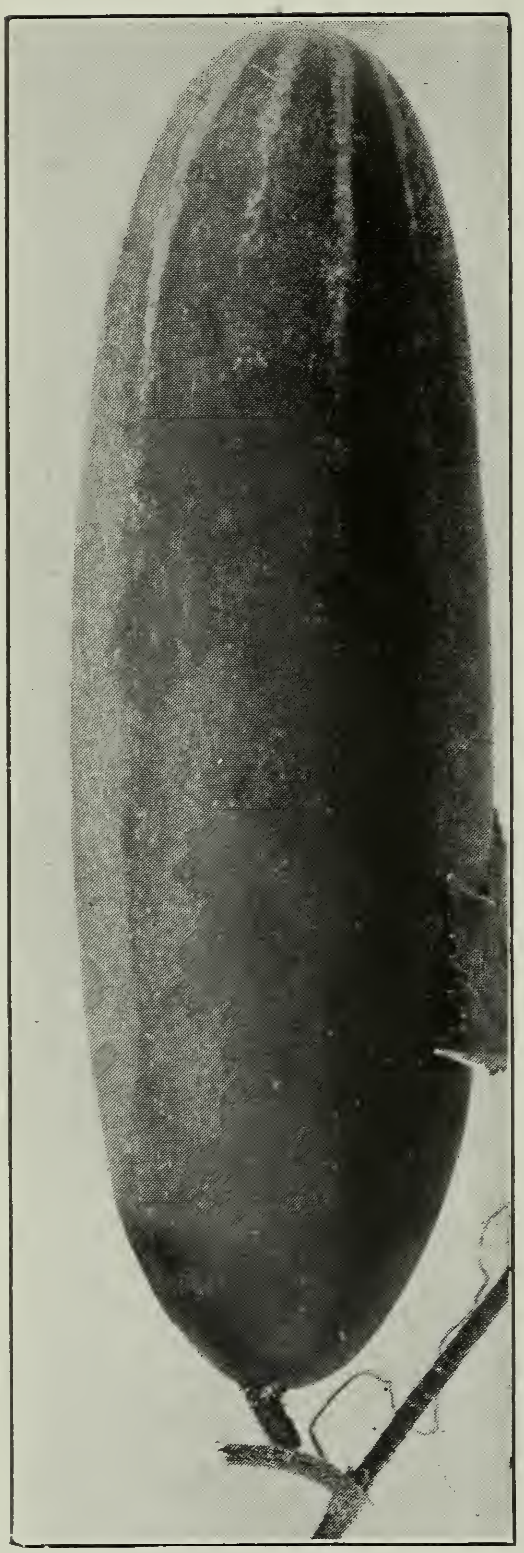


Early Cory Corn.

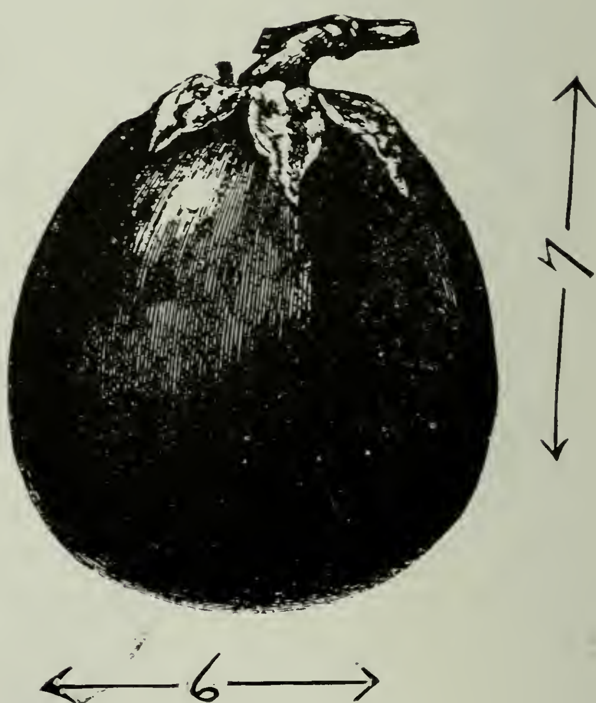


Evergreen Corn.

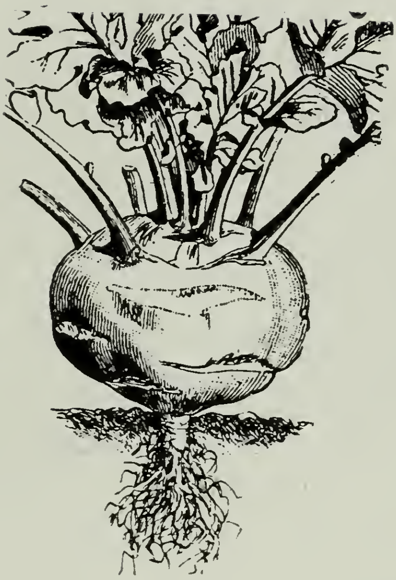
Gherkins.



Slicing Cucumber,
8 inches by 1¾ inches.

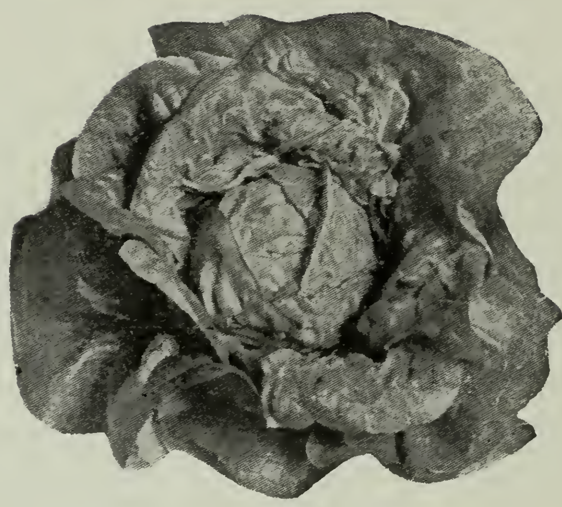


Egg Plant.

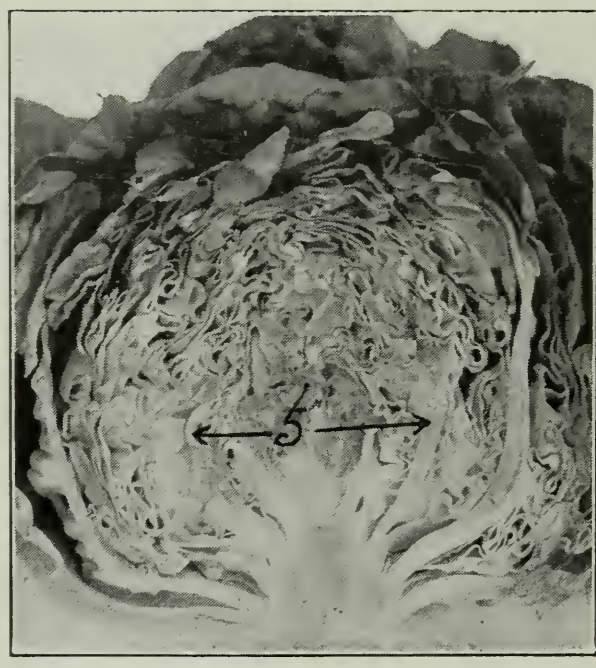


Kohl Rabi.

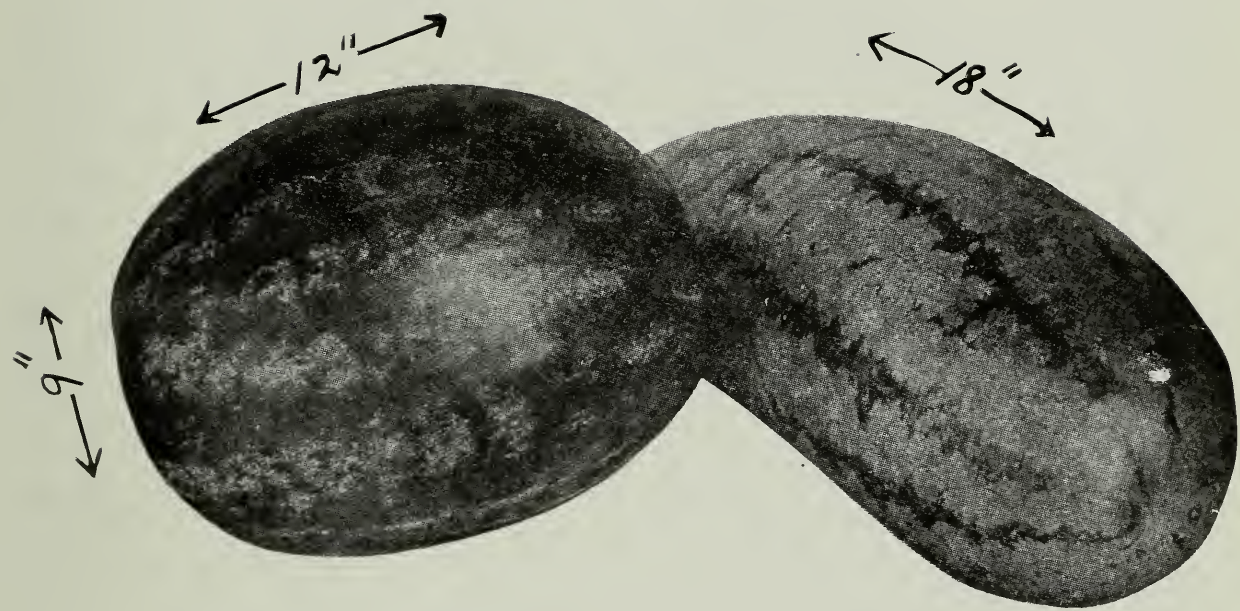
Grand Rapids Lettuce.



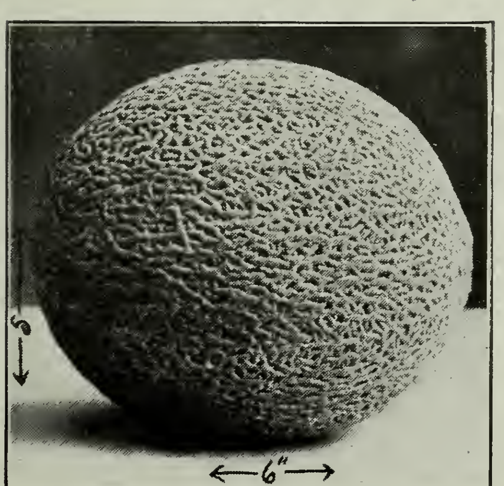
Cabbage Lettuce.



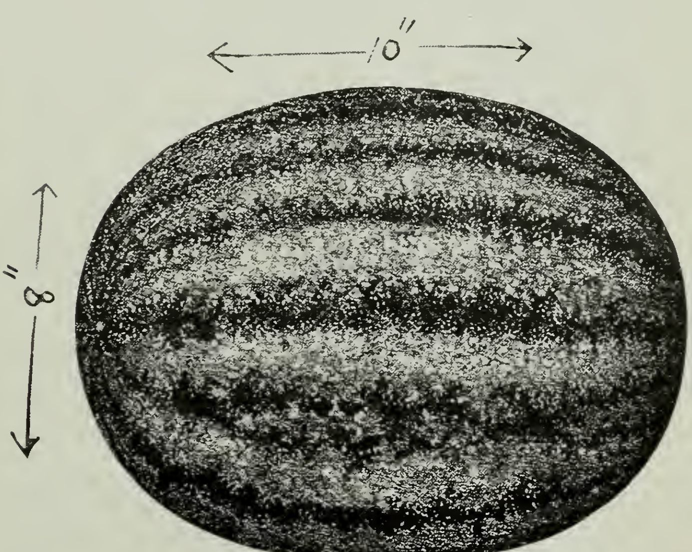
Heart of Head Lettuce.



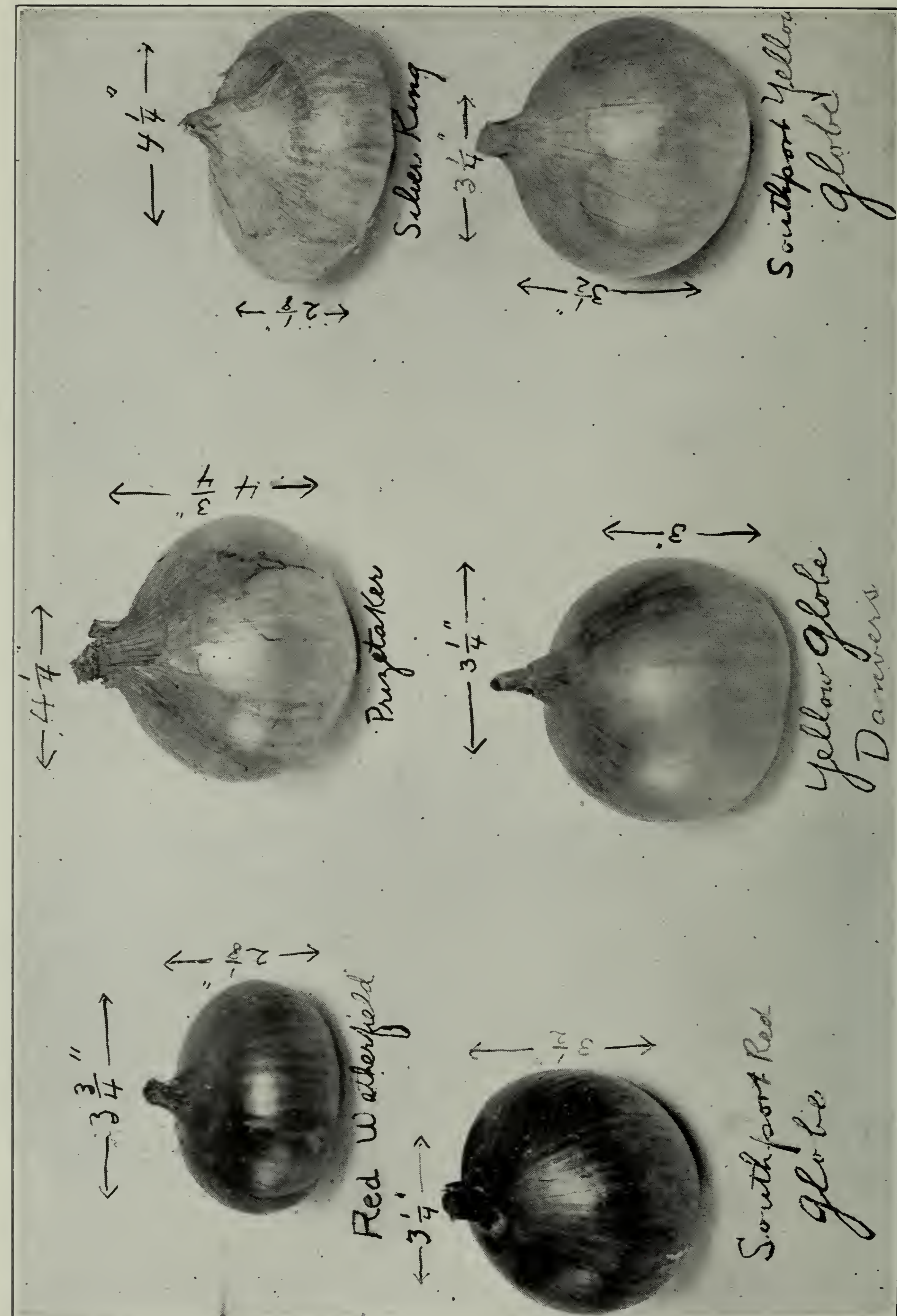
Watermelons.



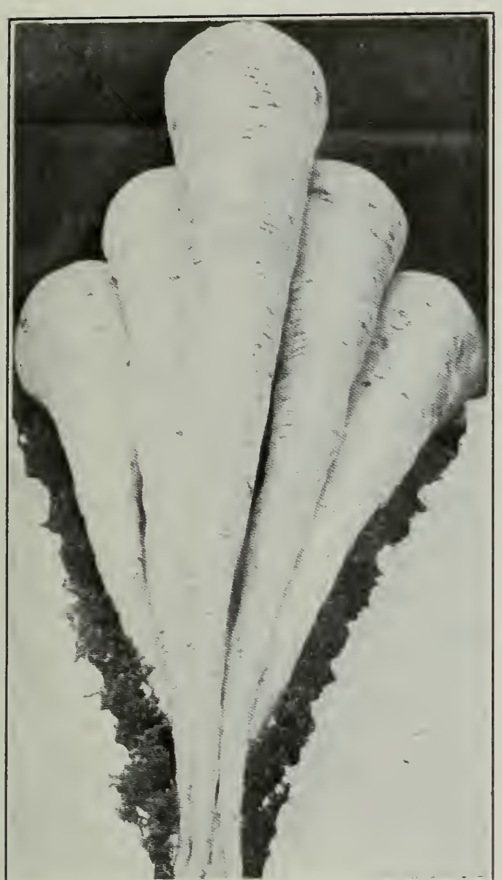
Muskmelon.



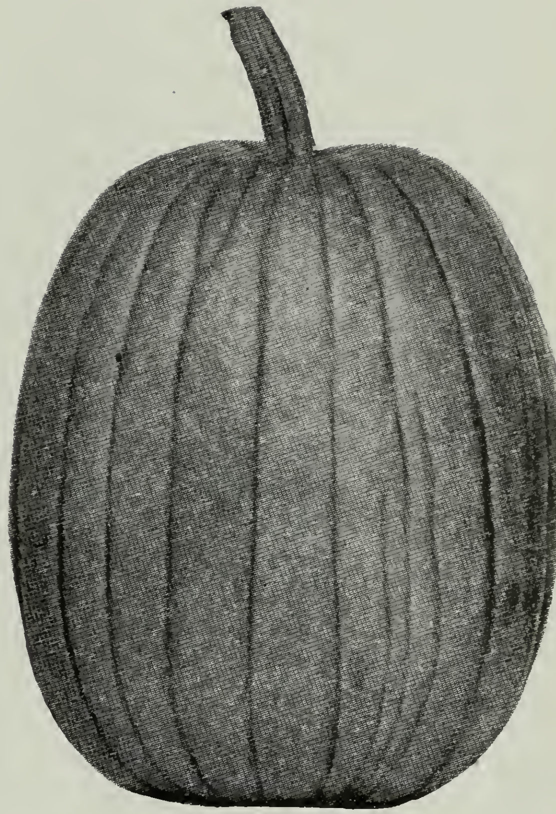
Citron.


Silver King
Southport Yellow Globe
Prizetaker
Yellow Globe Danvers
Red Wetherfield
Southport Red Globe

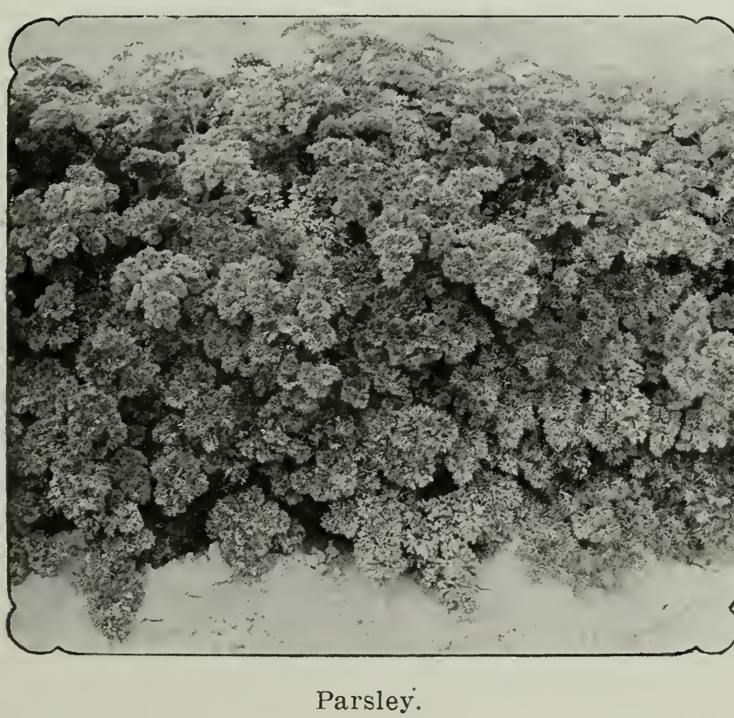
ONIONS.



Parsnip.

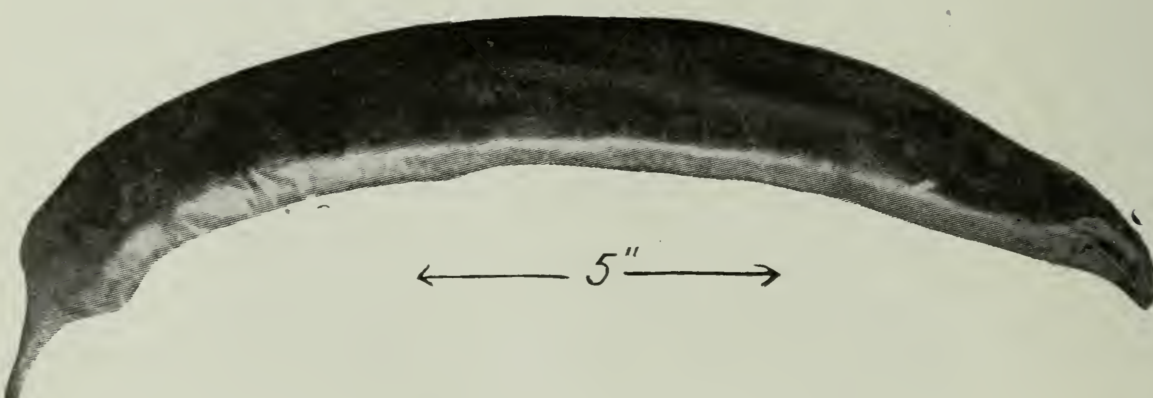


Pumpkin.

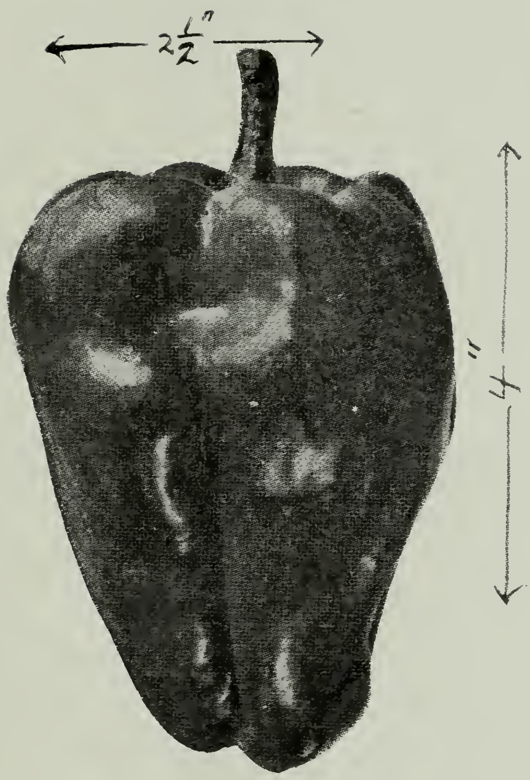


Parsley.

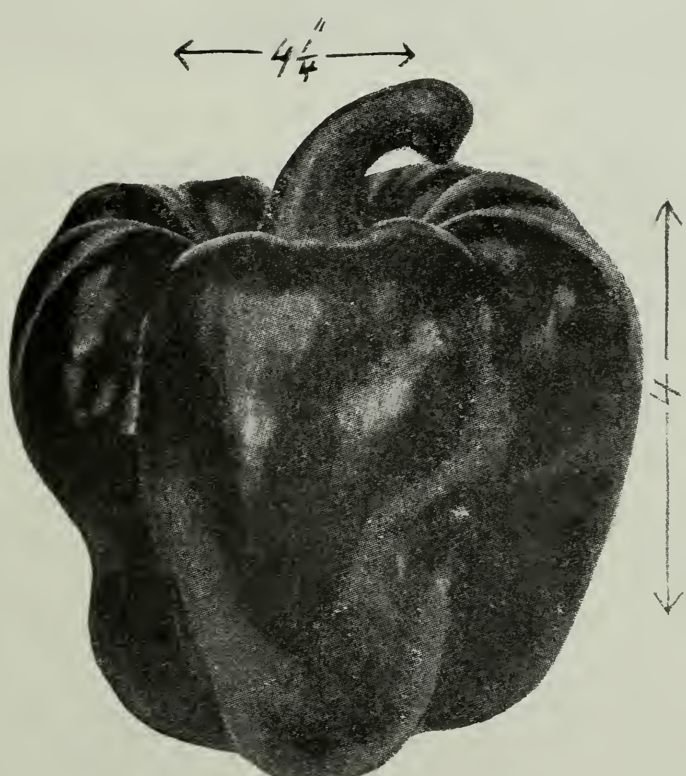
Peas.



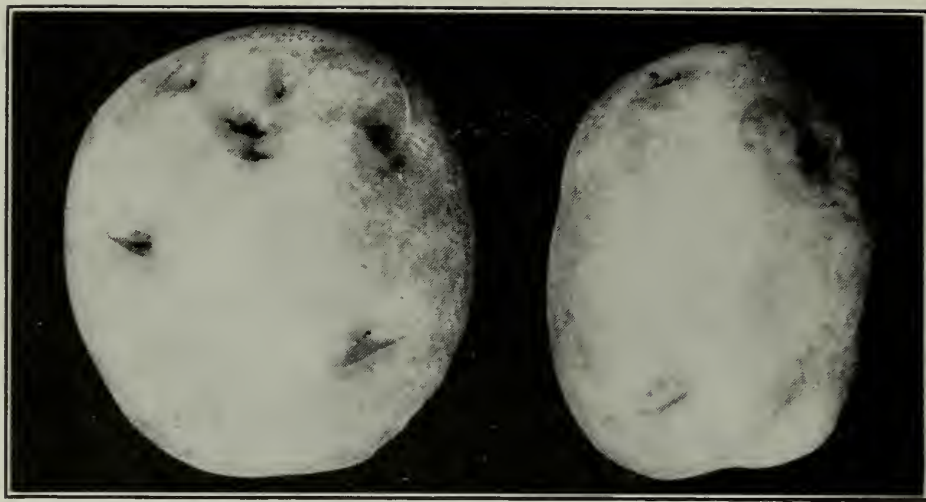
Long Cayenne Pepper.



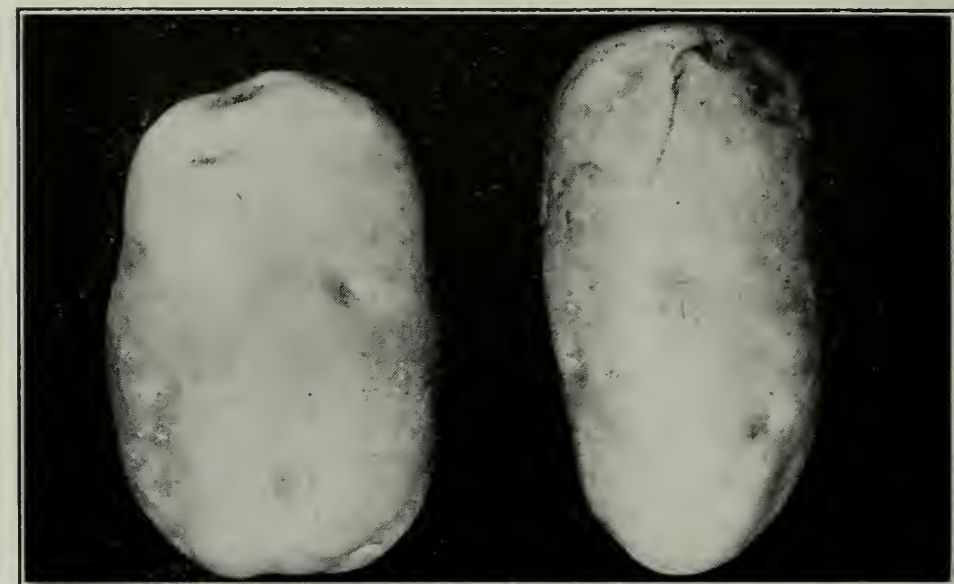
Ruby King Pepper.



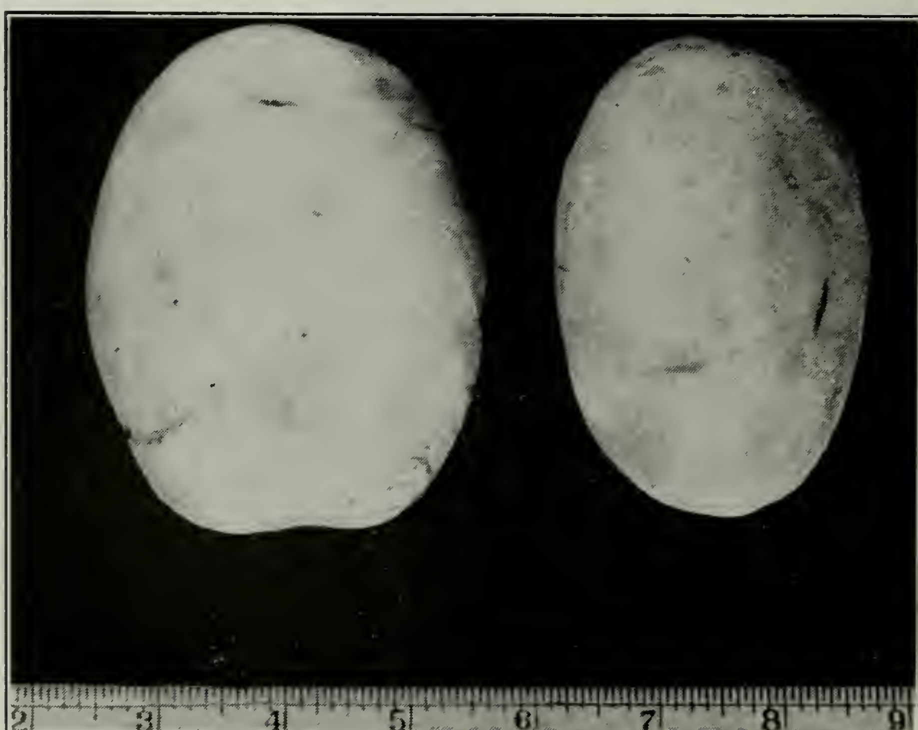
Chinese Giant Pepper.



Irish Cobbler Potato.

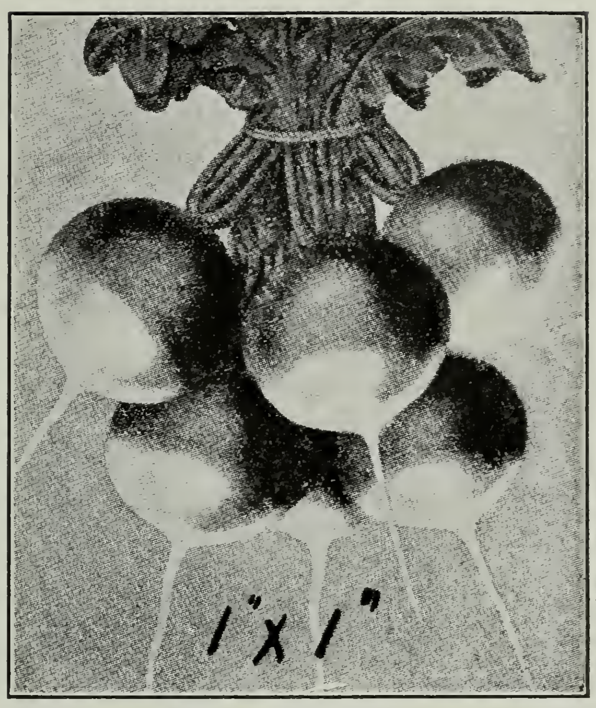


Green Mountain Potato.

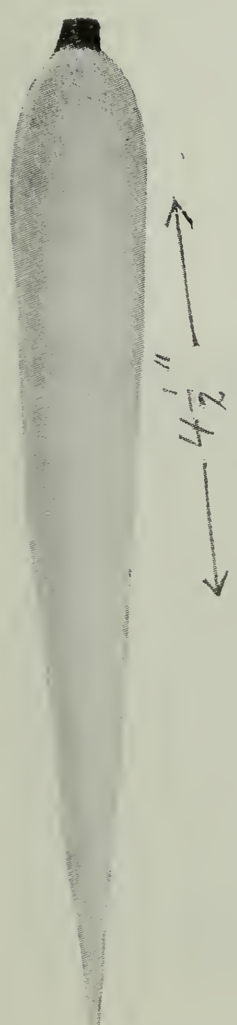


Rural New Yorker Potato.

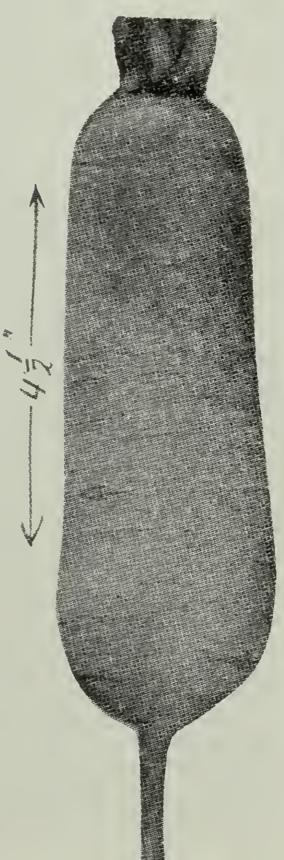
French Breakfast Radish.



Scarlet Turnip White-tip Radish.

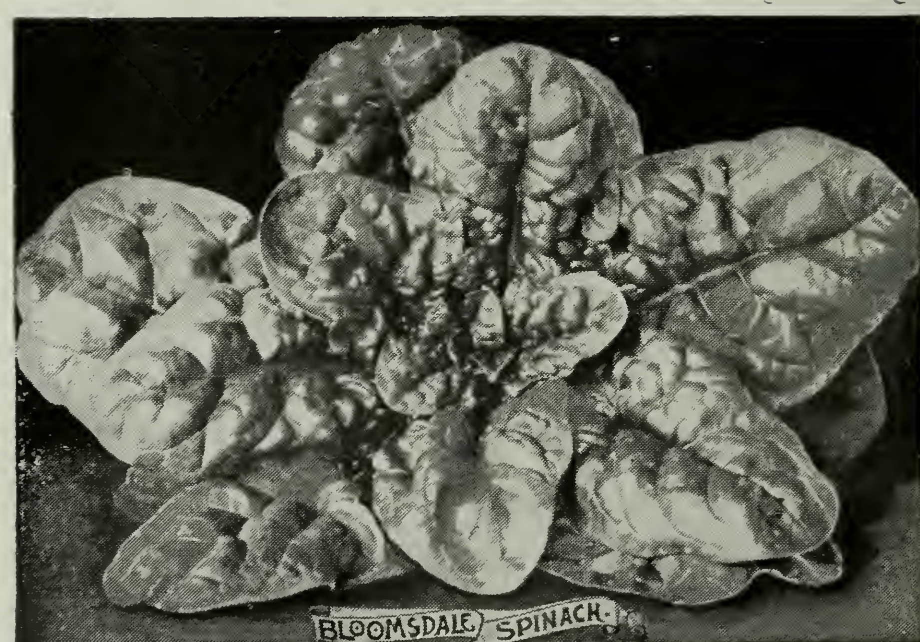


White Icicle Radish.

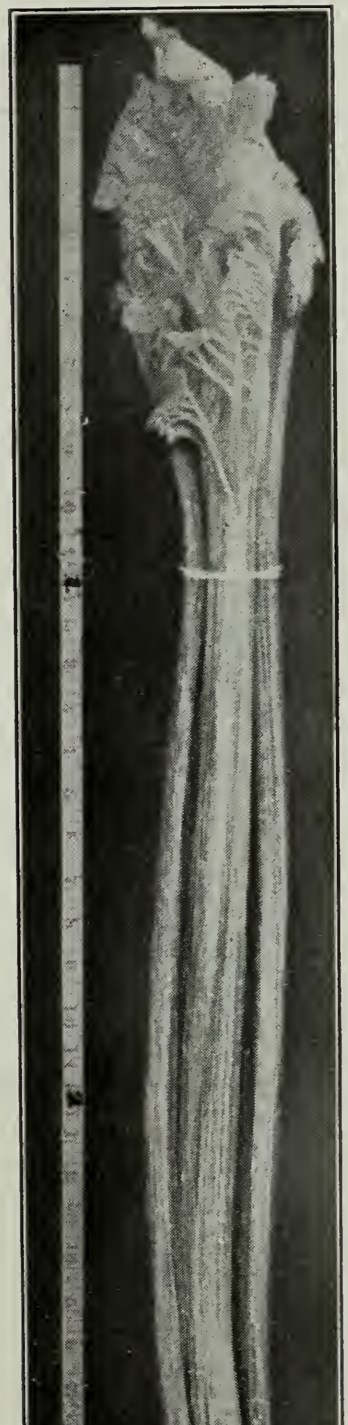


China Rose Radish.

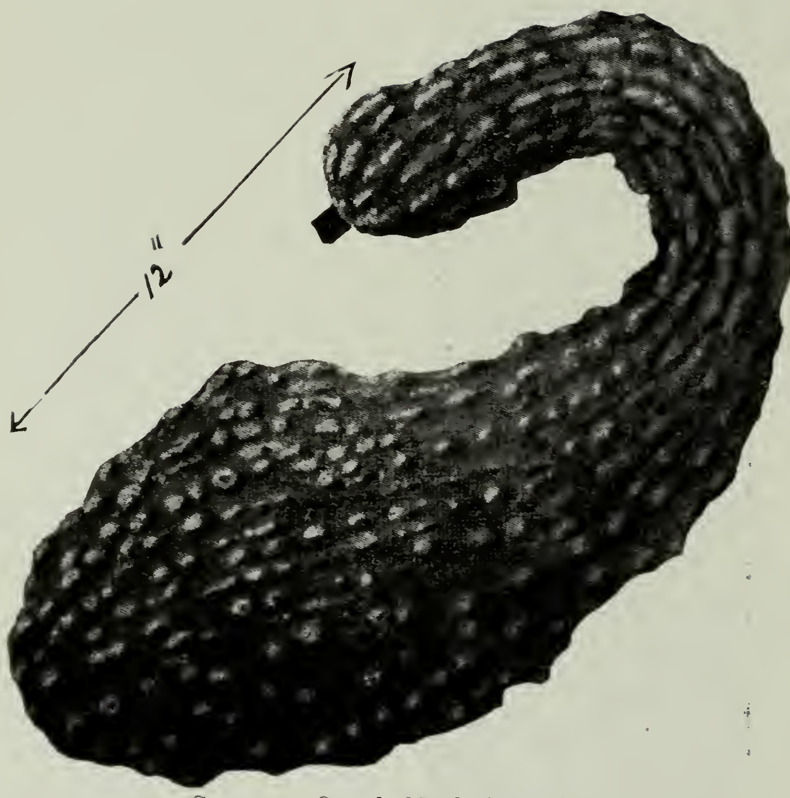
Salsify.



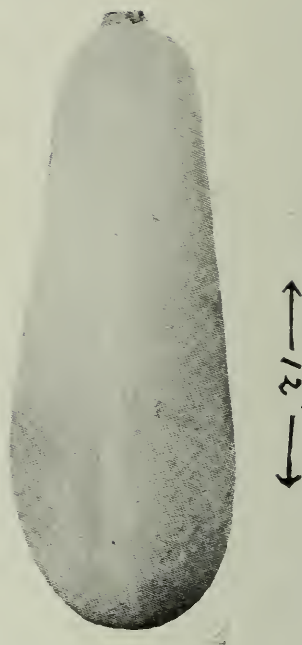
Spinach.



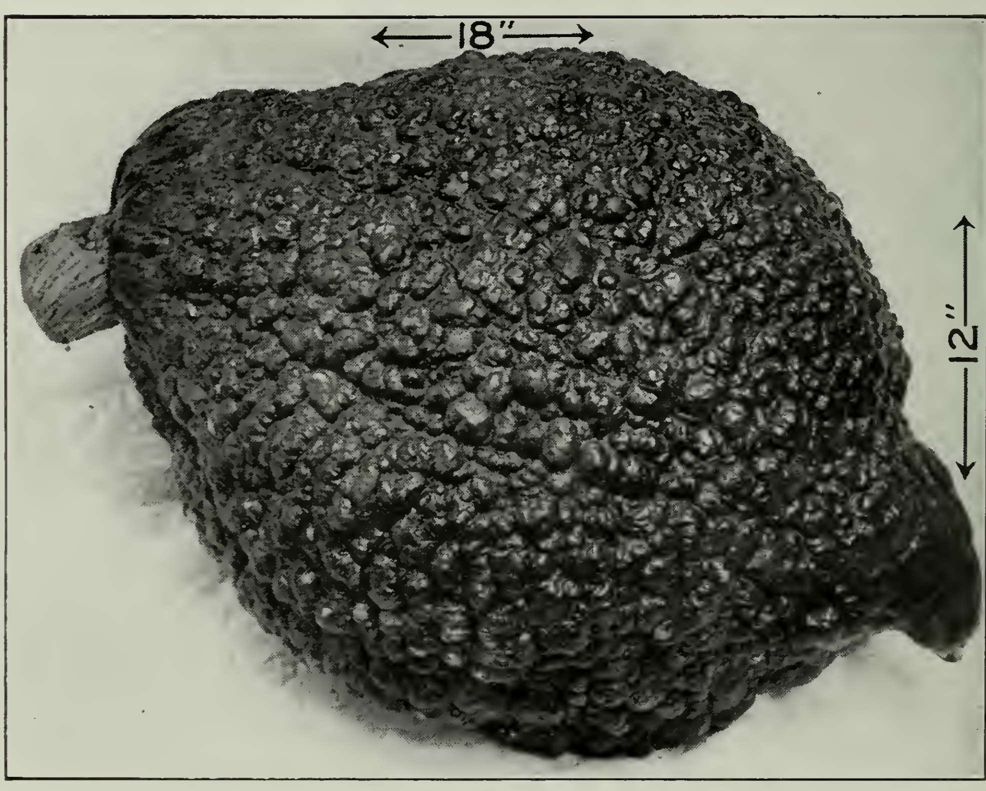
Rhubarb.



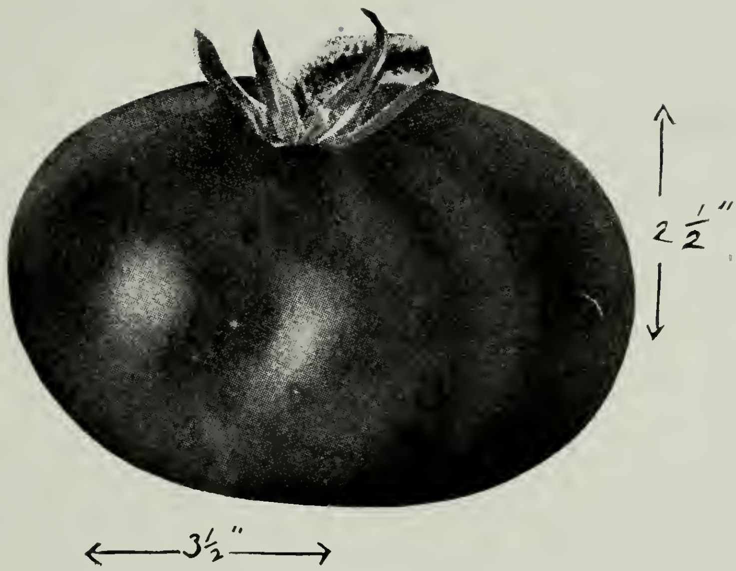
Summer Crook Neck Squash.



Vegetable Marrow.



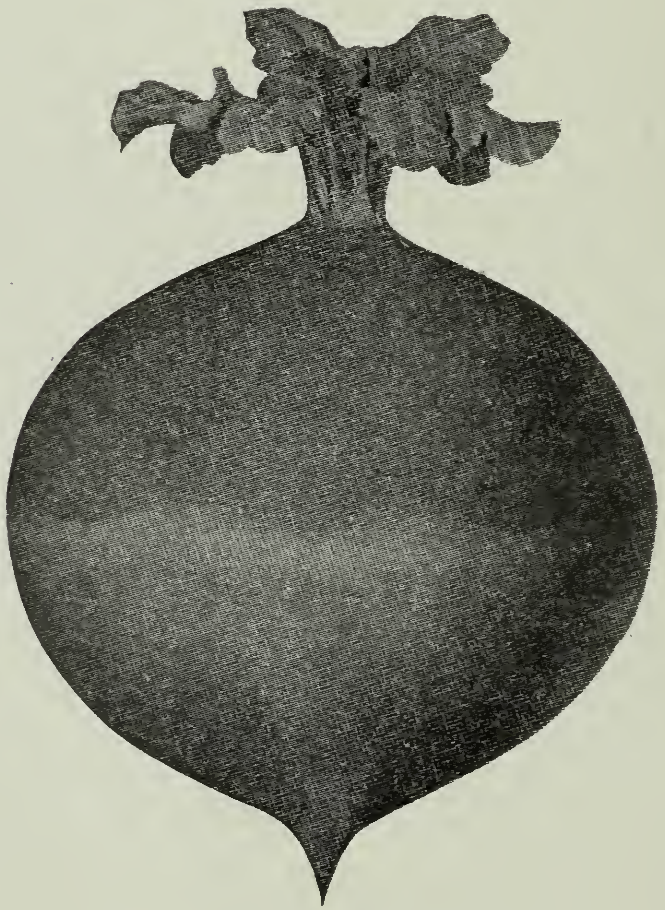
Warted Hubbard Squash.



Earliana Tomato.

Bonny Best Tomato.

Golden Turnip.



Swede Turnip.

Ontario Department of Agriculture

FRUIT BRANCH

BULLETIN 271

THE APPLE MAGGOT

By

L. CAESAR, B.A., B.S.A.
Provincial Entomologist

And

W. A. ROSS, B.S.A.
Entomological Branch, Dominion Department of Agriculture

Fig. 1.—Apple Maggot Adult (female), enlarged about four times.

TORONTO, ONTARIO, MAY, 1919

[illegible]

BULLETIN 271] [TORONTO, MA,Y 1919

Ontario Department of Agriculture

FRUIT BRANCH

THE APPLE MAGGOT

By L. CAESAR and W. A. ROSS

SUMMARY.

For over twenty years the Apple Maggot or Railroad Worm has been recognized as a pest of apples in Ontario. From time to time it has appeared in large numbers in infested orchards and has caused serious losses, in some instances amounting to the entire crop. Up to the present the insect has been found in most of the southern counties extending from the Ottawa River on the east to Lake Huron and the Detroit River on the west, and it is highly probable that it occurs in all counties where apples are grown. Fortunately, the total number of infested orchards is small, probably less than five per cent. in any county and much less than one per cent. in the province as a whole.

It is worthy of note that well-cared-for orchards which are properly sprayed are, as a rule, free or almost entirely free from this pest.

The adult insects commence to emerge from the soil in late June and early July, and continue to emerge for about seven weeks. They are blackish, two-winged flies, a little smaller than house-flies. The abdomen of the female is crossed by four white bands, and that of the male by three. The wings have conspicuous dark markings, arranged as shown in Fig. 3. Several days after emergence the female fly begins egg-laying. By means of a sharp sting-like ovipositor she inserts her eggs beneath the skin of the apple. The eggs hatch in five to six days and the larvæ or maggots derived from them tunnel their way here and there through the flesh of the apple, leaving behind them trails of dead brown tissue. The larvæ become mature when the fruit is ripe, by which time it has usually fallen. The larvæ then leave the apples, enter the soil and change to the pupal stage, in which stage the winter is passed. Most of the pupæ transform to flies the following summer. However, a certain percentage of them remain in the soil until the second summer and then emerge as flies at the usual time.

Injury is caused chiefly by the maggots tearing the apple pulp with their hook-like mouth parts and absorbing the juices. Pulp affected in this manner becomes brown and tough; hence the term "woody" which is frequently applied to maggot-infested apples. Badly infested fruit may become so honeycombed with larval tunnels that it will break down into a rotting mass.

The wounds made in the apple by the flies in ovipositing and the killing of tissues by maggots working near the skin, may give rise to malformations.

Serious loss may also be caused by the tendency of infested apples to drop prematurely.

The flies have extensible mouth-parts with rasp-like lips, by means of which they feed on liquid or solid materials present on the leaves and fruit. This habit of feeding affords us a very satisfactory method of control by making it possible to poison the flies before they lay their eggs.

Control. Experiments conducted in Ontario during the past six years have definitely proved that the Apple Maggot may be controlled by spraying, at least twice, with arsenate of lead—2½ lbs. of paste to 40 gallons of water.

The first application should be made as soon as the flies begin to emerge, that is, *about June 25th* in the warmer portions of the province, such as the Niagara-Burlington districts and the counties bordering Lakes Erie and St. Clair and the Detroit River; *about July 1st* in moderately warm sections, such as most of the remaining counties west of Toronto and those along Lake Ontario as far east as Lennox and Addington; *about July 7th* in the counties farther north and east. In a cold, backward season this application should be put on one week later than the dates specified.

The second application should be given as soon as the first shows signs of disappearing, usually this will be about three weeks later. It must be borne in mind that the flies continue to emerge for about seven weeks, and that it is therefore essential to have poison on the trees for that length of time. In wet weather this may mean one or more extra applications.

Every application should be fairly heavy, and all trees in and around the orchard, except those with fruit nearly ripe, should be sprayed.

All useless seedling apple trees and hawthorns should be cut down.

THE APPLE MAGGOT.

(*Rhagoletis pomonella Walsh.*)

From time to time the Apple Maggot or, as many fruit-growers call it, the Railroad Worm, has appeared in large numbers in various parts of Ontario. In some orchards it has destroyed the entire crop and in others a large percentage of it. Such attacks have caused great anxiety not only to those whose orchards were infested, but also to all the fruit-growers who heard of the damage the insect had done, and who feared that it might spread to their orchards. Their fears were increased by learning that there was no known practicable remedy for the insect in large commercial orchards, the old remedy of gathering and destroying the fruit being considered impracticable except in small orchards.

In 1909 and 1910 the Apple Maggot was abundant in a number of localities east of Toronto. In the latter year the senior author visited these localities, saw the extent of the injury, learned of the fears of the fruit-growers, not only in the immediate vicinity but also many miles away, and then brought the matter to the attention of the Provincial Fruit Branch in Toronto. The result was that he was authorized to begin a study of the insect with the object of finding, if possible, a satisfactory method of control.

The first year of the investigation the junior author acted as an assistant, but after that year became a full partner in the investigation, in which henceforth he represented the Dominion Entomological Branch, to which he had been appointed at the end of the first year's work. Hence since 1911 the study of the insect and its control has been carried on as a joint enterprise of the Dominion and Provincial Departments of Agriculture.

Most of the life-history work was done during the years 1912 and 1913, after which time it was abruptly ended by the almost total disappearance through natural factors of the insects in the orchard in which the investigation was being carried on. However, every year since then observations and some further study have been made in various orchards. Infested orchards have also been found each year on which control measures have been tested.

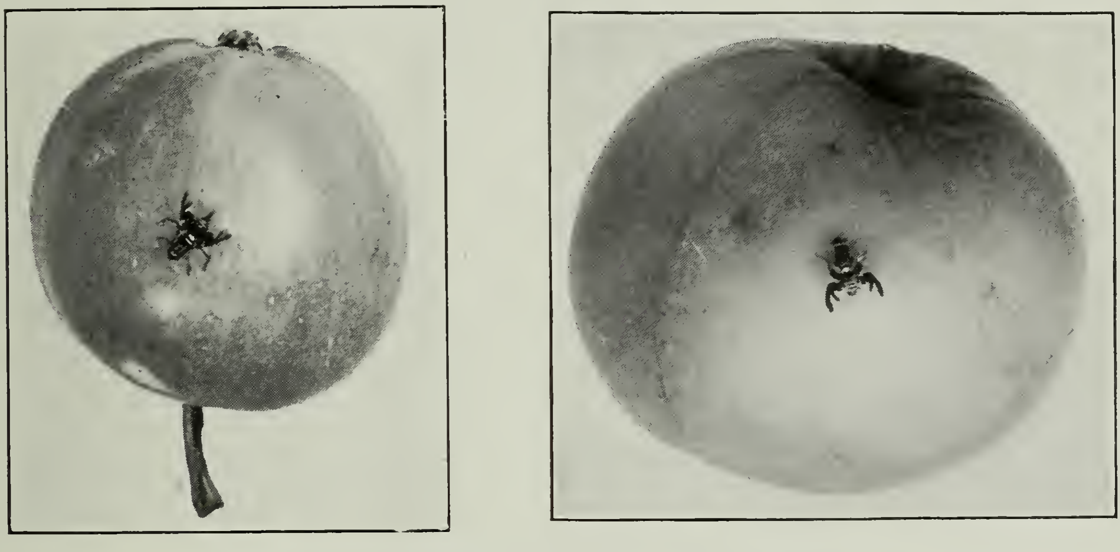


Fig. 2.—Apple Maggot adults on fruit, natural size.

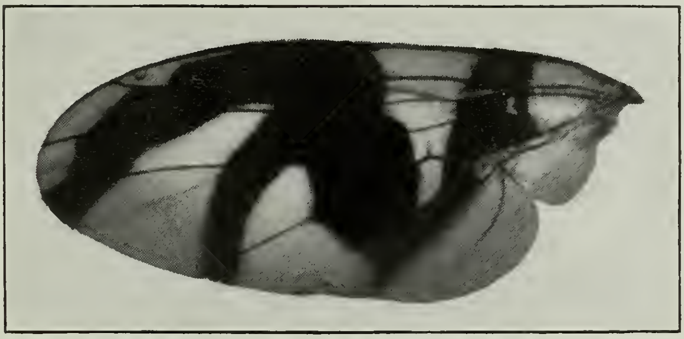


Fig. 3.—Wing of Apple Maggot adult, enlarged about twelve times.

The main object in view in beginning the investigation—the finding of a satisfactory method of control—has been attained. The additional object, to work out the life-history of the insect, has been largely accomplished, though there are several points, some of them of much importance, on which definite knowledge is still lacking. It is hoped that as soon as a favorable opportunity presents itself these points may be cleared up.

Fig. 4.—Larva of Apple Maggot, much enlarged, lateral view.

Description of the Insect.

The Apple Maggot is the larva or maggot of a pretty two-winged fly, a little smaller than the house-fly. The general color of the fly is black, but the eyes,

Fig. 5.—Pupa of Apple Maggot, much enlarged.

when the light shines on them, are a beautiful golden green, and the head and lower part of the legs are yellow. The abdomen of the female is crossed by four broad white bands and that of the male by three. Near the middle of the back there is a small, distinct, white, somewhat triangular area, and a white stripe runs along each side of the thorax from the base of the wings to the head. The wings have conspicuous dark brown markings or bands arranged as shown in Fig. 3. The arrangement of these markings makes it easy to distinguish this species from closely allied species like the two Cherry Fruit-flies.

The larva when full grown is a small, legless, nearly cylindrical, white maggot, about one-quarter of an inch long. One end of the body is blunt and the other pointed. There is no visible head, but at the smaller end there are two little black hooks which are used to rasp and tear the pulp of the fruit and free the juices,

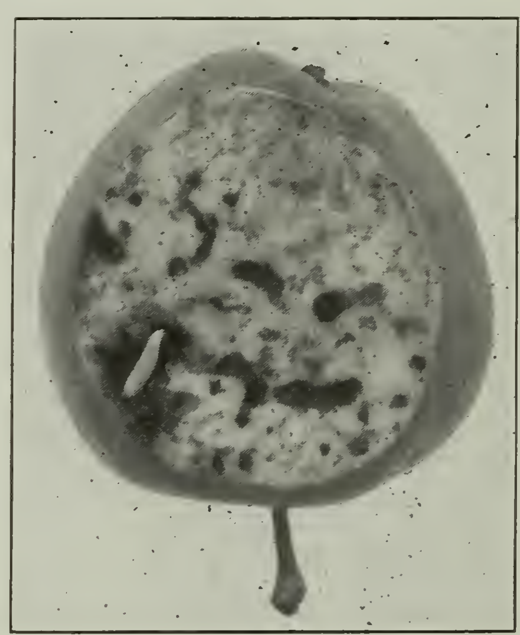


Fig. 6.—Section through an infested apple, showing a full grown larva, natural size.

which are then absorbed through a small opening close to the hooks. (See Figs. 4 and 6.) The larvæ are very small and hard to find in the apple until it is ripe. Then they grow quickly, and when the apples are mellow or over-ripe they can be found with ease in the broken down and decaying tissues.

How to Recognize the Work of the Apple Maggot.

To determine whether an apple is infested by the Apple Maggot, cut it through with a knife and observe whether there are little, brown, irregular areas and streaks here and there throughout the flesh, as shown in Fig. 7. If these are

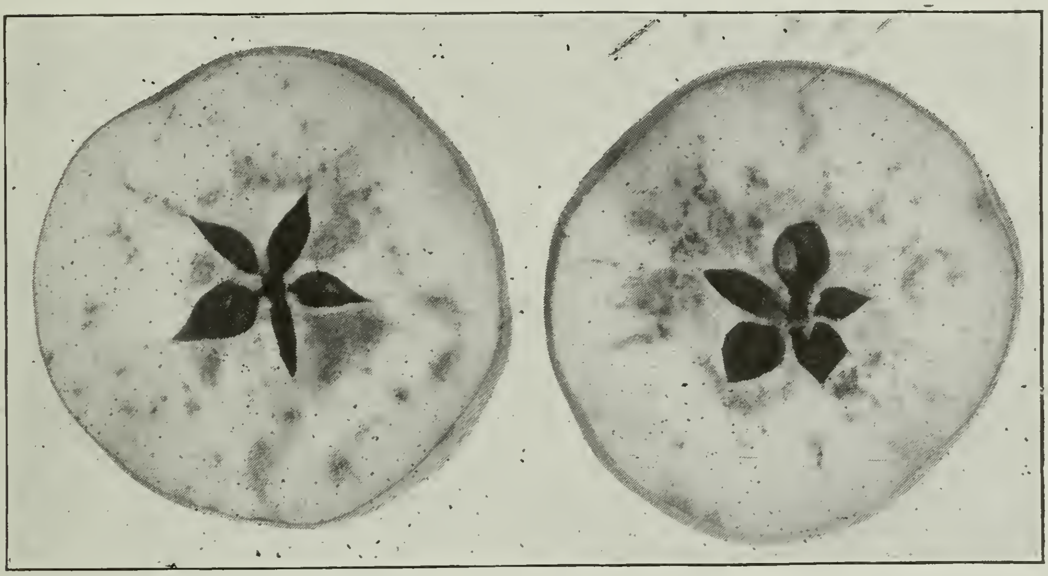


Fig. 7.—Cross-section of apples showing the work of the Apple Maggot before the apples are ripe.

present the probability is that the apple is infested, the brown areas or streaks being due to the killing of the tissues by the maggots as they work in various directions. There is a possibility, however, that the browning may be due to the disease known as Bitter Pit, Stippen or Internal Dry Rot. This common disease may show on the surface of the fruit as small pits or sunken areas, usually about one-eighth of an inch in diameter. Often, however, there is little or no evidence of the disease on the surface, but when the fruit is cut open many brown, dead areas will be found in the flesh. These are arranged usually in a much more regular manner than the brown areas caused by the Apple Maggot, and are as a rule more uniform in shape and size, being frequently about one-tenth of an inch in diameter and nearly circular. Sometimes, however, they vary much in size and shape. (See Figs. 8 and 9.)

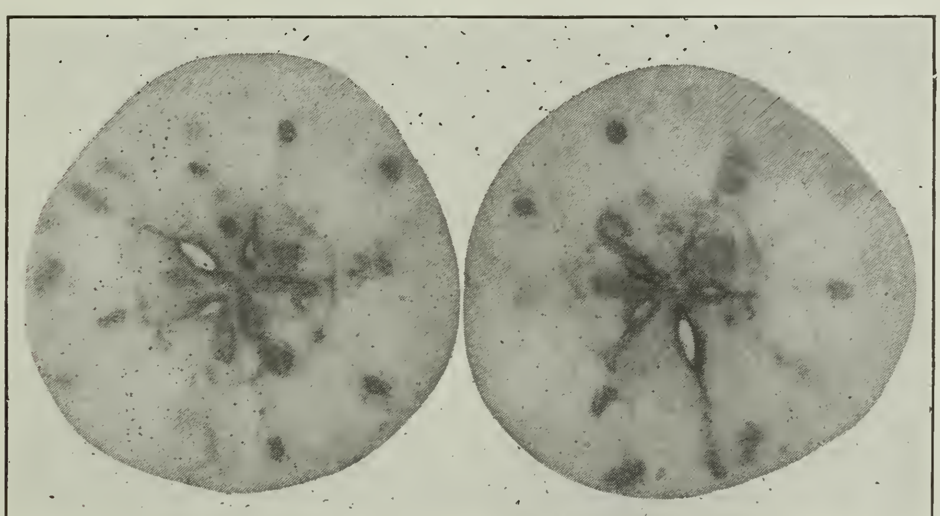


Fig. 8.—Cross-section of apple showing dead areas due to the Bitter Pit disease.

A simple method of determining definitely whether the browning of the inner tissues is due to the Apple Maggot or to the Bitter Pit or Dry Rot disease is to examine the surface of the fruit for evidences of the egg punctures made by the adults of the Apple Maggot. If these are present it is clear evidence that the apple is infested by the insect; if they are not present the trouble is due to Bitter Pit

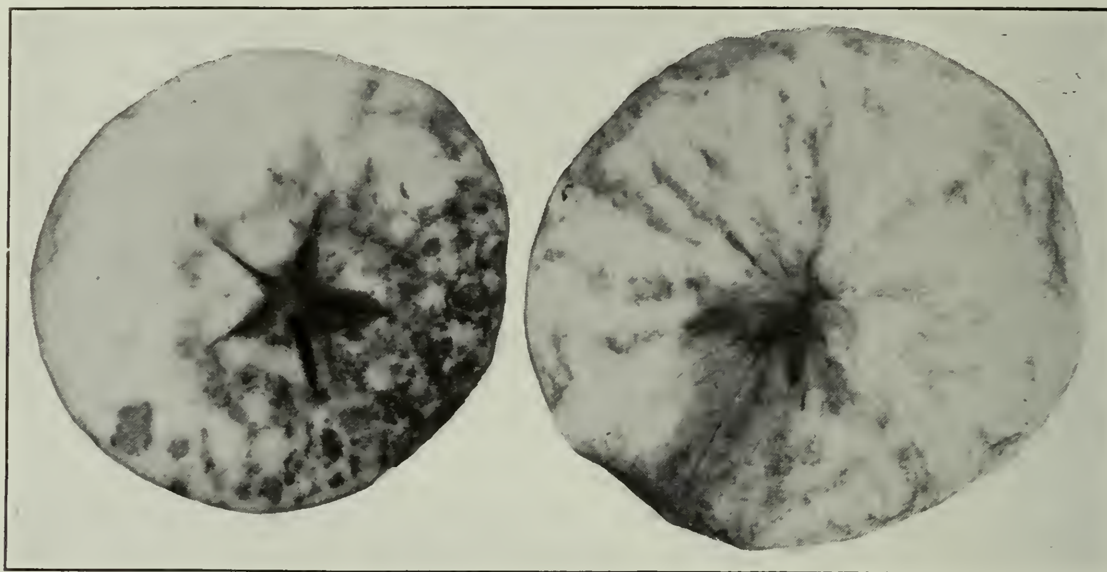


Fig. 9.—Cross-section of apples showing a different form from Fig. 8 of injury due to Bitter Pit disease.

Fig. 10.—Apple showing egg-punctures of the Apple Maggot in apples, natural size.

or Internal Dry Rot. Egg punctures are almost always easily seen even with the naked eye. (See Figs. 10 and 11.) They show as small, brownish, circular spots, about the diameter of an ordinary pin, and are usually, though not always, situated in little depressions caused by the tissues injured by the ovipositor not growing while those around them continue to grow. Sometimes a little white waxy substance forms over the puncture and conceals the brown colour.

The presence, therefore, of egg punctures and browned dry tissues within the fruit is clear proof of Apple Maggot infestation.

Fig. 11.—Apples showing egg-punctures and accompanying depressions, slightly reduced in size.

Brief History.

The Apple Maggot is by no means a new pest either in Canada or the United States. There are records of its presence in the United States more than fifty years ago, and in Ontario for more than thirty years. There seems to be no doubt that it existed in both Canada and the United States long before these dates, in fact the evidence strongly indicates that it is a native North American insect, and that before apples were introduced it probably bred in haws, later on acquiring the habit of attacking apples. Though present for so long a time it was not described or given its scientific name until the year 1867, when this was done in the United States by Walsh. In Ontario the late Dominion Entomologist, Dr. James Fletcher, reared it from haws in 1887, and since 1896 it has been reported from time to time in the province as an enemy of the apple. In the provinces of Quebec, New Brunswick and Nova Scotia the insect has doubtless attacked apples for many years, but definite records of its work do not go back in Quebec more than about twenty years, and in the other two not even that long.

Further information on the history of the insect in North America may be obtained from Bulletin 171, Agricultural Experiment Station, Durham, New Hampshire.

Present Distribution in the Province.

When this investigation was begun, it was supposed that the Apple Maggot occurred only in a few localities in three or four counties of the province, and was, therefore, a very local pest. The writers, however, largely as a result of their own observations have found it to be present in the following counties:—Carleton, Dundas, Grenville, Leeds, Lennox and Addington, Hastings, Prince Edward, Northumberland, Durham, Ontario, York, Peel, Wentworth, Lincoln, Welland, Norfolk, Kent, Essex, Lambton, Middlesex, Brant, and Wellington. These counties extend from the Ottawa River on the east to Lake Huron and the Detroit River on the west. The other counties have not to any appreciable extent been inspected, but it is reasonable to assume that since the insect has been found in so many counties it probably occurs in every county where apples are grown. Its range is, therefore, wide. Fortunately, the total number of orchards infested is small, probably less than 5 p.c. in any county, and much less than 1 p.c. in the province as a whole. In fact, in several counties the insect was found only in apples growing in towns and villages, places where the conditions seem to be specially favorable for its existence.

Food Plants.

In Ontario the Apple Maggot has been found infesting only the fruit of apples, crab apples, and a few of the many species of haws. In parts of the United States* a fruit fly seemingly identical with it except in being smaller has been bred from huckleberries and blueberries. In British Columbia† a similar insect is common in the fruit of snowberry. However, as neither of these insects, according to present knowledge, will breed in apple, there is some doubt as to whether they are really the same species as the Apple Maggot. This doubt is strengthened by the fact that the adults of the blueberry-huckleberry form and of the snowberry insect are very timid and difficult to capture even with a net, whereas the adults of the apple species are sluggish and may be readily captured with a cyanide bottle without the aid of a net.

Comparative Degree of Susceptibility to Attack of the Different Varieties of Apples and Crabs.

Any person who examines a moderately-infested orchard will readily discover that some varieties of apples are much worse attacked by the Apple Maggot than others. This is so commonly true that those who are familiar with the insect's habits, when seeking to discover whether it is present in any particular orchard, always ask to be shown certain varieties such as Early Harvest, Sweet Bough, Gravenstein, Snow, Wealthy, Alexander, Tolman or Spy, because they know that these are among the insect's favorites, and that if it is in the orchard at all it will be found on some of these.

In seasons when there is not a great number of flies these or other favorite varieties may be the only ones attacked, or the only ones at all severely attacked, but in seasons when the flies are very abundant almost every variety will have many apples infested, while not a single fruit may escape on the favorite varieties. The only varieties that have been exempt from attack in the orchards under observation were the Arctic and Stone, but as these were found only in moderately-infested orchards it is no proof that in the case of a badly-infested orchard they would escape.

It is worth mentioning that in the early part of the season the insects usually confine their attention to their favourite earlier varieties; then as the season advances and these become nearly ripe, they attack the later ones. For instance, a Snow apple and an unnamed early fall apple were situated side by side. At first the fruit on the Snow was uninfested, whereas the flies were readily observed ovipositing on the fruit of the other tree and numerous egg punctures could be seen. A week or two later the flies became common on the Snow fruit and it became just as badly punctured as the other, almost every apple being attacked. Tolman Sweet is a variety very subject to attack, yet many eggs will be laid in early varieties before oviposition begins on it.

The following table gives the result of the writers' observations upon the degree to which the different varieties of apples and crabs are subject to attack. It does not include all varieties grown in Ontario, but only those found in the orchards studied.

*Woods, W. C.—Maine Agr. Exp. Sta. Bul. 244, pp. 252-266.
†Downes, W.—Can. Ent., Vol. LI, No. 1, pp. 2-4, Jan., 1919

TABLE I.—SHOWING THE DEGREE OF SUSCEPTIBILITY TO ATTACK OF THE VARIOUS VARIETIES OF APPLES AND CRABS.

Alexander—Moderately susceptible.
Astrachan.—Slightly susceptible.
Arctic—Very slightly, if at all, susceptible.
Baldwin—Slightly susceptible.
Baxter—Slightly susceptible.
Ben Davis—Moderately susceptible.
Blenheim—Slightly susceptible.
Brockville—Slightly susceptible.
Cayuga—Moderately susceptible.
Colvert—Moderately susceptible.
Cooper's Market—Moderately susceptible.
Cranberry Pippin—Moderately susceptible.
Duchess—Slightly susceptible.
Early Harvest—Very susceptible; one of the worst attacked.
Gideon—Moderately susceptible.
Golden Russet—Slightly susceptible.
Haas—Moderately susceptible.
Holland Pippin—Slightly susceptible.
Hurlburt—Slightly susceptible.
Hyslop Crab—Moderately susceptible.
Jennetting—Moderately susceptible.
King—Slightly susceptible.
Maiden's Blush—Moderately susceptible.
Mann—Very slightly susceptible.
McIntosh—Slightly to moderately susceptible.
Pewaukee—Slightly susceptible.
Phœnix—Moderately susceptible.
R.I. Greening—Moderately susceptible.
September Sweet—Very susceptible; one of the worst.
Snow—Very susceptible; one of the worst.
Spy—Very susceptible.
Stark—Slightly susceptible.
St. Lawrence—Moderately susceptible.
Stone—Apparently immune.
Strawberry Seedling—Very susceptible; one of the worst.
Sweet Bough—Very susceptible.
Tolman—Very susceptible; one of the worst.
Transcendent Crab—Very susceptible.
Wagner—Moderately susceptible.
Wealthy—Very susceptible; one of the worst.
Whitney Crab—Moderately susceptible.
Wolf River—Very slightly susceptible.
Yellow Bellflower—Moderately susceptible.
Yellow Transparent—Slightly susceptible.

Exceptions.

In most districts natural fruit or seedling trees are to be found and where these occur in an infested orchard they almost without exception are severely attacked.

Some of the varieties classed above as only slightly or moderately susceptible are sometimes under exceptional circumstances, such as the absence of other more susceptible varieties, severely attacked. For instance, Duchess is usually but little infested, yet at Lyn, Leeds County, a crop of Duchess was in 1915 almost totally ruined by the Apple Maggot. In this case the explanation seemed to be that the flies had almost no option but to attack this variety.

Nature of the Injury and Economic Importance of the Insect.

A brief account of the nature of the injury done by this pest has already been given under the heading "How to Recognize the Work of the Apple Maggot," but fuller details are desirable.

The female fly lays her eggs in the fruit after first piercing the skin with her sharp sting-like ovipositor. (See Fig. 12.) The egg is placed in the pulp a little below the surface. After hatching the larvæ begin to work their way here and there through the flesh, tearing the tissues with their hooks as they go and absorbing the juice thus liberated. The injured tissues die and turn brown, thus

Fig. 12.—Abdomen of female showing the ovipositor protruded (much enlarged).

leaving a trail wherever the larvæ go. There may be as many as forty or fifty eggs laid in a single apple, hence many brown trails may be found crossing and recrossing each other. Thus a large proportion of the cells of the apple may be drained of their juices and become brown and tough in texture. Such apples are often spoken of as "woody" and are not fit for sale or even for home use. They are likewise not good for canning or evaporating.

So long as the apple is firm and not ripe the maggots remain small and the interior of the apple does not collapse, but from the time the fruit begins to ripen

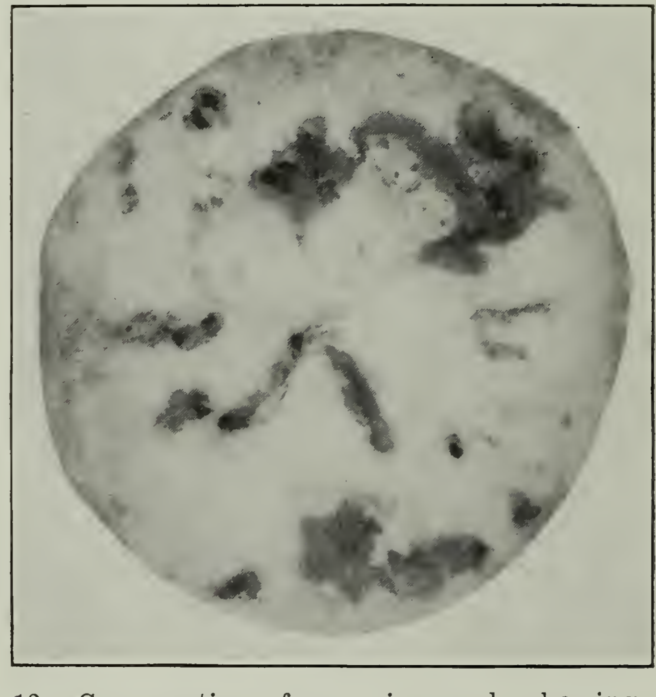


Fig. 13.—Cross-section of over-ripe apple showing the way the maggots often break down the tissues.

until it is over-ripe the maggots grow rapidly, probably because of the plentiful supply of sugar now available. They then soon destroy so much of the pulp that large collapsed areas here and there may be seen in it when cut open; in fact, in some cases almost the whole interior may become a broken down, unsightly, rotting mass. (See Fig. 13.) Most apples would of course be marketed before this state

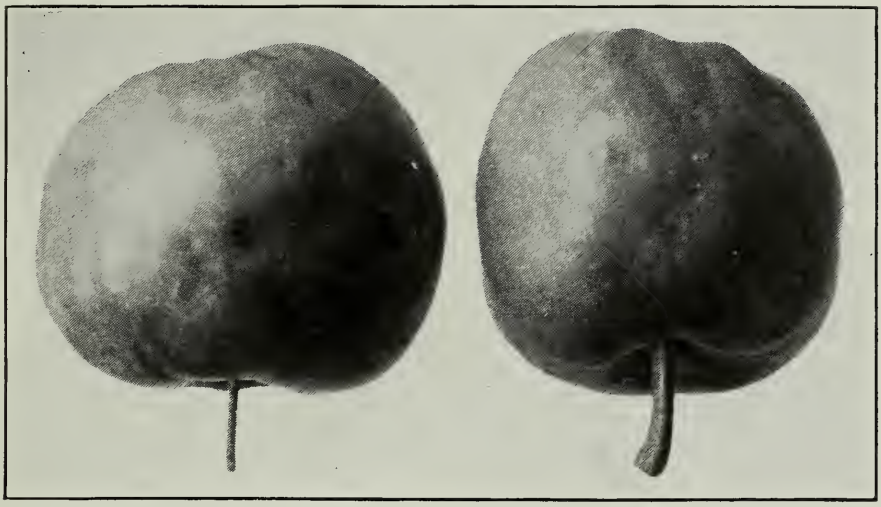


Fig. 14.—"Knobby" apples, malformations due to the work of the Apple Maggot.

of affairs had ensued; nevertheless the process would continue in the marketed fruit, and the purchaser would be disappointed and disgusted when he came to use the apples.

As to the effect upon the exterior of the apple, most varieties that have many egg punctures soon become noticeably deformed as a result of the numerous sunken areas, brought about partly by each egg puncture checking growth wherever it occurred and partly by the maggots at times working near the surface, killing the tissues below the skin and preventing the proper, uniform development of the fruit at such places. These badly-deformed apples are sometimes spoken of as "knobby." (See Fig. 14.)

A third injury is caused by the tendency of many infested varieties of apples to drop prematurely. This is a common occurrence and has been noted especially in the case of Alexander, Wealthy, Snow, Spy and Cayuga.

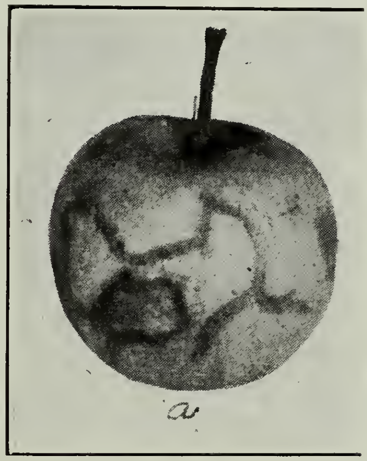


Fig. 15.—Apple showing the tunnels of larvæ close to the skin.

Inasmuch as whole orchards may have almost every apple badly infested and ruined, it is clear that the Apple Maggot is capable of causing great losses, and were it commonly distributed in all orchards of the province as the Codling Moth is it would rank as the worst of apple insects. Fortunately, as has already been shown it is not found in most orchards in any county, and in fact very seldom in as many as 5 per cent. of the orchards of any one county. In many counties it seems to be restricted almost entirely to villages and towns, often, however, doing much damage in these. In no one orchard is it equally abundant every year; some years it almost disappears, but a few years later becomes numerous again.

In concluding this aspect of the subject, it may be said that if for any reason the orchards in any part of the province where the insect is now at all common were to become neglected or left unsprayed, there is good reason to believe that the insect would gradually spread through these and in years favourable for its development destroy great quantities of fruit.

LIFE-HISTORY.

The Apple Maggot like other two-winged flies goes through four stages in its life-history, namely, the adult or fly, the egg, the larva or maggot and the pupa. These will each be discussed now in turn.

The Adult.

Time of Earliest Emergence.—The time at which the first flies appear in the orchard depends chiefly upon climate, though moisture may play some part. In the warmer parts of Ontario the flies begin to appear earlier than in the colder parts, and in any particular locality they appear earlier in a warm season, especially if June has been warm, than in a cold season.

In cages at Bowmanville in 1911 the first fly emerged on July 10th, in 1912 on July 6th and in 1913 on July 7th. In 1913, however, flies had emerged at Bowmanville in a village orchard earlier than July 6th, for several egg punctures were found on July 9th and several of the eggs laid had hatched. Therefore, allowing five days at least from emergence to oviposition and five days for the eggs to hatch, emergence must have taken place as early as June 30th and probably a few days earlier.

In 1914 daily inspections of an orchard in Dundas County were made and the first two flies were seen emerging from beneath a heap of decayed apples on July 10th, though no flies were observed on the trees till July 14th. At Vineland, Niagara district, in the same year they began emerging on July 2nd.

In 1915 the first flies were seen at Simcoe in Norfolk County on July 6th. Daily observations had also been made in the orchard here before this date.

In 1916 in Leeds County, on July 18th, ten flies were found and about thirty egg punctures. These flies must have emerged by July 8th, and probably a few days earlier.

In 1917 in Leeds County, in this same locality the date of emergence must have been later than in 1916, because no flies could be found on July 14th or 15th, though they appeared later. The date was not determined because the writers could not remain longer in the district.

In 1918 at Belleville four flies, but no egg punctures, were found on July 10th, and at Brighton the first fly was seen on July 13th. Careful daily searches had been made in the orchard at the latter place for a week or more before this date.

The above data would lead to the belief that in an average year the flies begin to emerge about the first week in July. We believe, however, from the fact that at Bowmanville in 1913 several flies had evidently emerged the last week in June, and that in 1914 they began emerging eight days earlier in the Niagara district than in Dundas County, we are justified in assuming that in the warmer parts of the Province such as the counties in the Niagara district and along Lake Erie, emergence regularly begins in a warm season about June 25th, along the north shore of Lake Ontario about July 1st, and further east and north about July 7th. In a cold season these respective dates would each be about a week later. In any season we should expect the flies to emerge a little earlier in a sunny, sheltered orchard than in an exposed one. It is interesting to learn that in Nova Scotia with its more backward spring the flies do not begin to emerge until about a month later than in Ontario.

TABLE 2.—SHOWING DATES OF EMERGENCE OF APPLE MAGGOT ADULTS AT BOWMANVILLE, 1912.

Daily Emergence.		Daily Emergence.	
Date	Number	Date	Number
July 6	1	August 1	14
" 7	3	" 2	14
" 8	8	" 3	10
" 9	11	" 4	9
" 10	33	" 5	14
" 11	53	" 6	12
" 12	55	" 7	5
" 13	37	" 8	5
" 14	53	" 9	5
" 15	22	" 10	1
" 16	26	" 11	3
" 17	26	" 12	2
" 18	30	" 13	0
" 19	24	" 14	1
" 20	32	" 15	1
" 21	36	" 16	0
" 22	21	" 17	2
" 23	34	" 18	0
" 24	16	" 19	3
" 25	16	" 20	2
" 26	44		
" 27	44		
" 28	30		
" 29	23		
" 30	32		
" 31	17		
			Total 830

SUMMARY OF TABLE 2.

1st week, July 6—July 12, 164 adults or 19.7%
2nd week, July 13—July 19, 218 adults or 26.2%
3rd week, July 20—July 26, 199 adults or 23.9%
4th week, July 27—Aug. 2, 174 adults or 20.9%
5th week, Aug. 3—Aug. 9, 60 adults or 7.2%
6th week, Aug. 10—Aug. 16, 8 adults or .96%
7th week, Aug. 17—Aug. 20, 7 adults or .84%

TABLE 3.—SHOWING DATES OF EMERGENCE OF APPLE MAGGOT ADULTS AT BOWMANVILLE, 1913.

Daily Emergence,		Daily Emergence.	
Date	Number	Date	Number
July 7	1	August 1	8
" 8	0	" 2	21
" 9	0	" 3	2
" 10	2	" 4	8
" 11	0	" 5	8
" 12	0	" 6	3
" 13	0	" 7	5
" 14	2	" 8	3
" 15	0	" 9	0
" 16	4	" 10	0
" 17	4	" 11	4
" 18	8	" 12	4
" 19	5	" 13	1
" 20	7	" 14	0
" 21	17	" 15	5
" 22	13	" 16	4
" 23	6	" 17	1
" 24	19	" 18	1
" 25	16	" 19	1
" 26	34	" 20	0
" 27	14	" 21	0
" 28	18	" 22	4
" 29	16	" 23	1
" 30	18	" 24	0
" 31	21	" 25	0
		" 26	0
		" 27	1
		" 28	0
		" 29	1
			Total 311

SUMMARY OF TABLE 3.

1st week,	July 7—July 13,	3 adults or	.96%
2nd week,	July 14—July 20,	30 adults or	9.6%
3rd week,	July 21—July 27,	119 adults or	38.2%
4th week,	July 28—Aug. 3,	104 adults or	33.4%
5th week,	Aug. 4—Aug. 10,	27 adults or	8.6%
6th week,	Aug. 11—Aug. 17,	19 adults or	6.1%
7th week,	Aug. 18—Aug. 24,	7 adults or	2.2%
8th week,	Aug. 25—Aug. 29,	2 adults or	.64%

Emergence for the first few days as seen in the tables and observed in the various orchards is slow, especially if the weather is cool, but it soon accelerates and in a week or so numerous flies may be seen on the trees if the year is to be one of bad infestation.

Time of Maximum Emergence.

An examination of Tables 2 and 3 shows that the vast majority of the flies emerged during the last three weeks in July. Observations in the orchards indicate that the flies are present in greatest numbers the latter part of July and the first two weeks in August.

Time of the Disappearance of the Flies from the Orchard.

The tables show that adults may continue to emerge up to almost the end of August; however, the percentage of those emerging after the first week in August is small and by the 20th of that month the number of individuals to be found on the trees diminishes quickly. By the end of August they have often totally disappeared. Some years, however, they continue to be found in small numbers up to the middle of September.

The following data have been obtained on the date of disappearance. In 1911 at Bowmanville all had gone by August 27th, and in 1915 at Simcoe by August 31st.

In 1912 a few flies were found at Bowmanville up to September 15th and in 1917 at Stoney Creek (Niagara district) up to September 17th. Accurate data have not been obtained for the other years.

Length of Life of the Flies.

In cages well protected from excessive heat, three individuals (one male and two females) were kept alive for over five weeks, and a single female for forty-six days, or six weeks and four days. The great majority, however, of the many flies used in the experiments died much earlier. Some writers suppose that because flies do not act normally in cages they therefore live longer in the open and that under normal conditions in the orchard they probably live for at least five weeks. This is very doubtful, because, as shown in tables 2 and 3, large numbers of flies emerge the last week of July, and yet in the orchard it is not unusual to find all the flies gone by August 31st. It would therefore seem justifiable from the tables and the information given above on the date of disappearance to suppose that the average length of life was not much more than three weeks, though some individuals may live a good deal longer. It is likely that some years many flies die in times of drought from lack of moisture just as they do in cages. It is also likely that chilly nights towards the end of August kill many.

Proportion of Males to Females.

In rearing cages the number of males compared with females was as follows:—

	Males.	Females.
In 1912	292	538
In 1913	85	226
In 1914	44	76
Totals	421	840

This shows that almost twice as many females as males emerged from the cages. Yet in the orchard on almost every occasion each year the males appeared to be more numerous than the females, the proportion often being as high as four males to one female. The explanation of these conflicting facts has not been found.

Habits of the Adults.

In an infested orchard the flies may readily be observed on the leaves and fruit. They are sluggish, much more so than most species of flies. This characteristic is more pronounced during cool weather and in the early morning. In the warm part of the day they are as a rule most in evidence and most active, and as might be expected usually prefer the sunny side of the tree. Here, when not feeding, the majority may, especially in hot weather, be found resting on the under surface of the leaves. This is also a common place of refuge during rain.

The feeding habits of the flies have given the clue to the only satisfactory method of control; hence a knowledge of the structure of the mouth parts and of the feeding habits is important. The mouth parts resemble those of the common house-fly. Fig. 16 shows their general appearance when protruded as in search of food. When not feeding they are usually withdrawn into a fold in the head where they are more or less concealed. At the outer extremity there is, as shown

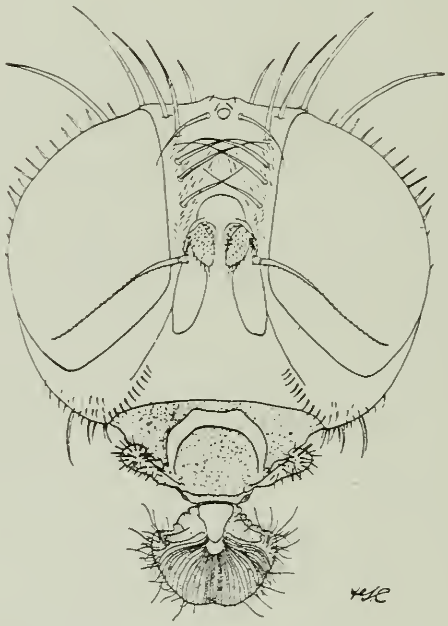


Fig. 16.—Head of Apple Maggot adult, showing mouth parts protruded, greatly enlarged. Observe the large lip-like structure and the row of rasps on its surface.

in the figure, a broad structure which when closely examined resembles a pair of lips, and can be opened or closed like lips. On the lower or feeding surface of these lips, are numerous rasping structures which are used with the assistance of a salivary secretion to help in breaking down and dissolving solid substances; for solids cannot be fed upon until they are either dissolved or broken up into such minute particles that they can be sucked in along with the liquid.

Feeding commences soon after emergence and continues as long as flies are present in the orchard. Freshly emerged adults placed in vials invariably applied their mouth parts to the sides and lapped up the moisture adhering to the glass. On the trees individuals when not resting may be observed numerous times in the day moving about over the leaves and fruit with their mouth parts applied to the surface in search of food. We have observed them feeding upon water, aphis honey-dew, apple juice, sweetened and non-sweetened liquid poisons, also upon dry arsenate of lead, whether sweetened or not. Our observations indicate that they will attempt to feed upon almost any substance, whether liquid or solid, which they find upon the surface of the foliage or fruit and that there is no evidence that they are attracted to any particular substance or bait.

Length of Time From Emergence Until Eggs are Laid, or Preoviposition Period.

When the flies emerge the eggs in their ovaries, as shown by dissections, are in a very immature stage and a number of days are required to elapse before egg-laying can begin. How long this period is has not been definitely determined nor has any satisfactory method of discovering it been found. Large numbers of newly emerged flies were confined in various kinds of cages but only three individuals laid eggs. In two of these instances the preoviposition period was thirteen and fourteen days respectively and in the third twenty-four days. Several females were observed making futile attempts to oviposit when they were from eleven to sixteen days old.

The foregoing data would indicate that probably eleven days was the minimum period, but it would not be safe to consider that this was correct, because flies do not act normally in cages. O'Kane in New Hampshire and Brittain in Nova Scotia found that in a few cases, but only in a very few, flies in cages oviposited in less than a week. Our observations in the orchard would lead us to believe that in the case of some individuals at least the period may not be longer than a week and possibly shorter.

Egg-laying Habits.

The female fly has a sharp, sting-like ovipositor, as shown in Fig. 12. When ready to oviposit she raises herself on her legs, bends the abdomen at almost a right angle and gradually by repeated thrusts forces the ovipositor through the skin of the apple into the pulp beneath. The egg is then passed down and deposited a short distance below the skin. The whole operation takes from thirty seconds to seven minutes with an average of about one and a half minutes. Once the ovipositor has been withdrawn it is carefully cleaned or brushed by the hind legs.

A fly has been observed to deposit several eggs in half an hour, but the total number of eggs laid by any one fly during her life has not been determined. An examination of the ovaries shows that each female is potentially capable of laying several hundred eggs.

Many eggs may be laid in a single apple. In one case ninety-three egg punctures were found in a Snow, and in six Snow apples on the same tree a total of three hundred and ninety-three egg punctures.

Flies sometimes go through all the actions of ovipositing without any eggs being laid. The total percentage of such eggless punctures is not easy to determine accurately, but is apparently small.

The Egg.

Description.—The eggs are very small, white or cream in colour. nearly elliptical in shape and almost four times as long as wide. Being situated in the pulp beneath the skin they can be seen only by dissecting them out.

Length of Incubation Period.

The length of this period was determined for fifteen eggs. Seven of these required five days each to hatch; four, six days; two, seven days; one eight and one nine. The larger number therefore hatched in five days, but the average was six days. These determinations were made during the month of August in 1912.

Mortality of Eggs.

By the examination of a large number of egg punctures it was found that eggs had hatched in an average of 78.7 per cent. of these. The remaining 21.3 per cent. represent eggs that for any reason, such as infertility, failed to hatch and also punctures made without any eggs being laid. As the percentage of the latter was difficult to determine accurately no attempt was made to separate the two.

TABLE 4.—SHOWING THE PERCENTAGE OF EGG PUNCTURES IN WHICH THE EGGS HATCHED AND THE PERCENTAGE MORTALITY.

Variety	No. of Egg Punctures	No. of Eggs Hatched	Percentage Hatched	Percentage Mortality
September Sweet....................	947	778	82.2	17.8
Snow	660	420	63.7	36.3
Spy................................	503	439	87.3	12.7
Seedling	237	209	88.2	11.8
Total	2347	1846	Average 78.7	Average 21.3

The Larva.

Description.—The larva is maggot-like and when full grown about a quarter of an inch long, white in colour, roughly speaking cylindrical, blunt at one end, and tapering towards the other. It has no legs and no distinct head. Two little black hooks at the small end act as jaws and tear the tissues of the pulp, thus releasing the juice, which is then absorbed through the inconspicuous mouth. Though legless the larva can move about slowly, both inside the fruit and on the soil after emerging.

Larvæ are hard to see in the fruit until it is very ripe, because they remain small so long as the fruit is immature, but develop rapidly after it has ripened.

Length of Larval Life.

The length of larval life varies greatly because it depends entirely upon the fruit itself; since the larvæ never mature no matter how long they are in the apples until these are ripe, or more correctly mellow and often beginning to break down. Hence in harvest apples the larval life may be not more than about three weeks, whereas in winter apples such as Spy it may be more than two months.

Mortality of Eggs and Larvæ Combined.

We have already pointed out that not all of the eggs which are laid hatch: nor do all the larvæ hatched from the eggs reach maturity. The total percentage of mortality in both stages is high, and in the case of infested winter varieties may be as high as 100 per cent. The data presented in Table No. 5 indicates that the early varieties of apples lend themselves particularly well to the breeding and multiplication of this insect and that in winter varieties only a small number of maggots survive.

TABLE 5.—SHOWING THE PERCENTAGE OF MORTALITY OF EGGS AND LARVAE COMBINED IN 1912 AND 1913.

Variety	Date Apple Dropped	No, of Apples	No. of Punctures	No. of Larvae Emerged	Percentage Mortality
1912					
Harvest	Aug, 15	32	242	52	78.5
Early Seedling	" 15	15	300	26	91.4
September Sweet	Sept. 7	17	960	114	88.1
Spy	" 13	23	147	2	98.6
Snow	" 13	24	190	6	96.8
Spy	Oct. 5	many	many	0	100
Tolman	Sept. 18	26	many	0	100
Tolman	....	many	many	0	100
1913					
Harvest	Aug. 11	99	192	70	63.5
Early Seedling	" 22	64	175	83	52.5
Tolman	Sept. 13	54	208	3	98.5
Snow	Aug. 25	73	344	172	50.0
Snow	Sept. 11	87	478	92	80.8

Number of Larvæ per Apple.

The greatest number of larvæ obtained from a single badly infested fruit was 12. From twenty-two apples of the September Sweet variety 207 larvæ were

Fig. 17.—Apple showing many egg-punctures and three exit holes, the latter being each several times larger than any of the former.

reared, or an average of 9.4 per apple. It is seldom, however, that the number reaches nearly so high as this, and in winter varieties, as shown above, it is very small.

Emergence of Larvæ from the Fruit.

When the larvæ are full grown they make a hole in the skin of the fruit and work their way out through it. (See Fig. 17.) By this time the fruit has almost always fallen. Occasionally a few apples hang on the trees and rot, and any larvæ in them simply come out and drop to the ground. Once out of the apples the larvæ seek a suitable place to pupate.

The Pupa.

The larva or maggot of many species of two-winged flies when full grown and ready to pupate contracts the larval skin into an oblong or barrel-shaped case called a puparium and later within this case changes to a true pupa. Fruit growers, however, never see this real pupa and always speak of the puparium as the pupa. For the sake of simplicity it seems advisable to follow this custom and to use the term pupa to include both the puparium and the real pupa within it.

The larvæ of the Apple Maggot usually pupates within twenty-four hours after leaving the fruit. The pupa in size and shape resembles a small plump grain of wheat. At first it is golden-brown in colour but becomes darker with age. (See Fig. 5.)

Where the Pupæ are Found.

A few pupæ may be found within rotting fruit, especially crab apples; a large number occurs just below rotting apples, especially if these are in a heap; but the vast majority are within the soil itself and at an average depth of between one and two inches. A considerable number are sometimes in the third inch, but very few out of the hundreds examined in various soils were deeper than this. In grass or sod they are not, as a rule, found quite so deep as in cultivated, loose soil. If the soil is hard they may often be found on the surface hidden around the crown of the grass or other plants.

Duration of the Pupal Stage.

All the pupæ remain in the various situations mentioned here, unless destroyed in some way, until the following summer. Then by far the greater number of them transform and emerge as flies. The remainder stay in the soil as pupæ all that season and the following winter, and the second summer at the usual time emerge as adults, thus making a two year life cycle for these instead of the more common one year life cycle.

Data on the Two Year Life Cycle.

From pupæ of the year 1911, in 1913 there emerged 5 females and 4 males, and from 61 pupæ of 1912 in 1914, 3 females and 1 male.

In the fall of 1913 the following percentages of healthy pupæ were recovered from four rearing boxes: 12 per cent., 10 per cent., 18 per cent. and 10 per cent. respectively. These, therefore, belonged to the two year cycle.

From a rearing box in which an unknown number of maggots pupated in 1913, 64 flies emerged in 1914 and 19 in 1915, that is 23 per cent. of the total number of flies secured from this cage had the biennial habit.

Is There a Second Brood of Adults?

All the evidence obtained at Bowmanville from our life-history studies, in which this point was kept in mind, showed that in that locality, and doubtless in similar or colder localities, there is not a second brood. At Grimsby, however —a much warmer part of the province—an adult male and several apparently fresh egg punctures were found on September 25th, 1915, though all adults in the equally warm district of Simcoe, Norfolk County, had disappeared by August 31st. This caused a suspicion that there might be a partial second brood at Grimsby. To test this, in 1917 badly-infested Early Harvest apples were placed under cheesecloth beneath a large peach tree where they were sheltered from the sun. The tree was 100 feet or more away from the nearest apple tree. Between September 19th and 21st two adults emerged in this cage. These were all that emerged. This indicates that there is a partial second brood some years in the south-western or warmer parts of the province. It must, however, be a very small and almost insignificant one, otherwise the flies could scarcely have escaped our attention.

Do Flies From Pupæ From Early Varieties Emerge Earlier Than Those From Later Varieties?

Large numbers of infested summer, fall and winter (Tolman) varieties were collected in 1911 and placed in ground boxes. The next spring 300 pupæ from the summer and 300 from the fall apples were put in the ground cages. Unfortunately, no pupæ were obtained from the winter apples, doubtless because of the failure of the maggots to mature. On July 8th flies commenced to emerge from the pupæ derived from fall apples and on the following day from those from the summer apples. The exact data are as follows:—

Summer Varieties:

Cage 13, flies commenced to emerge July 9th.
Cage 16, " " " " 10th.
Cage 17, " " " " 10th.

Fall Varieties:

Cage 14, flies commenced to emerge July 8th.
Cage 15, " " " " 10th.
Cage 18, " " " " 10th.

This shows that so far as summer and fall varieties go there is no difference between the dates of emergence. It is very doubtful whether any difference would be found even if pupæ from winter varieties had been used, and it is probably safe to consider that the earliest flies seen in the orchard on any particular tree may not have come from the infested fruit of that particular tree alone but also from that of the other infested trees whether early or late varieties.

Natural Control.

It has been shown that there is commonly a great mortality of eggs and larvæ in the fruit, often reaching in the case of winter varieties to as high as 100 p.c. and even in the case of summer varieties seldom going below 50 p.c. The causes of this mortality are not known except that in winter varieties it is apparently due to the fruit not becoming sufficiently mellow to allow the larvæ to mature, enter the soil and pupate before the very cold weather comes and destroys them.

Not only do great numbers of eggs and larvæ perish, but also numerous pupæ; in fact, it would appear that the greatest mortality often occurs between the time when the larvæ leave the fruit and the time for emergence of adults the following summer. Some years the destruction of pupæ is much greater than others. For example, we have several times placed numerous badly infested very ripe apples in heaps so that the following year we might secure flies from the pupae from these if desired. Some years many flies could thus be secured, other years almost none. Similarly in boxes the number of flies emerging from a known number of pupæ of the previous year varies greatly from year to year. For instance, in 1912 53 p.c. of the pupæ in boxes transformed to flies, whereas in 1913 only 26.9 p.c.

The much greater mortality of the insects some years than others leads, of course, to there being much less injury some years than others. Every student of the Apple Maggot must have observed this great fluctuation in numbers. The insect will become very abundant in an orchard for a year or commonly for several years, then almost disappear for several years, only to reappear in large numbers later. Our knowledge of the factors responsible for these great fluctuations is very meagre. Parasitism by other insects is apparently of little if any importance, because in none of our experiments with eggs, larvæ, pupæ and adults did we secure any parasites, nor did we see any evidence of their work in the orchard. It is true that a four-winged parasite has been found in Nova Scotia, but even there only in small numbers. Birds doubtless feed upon exposed larvæ and pupæ, spiders upon adults, ants upon larvæ when seeking to pupate and upon flies when emerging and still helpless, and there is reason to suppose that ground beetles sometimes destroy pupæ. But the combined work of these enemies is not sufficient to account for the extraordinary decrease in numbers of the Apple Maggot some years compared with others. The main cause is probably due to the difference in weather conditions of one year compared with another, but just how weather conditions act is not very clear. The following appear to be possible explanations:—

First, if there have been heavy rains in June followed by drought the surface of the soil becomes hard and baked and many flies will be unable to emerge through it; for instance, in 1912 only 40 flies emerged from 200 in a box where the soil was heavily watered and then packed to form a firm surface, while in a check box where this was not done 106 emerged out of 200.

Second, if the soil is very hard and baked many larvæ after leaving the fruit are unable to enter it and many others do so only with great difficulty. In October, 1913, 95 newly emerged larvæ were placed in orchard soil which had been beaten by rain and baked by the sun. Only 42 of these were able to enter the soil, the others pupating on the surface.

Third, a hard condition of the surface soil, as just stated, leads to many larvæ pupating above ground either on the exposed surface or among the roots of grass and weeds. Such pupæ in a time of drought usually perish. In a box 400 pupæ were exposed on the loose surface of the soil and from these only one fly emerged. In the same way it is reasonable to suppose that since many pupæ in almost any soil are found in the first inch of soil and since pupæ cannot withstand prolonged absence of moisture very many of these must perish in years when the soil becomes dried out for long periods in July and early August.

From what has been said above it would follow that the insects would ordinarily be most numerous in situations where the soil is of such a nature as to allow the larvæ to find good pupation quarters with ease, or in other words orchards in which the soil surface is loose either from late cultivation year after year or because the trees are thick, affording a dense shade, and where weeds and rubbish abound on the ground. The fact is that usually it is just such orchards, provided they have not been regularly and heavily sprayed with a poison each year, that are worst infested. Fruit trees in villages and towns are commonly worse infested year after year than those in orchards, and apparently chiefly for the reason that conditions in the former are specially favourable for pupation. Such trees are usually situated in gardens that are on the one hand kept well cultivated, or on the other hand abound in weeds and rubbish to such an extent as to prevent the baking of the soil. Moreover, in towns and villages strong, drying winds cannot play the same part that they do in a more exposed orchard.

CONTROL MEASURES.

Cultural Methods.

Experiments with pupæ in plots in which the soil was frequently stirred showed that such stirring had practically no effect in lessening the number of adults that emerged. Moreover, some of the worst infested orchards were those on which good cultivation was practised. As the pupæ lie loose in the earth, one would not expect them to be injured by stirring. The fact would appear to be that cultivation, especially if continued late, would favour the increase of the insects, because it would afford more nearly ideal conditions for pupation.

Deep ploughing may bury many of the pupæ under five or six inches of earth, but this does not prevent the flies from coming up. We found that when pupæ were buried even eighteen inches deep flies still emerged; other experimenters have had the same experience. So that neither as a result of stirring the pupæ or burying them deeply is cultivation any assistance as a control measure.

Soil Insecticides.

When the work was begun, and before a satisfactory method of control was discovered, it was hoped that an insecticide might be found which by being worked into the soil would destroy the pupæ. The following substances were tested at even greater strengths than would have been practicable under orchard conditions: Apterite, Vaporite, Cliff's Manurial Insecticide, Vermine, Jeye's Fluid. brine, lime-sulphur, pyrethrum in water, kerosene emulsion, bluestone and lime. Some of these reduced the number of emerging adults considerably, but as these substances are all expensive and, as a much cheaper and much more satisfactory remedy has been found, it is unnecessary to consider them further.

Chickens.

Wherever many chickens have free run of the orchard and the latter is cultivated, large numbers of the pupæ are devoured and sometimes the pest is held completely in check.

Destruction of Fallen Fruit by Hand or by Domestic Animals.

There is no doubt that if all the fallen fruit is gathered sufficiently frequently and destroyed, and this continued over a period of two years, it will practically eliminate the Apple Maggot, unless infested orchards are close by. This was demonstrated in 1911, 1912 and 1913 in a small isolated orchard near Bowmanville. Hogs were utilized to some extent in the work, but most of it was done by hand.

This method is applicable rather to a few trees in a village or town garden than to a commercial orchard. The amount of work involved even on one acre when the crop was heavy was found to be vastly greater than anticipated, and so great that almost no fruit-grower would perform it; in fact it is in our opinion an impracticable method of control in commercial orchards, except possibly in the few cases where hogs, sheep or cattle are allowed to run in the orchard in sufficiently large numbers to keep the ground free from "drops."

Much data was obtained on the frequency with which drops of the different varieties should be gathered to prevent larvæ emerging, but an account of this under the circumstances seems unnecessary.

Spraying With Arsenicals.

A study of the structure of the mouth parts and of the feeding habits of the adults have led investigators of this insect to believe that if poisons were sprayed on the leaves and fruit these would be fed upon and cause death.

At first it was supposed that the poison must be in the form of a liquid and that it must be combined with some sweet, attractive substance, such as molasses, before the flies could or would feed upon it. Later, however, both as the result of cage experiments and of orchard observations and tests, it was seen that the poison need not be in liquid form, but that arsenate of lead could be used. The next discovery was that the molasses or any other sweetened substance was not necessary, because the flies fed upon the small particles of arsenate of lead even after all the water used in the spraying had evaporated. The fact that molasses may be omitted and that the arsenate of lead and water are sufficient is a great boon, because molasses is costly, tends to injure the foliage, and causes the mixture to wash off faster than it otherwise would.

Experiments on Control by Spraying With Arsenicals.

That spraying with arsenicals will control the Apple Maggot even in the worst infested orchard has been proved by us as the result of six years' spraying experiments. At first, as will be shown, the results were inconclusive, because of defects in the methods employed, but with experience these weak points were eliminated and the last three years' tests gave most gratifying results. Cage experiments with poisoned sprays were also conducted, and not only corroborated the orchard results, but also demonstrated that the flies would feed upon the poison even where they had an opportunity of not doing so. These cage experiments will be referred to after the orchard experiments have been described.

Experiment 1. In 1913 at Bowmanville the Early Harvest and September Sweet trees in a village orchard were sprayed just as the flies began to emerge, and again four times later at intervals of a week or more. the large number of applications being due to the excessively wet weather in July and August. The mixture used was 2 lbs. arsenate of lead to 40 gals. of water containing 1 gal. of molasses. The remainder of the trees, including one Snow apple, were left unsprayed as a check. The results were inconclusive, for though there were fewer infested apples on the sprayed trees than on the Snow, yet a large number of the sprayed apples had also been attacked.

Experiment 2. In 1914 a large orchard of 25 acres or more at Mountain, in Dundas County, was sprayed twice with 2 to 3 lbs. arsenate of lead and 1 gal. of molasses to 40 gals. of water. The first spray was applied just as the flies began emerging, and the second between two and three weeks later. Suspecting that the failure to secure satisfactory results the year before was due to our having sprayed too small a portion of the orchard, it was decided that all the main bearing part should be treated, leaving as a check a block of about two acres arranged in four rows along the east side. This orchard had been badly attacked the previous year and many of the infested apples left upon the ground to rot. It contained many varieties, including several which were favourites of the Apple Maggot.

The result of the experiment as seen in September was that in the whole orchard. including the check, after much searching only ten apples with Apple Maggot egg punctures were found. This, of course, looked like a remarkable example of natural control and not the result of spraying; but there is no doubt that if it had not been for the spraying a considerable percentage of at least the favourite varieties like Tolman, Snow and Wealthy would have been infested; because at the close of the first application in July and again during the second application in August several dozen flies were observed on the trees, and there is no question that flies were also present in the interval between the two applications, though probably not in large numbers. Where flies are present eggs are sure to be laid unless the flies are killed by poison. Natural enemies do not destroy them to a sufficient extent to bring about the above result.

As to the freedom of the check from injury by the pest, there are two possible simple explanations. First, the season was very dry and the Codling Moth application, which had been heavy that year, still remained on the foliage to a considerable extent at the time of the first spraying for the Apple Maggot; hence the flies may have been destroyed by this poison. Second, the check strip was only 8 or 10 rods wide, and the flies as they moved about may have passed, and almost without doubt did pass, from the unsprayed to the sprayed trees and *vice versa*, thus becoming poisoned before they were ready to oviposit.

In an unsprayed orchard half a mile away approximately 50 p.c. of the fruit on the most susceptible varieties was punctured.

Experiment 3. In 1915 a small orchard of about 30 large trees at Villa Nova, in Norfolk County, was sprayed twice with the same mixture as used in 1914. As the season was very wet more applications should have been given, but, from lack of time, had to be omitted. Even so, the results were very encouraging, for, out of a small crop of only a few barrels, not more than from 10 p.c. to 12 p.c. had been attacked. The orchard was completely isolated and had been severely infested the previous year.

Experiment 4. In the same year an orchard in the suburbs of Simcoe was sprayed seven times with sweetened arsenate of lead. This large number of applications was necessary on account of frequent rains to keep the foliage and fruit covered with the poison. The results obtained here were disappointing, for though the spraying must have reduced the percentage of infested fruit, yet nearly 75 p.c. of the Tolmans and from 10 p.c. to 40 p.c. of the Snow and Spy apples were punctured. The cause of the failure of these numerous applications to protect this orchard was evidently the same as in the case of the Early Harvest and September Sweet trees in the Bowmanville orchard in 1913, namely, the proximity of other infested trees or small orchards to the sprayed trees. At Simcoe there were several such orchards a few rods away from the treated one. It is possible, too. that some of the very heavy wind storms may have had something to do with bringing in fresh flies, for in the worst storms the wind blew from the untreated orchards towards the treated. Up to the time of the first, which was also the worst, of these storms, no egg punctures and very few flies had been found, but after this there was a noticeable increase of the flies, and egg punctures soon followed. This, of course, is not proof that the wind was responsible for bringing in the flies, though if the facts could be known it would probably be found to be the correct explanation of their increased number.

Experiment 5. In 1916 three small orchards situated near each other at Lyn, in the County of Leeds, were each sprayed twice with the sweetened poison. The season was dry and the spray remained on well. These orchards had been so badly infested the previous year that most of the fruit had been left unpicked. Two of the orchards were on one side of the road and the other on the opposite side. No other orchards were to the south, east, or west of these, but to the north were several similar small ones, the nearest being 15 rods or so away. These orchards had also been badly attacked the previous year and were now left unsprayed as a check. Between these checks and the two sprayed orchards mentioned as being situated on the one side of the road, were a hedge and building which served to isolate them fairly well. The other sprayed orchard on the opposite side was not so well isolated, having no barrier between it and the checks. The result of the spraying was that the two orchards most isolated had over 96 p.c. of the apples on all varieties, including such susceptible ones as Tolman, Snow and Wealthy, free from egg punctures. The orchard on the other side of the road was not quite so clean, some of the Tolmans having as high as 25 p.c. of the apples punctured, though most of these had only one or two punctures each. In the check orchards on both sides of the road the Tolman, Wealthy, Snow and St. Lawrence had from 75 p.c. to 99 p.c. of the fruit with egg punctures, most of the apples having each many punctures.

Experiment 6. In 1917 these same three orchards were resprayed, this time with 2 to 3 lbs. arsenate of lead to 40 gals. of water without the addition of any molasses. As the season was very wet in July three applications instead of two were given to all except the summer varieties such as Duchess and Yellow Transparent. In addition, all trees in the nearest part of the check block were sprayed once in order to afford the test orchards some protection. The results were excellent; for in the most isolated orchard the fruit was all free from injury, and in the second best isolated orchard only a dozen apples on a Baxter tree had been punctured. (These egg punctures could all have been made in a single day by one female.) The third orchard in which some of the Tolmans in the previous year had as many as 25 p.c. of punctured fruit was almost as clean as the other two, not more than three score apples being affected, and these having each only one or two punctures. The check trees were not so badly infested as the previous year, though Snows, Wealthy, and St. Lawrence, and a seedling variety, had almost every apple attacked. (The Tolmans in the checks had no crop this year.)

Experiment 7. At Trenton this same year, 1917, an old isolated orchard of about thirty trees which had been badly infested in 1916 was heavily sprayed twice with arsenate of lead and water. Here, too, the result was that the fruit was almost entirely free from injury, only one dozen apples being found with any egg punctures. There was no check for this orchard.

Experiment 8. In the autumn of 1917 the worst infested orchard the writers had seen was found near Brighton. There were approximately 300 trees in it. The varieties were chiefly Ben Davis and Wealthy, with several Snow, one Yellow Bellflower, two or three Golden Russets, one St. Lawrence, one Tolman and a few other varieties. There had been a moderate crop that year, but every apple seen had been so badly attacked by the Apple Maggot as to be worthless and most of them had been left on the ground to rot. This would naturally give an ideal opportunity for a great number of flies to be present the next year, and thus for a thorough and final test of the poison spray. Accordingly arrangements were made whereby the entire spraying, including that for Apple Scab and Codling Moth, was taken in charge. Five sprays in all were given, namely, the dormant or semi-dormant spray, the spray just before the blossoms opened, the one just after the blossoms fell and then two more for the Apple Maggot itself. The first of these Apple Maggot applications was on July 12th and 13th, just as the first flies began to appear and the second the first week in August.

In order to protect the orchard from reinfestation from surrounding orchards the first orchard to the east was well sprayed, and also the one to the west, the owner himself doing the latter. This left only one unsprayed orchard nearby. It was situated over a height of land about 10 rods north of the extreme north-east corner of the sprayed orchard. This orchard, because of the elevation of the land between it and the test orchard and because of the direction of the prevailing winds, was felt not to be a menace and so was used as a check. The mixture used in the spraying was 2 to 3 lbs. arsenate of lead paste to 40 gallons of water.

The result of the spraying was very gratifying, for the orchard was not only beautifully free from Scab and Codling Moth, but also had less than 3% of the fruit infested by the Apple Maggot. This estimate includes fallen apples as well as those on the trees. One tree had between 5 p.c. and 8 p.c. of infested fruit, but this was far the worst tree, most of the trees having less than 1 p.c. and several being entirely free from injury. On the Tolman, which is usually as badly attacked as any variety, only two punctured apples could be found. There is no doubt that these results were due entirely to spraying, for one of the writers visited the orchard every two or three days from the time the flies began to emerge up to the end of July, and found that numerous flies were present. Some days fifty or more could be seen on any one of many trees, thus proving that if it had not been for the spraying there would have been plenty of flies to have utterly ruined the crop It was observed, too, that the poison must have had an effect upon the flies very soon after emerging, because of the several hundred flies seen on various occasions none were found mating nor was there any evidence of egg laying up to the date mentioned.

In the check orchard, which, according to the owner, had not been badly infested the previous year, and from which most of the fruit had been sold that year, not nearly so many flies per tree, even on the most susceptible varieties, could be found; in fact, 8 or 10 flies were all one could usually find in an hour. Some of these flies were mating and egg punctures could readily be found before the end of July. By the close of the season there were so many infested apples in it that the chief apple buyer of the county refused to purchase the fruit at any price. The same buyer, after carefully inspecting the sprayed orchard, not only stated that, in his opinion, the fruit was in first-class marketable condition, but also purchased the crop. In the check orchard we made a careful examination of Snow, Wealthy. Ben Davis and Phoenix trees and estimated that all of these had 75 p.c. and upward of the apples infested, many of the apples having so many egg punctures as to be deformed.

Cage Experiments on the Effect of Arsenical Poisons upon the Apple Maggot.

A series of experiments extending for one month was carried on in cages to see how long it took arsenate of lead and calcium arsenate respectively to kill the flies, and to test the effect of adding molasses to the former substance. A few tests were also carried on with a substance used in dusting orchards, composed of finely ground sulphur 85 p.c. and arsenate of lead powder 15 p.c.

The cages used were the ordinary Riley cages with cheesecloth on three sides and glass in front. In each of the check cages an apple branch with a few apples on it was placed in a bottle of water to keep it alive and healthy. This branch was, of course, taken from an unsprayed tree, and no poison put on it. In the cages where poison was used two small branches or twigs from this same tree were placed in bottles of water and the foliage and fruit of one of these was dipped in the poison mixture, while that on the other was not poisoned, the object being to see whether the flies in feeding would avoid the poisoned twig in favour of the other and thus escape death.

All cages were placed in an open air insectary built under the shelter of a large apple tree on the side of a steep hill, so that they were sheltered from the sun's rays and had the benefit of a constant movement of air.

TABLE 6.—SHOWING THE EFFECT OF ARSENICAL POISONS UPON THE ADULTS IN CAGE EXPERIMENTS.

Substance used.	No. of tests made	Total No. of flies used	Percentage of flies dead in 1 day	Percentage of flies dead in 2 days	Percentage of flies dead in 3 days	Percentage of flies dead in 4 days	Percentage of flies dead in 5 days
Arsenate of lead	5	46	17.4	56.5	78.2	94.6	100
Arsenate of lead and molasses	10	113	21.9	60.5	85.9	97.3	100
Calcium arsenate (arsenate of lime).	10	89	56.2	85.4	98.9	100	....
Sulphur 85% and arsenate of lead powder 15% dusted on fruit and foliage ..	4	37	24.3	51.6	81.1	81.1	91.5
Checks	9	97	0	1.0	5.1	6.2	6.2

An examination of the above table shows clearly the killing effect of the poison, the checks representing the normal death rate. It shows too that the flies in all the poisoned cages fed upon the poisoned foliage and fruit as well as upon the unpoisoned, and therefore have little or no power of selection, or at least, are not repelled by the poison. Calcium arsenate killed more rapidly than arsenate of lead, but unfortunately is not safe to use alone with water, as it will burn the foliage severely. Sweetened arsenate of lead killed a little, but only a little, more quickly than arsenate of lead alone. Arsenate of lead powder combined with sulphur was the slowest killing substance, some of the flies in these cages not dying until the sixth day. All poisons killed more than 50 p.c. of the flies in two days, and the vast majority in four days. The fact that a fly does not die for four or five days does not mean that it is as healthy as ever during most of this period; in fact, the poison seems to have an effect almost from the first in preventing mating and egg-laying.

The great advantage of using arsenate of lead and water without any molasses is its safety to the foliage and fruit, and its excellent sticking qualities which necessitate fewer applications.

DIRECTIONS FOR CONTROL.

The above experiments in orchards and in cages have shown that spraying with arsenate of lead is a satisfactory method of controlling the Apple Maggot. Similar results to ours have been obtained by Brittain and Good in Nova Scotia.

To make the spraying a success it must be done at the right time and every tree in the orchard must be sprayed; moreover, if there are badly infested orchards or trees close by they also must be sprayed. Failure to do this is evidently the explanation of the lack of success obtained by some investigators. It is a dangerous assumption to make that the flies do not move around from tree to tree in the orchard. The results obtained by spraying show that both this insect and its close relatives, the Cherry Fruit-flies, do move about much more than was previously supposed.

The mixture recommended is arsenate of lead paste 2½ lbs. to 40 gals. of water without any molasses or other sweetening. Arsenate of lead powder would perhaps do as well, but there is some doubt whether it sticks quite so long on the foliage.

The *first application should be given as soon as the flies begin to emerge* so that they may be killed before they can lay eggs. Hence the *date of this application* in an ordinary season in the warmer portions of the Province, such as all the counties bordering on Lakes Erie and St. Clair and the Detroit River, together with the Niagara and Burlington districts, *would be about June 25th;* in the moderately warm counties, such as the most of the remaining counties west of Toronto and those along Lake Ontario as far east as to Lennox and Addington it would be *about July 1st;* and in the counties farther north and east *about July 7th.* In a cold, backward season, especially if June is cold, this application should be postponed in each of these districts about one week.

The *second application should be made as soon as the first shows signs of disappearing.* Usually this will be in about three weeks, but in two weeks if the weather is wet. *A third application in about another two weeks should be given if there have been many heavy rains to wash off the second and is a good insurance in all cases the first year after a bad infestation.* It is necessary to remember that flies continue to emerge in the orchard for about seven weeks, and that the poison must be on the trees all that time to control them.

Every application should be fairly heavy, almost as heavy as for the Codling Moth; because the heavier and more thorough the application is the longer the poison will remain on the fruit and foliage.

At the first application no tree, whether bearing or not, should be left unsprayed, for the flies may remain on the foliage of a tree that has no fruit until they are ready to lay eggs and then for this purpose seek a tree with fruit. It is also well for the same reason to spray plum, cherry and pear or other trees if many of these are present.

At the second and third applications only those trees whose fruit is nearly ripe and that if sprayed would be dangerous to the consumer, should be omitted.

If infested orchards are close by, every effort should be made to have the owners co-operate by spraying them; for otherwise some years it will be found difficult to secure a high percentage of clean fruit. If, however, the orchards are 20 rods or so away the danger from them is not usually great.

All useless seedling apple trees and all hawthorns should be cut down or sprayed, as the insect will breed on them too.

In towns and villages where there are usually only a few apple trees in each garden, it is not easy to control the insect; because spraying the trees of one garden and not those of the neighboring gardens is not sufficient. In such cases keeping the fallen fruit picked up and shaking off and gathering all infested fruit just before it becomes ripe and then boiling or burning this, where there are no hogs or cattle to which it may be fed, will help much if widely practised. The best plan, however, would probably be to purchase a community spray machine and pay somebody to spray all the trees in the village according to the directions given above. Every kind of fruit tree should be sprayed and not apples alone. A line of hose 100 feet or more in length would make the work easier as it would avoid the necessity in many cases of driving the machine into the gardens. If such a machine were purchased it could be used also for all the regular sprays that are so valuable in producing clean fruit.

Two years of careful treatment should almost exterminate the Apple Maggot in any orchard unless situated close to untreated, infested orchards. One year's treatment is not sufficient because some of the pupae, as previously shown, pass two winters instead of one in the soil. The flies from these would therefore attack the apples the second year no matter how complete the control of the pest the first year.

After two years' treatment it should be possible usually to rely upon the regular Codling Moth spray or this supplemented by one application the first week in July.

There seems no doubt that wherever the Codling Moth spray has been heavily applied year after year it has controlled the Apple Maggot, but where it was applied lightly or applied some years and omitted others it has not done so.

Acknowledgements.

The use of a poison spray to control the Apple Maggot was first suggested to the writers by the results obtained from sweetened poisons on other species of fruit-flies in Italy and South Africa. The main suggestions, however, were received from the work of J. F. Illingworth, of Cornell University, Ithaca, N.Y., who was the first entomologist in North America to demonstrate the value of this method against Cherry Fruit-flies and the Apple Maggot.

BULLETIN 272] [JULY, 1919

Ontario Department of Agriculture

ONTARIO VETERINARY COLLEGE

Contagious Abortion in Cattle

C. D. McGILVRAY, M.D.V.

This bulletin on Contagious Abortion in Cattle has been prepared to meet a popular demand and to furnish such information regarding this disease as may seem justified. It is hoped that it may prove useful to veterinary surgeons as well as to owners of breeding cattle. In its preparation the use of technical terms has been avoided where possible. Articles on abortion by various authorities have been freely consulted and drawn upon, of which due acknowledgement is hereby made. Among the writings referred to are those of McFadyean and Stockman, of Great Britain; Williams, Mohler, Eichhorn, Schroeder, Cotton and Giltner, of the United States.

NATURE AND CAUSE OF THE DISEASE.

The condition known as abortion, or "slinking the calf," is one which is often encountered among pregnant cattle. Its occurrence is increasing, and is becoming more acutely felt by many breeders, by noticeably lessening the productiveness of their herds. It has commonly been ascribed to result from a variety of causes, such as errors in feeding and watering, accidents and injuries of all kinds, influences of the weather, and also to supposed defects in the male parent.

While abortion, no doubt, may result in some cases from such causes, nevertheless they account for only a very small percentage of the cases in cattle, the larger percentage resulting from a COMMUNICABLE DISEASE, which is termed CONTAGIOUS ABORTION.

This disease may be described as a contagious affection of cattle, which is manifested by the premature expulsion of the fetus, or untimely delivery of the calf, owing to an infectious catarrh, or inflammation, set up in the womb. The cause of this has been shown to be a germ known as the *Bacillus abortus*, or Bang's Bacillus of Cattle Abortion.

METHODS OF CONTRACTING THE DISEASE.

The disease is generally first introduced into a healthy herd through obtaining breeding cattle from a diseased herd, thus constituting a carrier medium of infection from one herd to another. The manner in which cattle contract the disease or infect each other has been a matter of some dispute. Somewhat extensive investigations have been conducted in Great Britain and America, and the conclusions would seem to warrant the recognition of two channels, by either of which the disease germs may enter the system and reach the womb. One means of entrance is by the mouth with infected feed, water, and milk, and the other by the genital passage.

With regard to infection entering the system by the mouth, some investigators consider that it is probably one of the most common means by which cattle contract the disease. The explanation of this is that an infective discharge containing great numbers of the bacilli, or disease germs, is frequently expelled from the womb of affected cattle. The infective discharges, on being expelled, are very liable to contaminate the bedding and fodder, such as hay and straw, pasture and water, which, in turn, are taken into the mouth and consumed by other pregnant cattle. The germs of the disease, being thus taken into the mouth with the feed and water, are swallowed, and pass into the bowels, from which they are absorbed and are carried by the blood throughout the system until they reach and finally locate themselves in the wall of the pregnant womb, which is their favourable place of abode. It is also claimed that the germs, in some cases, locate themselves in the udder and lymph glands, where they remain stationary for a variable period, and are given off in the milk from time to time. It is also claimed that infection of the surface of the udder and teats occurs by contamination with discharges passing down from the vulva. The surface of the udder and teats, thus contaminated, permits infection of the milk, either while the calf is sucking, or by the hands while milking. By this means it is thought that calves sometimes contract the disease from the milk and grow up infected.

With regard to infection taking place by means of the genital passage, this was formerly thought to be the only method of entrance. It was believed that the discharges from aborting cows, dropping in the stable gutters and against the stalls, infected others by direct contamination of the genitals, or by being switched by the tails of infected cows against the genitals of other pregnant cows occupying adjacent stalls. It was also contended that the infection was chiefly conveyed from female to female through the medium of the bull during service.

Due regard and consideration must always be given to each of these factors as likely means of conveying infection; also that infection frequently takes place by the mouth, through ingesting food, water, and milk, contaminated with infected discharges from aborting cattle.

Irrespective of the manner by means of which the germs may have entered the body, upon their reaching the womb of pregnant cattle they begin to operate harmfully by giving rise to a catarrhal condition, or inflammation, of its surface, and also of the contacting fetal membrane, causing a gradual separation of the placenta, which forms the nutritive medium of connection between the mother and the fetus. The disturbance of this nutritive connection usually results in causing the death of the fetus and its premature expulsion, which is termed Abortion.

SYMPTOMS AND COURSE OF THE DISEASE.

Abortion may take place without any special indications of its approach, and the animal may appear quite well up to the time when the fetus is being expelled.

The actual abortion may entirely escape notice if it occurs during the early stages of pregnancy, as the small fetus or embryo and the membranes are easily expelled, and the owner's suspicions are only aroused when he finds certain of the cows or heifers, considered safely in calf, to be again in season. Even when the fetus is fairly well developed during the advanced stages of pregnancy, it may be expelled without notice, and the accident is first discovered by the presence of the aborted calf and the membranes behind the cow.

In other cases, indications of its probable approach are manifested by the animal. She is noticed to be restless and uneasy and to keep whisking the tail. The udder may become enlarged and full, denoting the appearance commonly termed "making a bag." The vulva appears swollen, and coming from it may be noticed a brownish-coloured sticky discharge. There may also be present the usual manifestations of impending expulsion of the fetus, such as straining. It has also been noticed, in a large number of cases of cattle abortion, that after expulsion of the calf, the after-birth is retained, or, as commonly expressed, the cow fails to clean. Even where the after-birth is not retained, a brownish discharge may continue to come from the genital passage for several weeks. So frequently does retention of the after-birth and this discharge occur in contagious abortion that they are considered as being significant of the disease in a herd even when the calves are carried the full time. The course of the disease is, as a rule, slow, and the period at which the abortion takes place is variable. The majority of cases seem to be noticed between the fifth and seventh months of pregnancy. The usual experience in outbreaks of contagious abortion is that during the first two or three years of its appearance in a herd it claims many victims, and then becomes reduced to a smaller number of cases occurring each year, unless many new females are introduced or young heifers are growing up, which in turn become attacked. Amongst infected cows a large percentage abort twice in succession, and a certain number three times, after which they appear to acquire a degree of immunity or resistance to the disease, which enables them to reach the normal period of calving. This feature has apparently led some to volunteer the statement that the disease will disappear of its own accord, or run itself out of a herd, in the course of three or four years, provided no freshly-infected cows are introduced. This contention is, however, not altogether tenable, because, even when no freshly-infected cows are introduced, the tendency is for the disease to prevail and attack the young females in the herd, unless special measures are taken to protect them. It has also been observed that in herds where contagious abortion prevails, many of the calves, while born at normal time, arrive weak and puny, and become affected with scours and pneumonia, causing death in many cases. Likewise it has been noticed, where there is abortion in a herd, that sterility, or barrenness, prevails among both cows and heifers, so that the number of "shy breeders" increases in the herd. This phase of the disease seriously reduces the productiveness of many herds. The cause of sterility in these cases is a resulting diseased condition of the womb and ovaries, the latter becoming cystic and with retained *corpus luteum* present, or the so-called brownish bodies, in the ovaries.

MEANS OF DETECTING THE DISEASE.

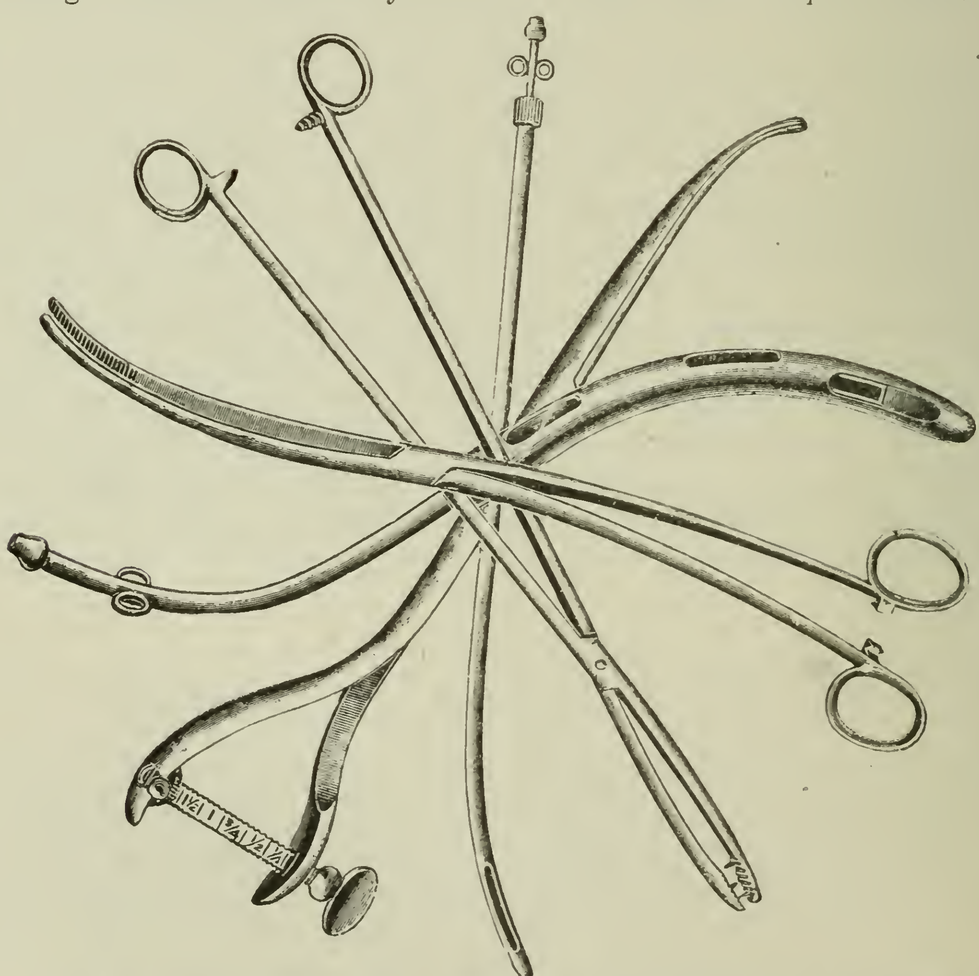
The importance of being able, if possible, to detect and recognize the disease when it first occurs in a herd is apparent, so that steps may be taken to arrest its progress. In this regard the safest course to pursue is to accept the fact of any cow aborting on premises formerly exempt as a sufficient reason for suspecting that the disease has been introduced, and particularly where new females have entered the herd. Additional cases of "calf slinking" occurring at intervals in the herd should be considered confirmatory of contagious abortion being the cause. Experiments have been made with the view of devising some satisfactory method of test capable of determining the presence of latent infection in female cattle, pregnant or otherwise. Among the methods used for this purpose may be mentioned the abortin test, the agglutination and complement fixation tests.

THE ABORTIN TEST.

This test is known also as the reaction method and consists of the injection, under or in the skin of suspected females, with a substance called abortin, which is an extract prepared from artificially grown cultures of the bacillus of cattle abortion. It is used in a manner somewhat similar to that in the application of the subcutaneous and intradermal tuberculin tests. The Subcutaneous Abortin test is manifested and interpreted by a rise in temperature exceeding 104 deg. Fahr., which begins about the fourth hour after injection and lasts usually until about the fourteenth hour.

The Intradermal Abortion test has been advocated as a better method. The reaction by this method is manifested by a swelling of the skin at the point of injection, which is made at the root of the tail.

Attempts have been made to extol commercially the use of these tests. Their reliability, however, is doubted, as the results have not proved uniformly satisfactory. It would appear that while a rise of temperature or a local swelling after injection of abortin may be indicative of infection, on the other hand the absence of this reaction is not considered a safe criterion as to the freedom from infection. This is owing to the fact that many infected animals fail to respond to the test.



Set of instruments used in the operative treatment of irrigating the womb of cows to overcome sterility following abortion. The above set includes the Albrechtsen uterine dilator and return flow catheters and a pair of the Knowles uterine forceps.

THE AGGLUTINATION AND COMPLEMENT-FIXATION TESTS.

These are serologic or blood tests of a somewhat delicate and complicated nature. They can only be properly performed in a suitable laboratory by a skilled person. For making these tests, samples of blood are taken, with proper precautions, from suspected cattle and sent to a laboratory for examination. The results are based upon the specific action which cultures of the abortion bacillus have upon the blood serum of the animal. These tests, when properly performed, appear to be the most trustworthy as yet for the detection of latent infection in cattle, both before and after the act of abortion.

METHODS OF PREVENTION AND TREATMENT.

Up to the present, the essential basis of dealing with contagious abortion in cattle is by sanitary measures. This consists in adopting measures to protect a sound herd from becoming infected and to control the disease in an infected herd. Important requisites towards this end consist in preventing infected cows from mingling with healthy ones, and the separation of any suspected aborting cattle from other pregnant cows and heifers. In adding breeding cattle to a herd, careful enquiries should be made to ascertain if the herd from which they are being obtained is free from abortion disease. If doubt exists as to their freedom from this disease, the newly obtained pregnant females should be kept separate until they calve.

All cases of abortion should be regarded, irrespective of excusable circumstances, as at least probably the contagious form and precautions taken accordingly. As soon, therefore, as any animal in the stable shows signs of aborting, or has aborted, it should at once be removed to a separate stable. The feed should be removed from the mangers and all bedding and litter from the stalls burned, as well also as the aborted fetus and the after-birth. The stable walls and stalls, including the floor and gutters, should be thoroughly cleaned and disinfected with lime wash.

The aborting cow is very liable to retain the after-birth, and should have the membranes carefully removed if not expelled within two or three days. During this time the womb should be washed out once every day with a lukewarm antiseptic solution, such as a one per cent. solution of lysol, or with a one-in-one-thousand solution of potassium permanganate. After expulsion or removal of the after-birth the womb should be flushed out with about two gallons of a one per cent. Lugol's solution of iodine, followed by a saline solution made by adding two ounces each of fine dairy salt and bicarbonate of soda to a pail of clean lukewarm water.

The flushing may be repeated once a week for a month by the use of the Albrechtsen uterine return flow catheter. This method of treatment is recommended for the prevention of sterility in breeding females, particularly valuable pure-breds.

In many cases the frequency of washing of the womb may be reduced by the use of antiseptic powders in capsules. For this purpose a gelatin capsule containing an ounce, composed of equal parts of iodoform and boracic acid, may be introduced into the womb a few hours after calving, and then repeated the following day. This practice has been found useful, particularly in cases where the after-birth is retained.

The aborting cows, and all the exposed pregnant ones, particularly those occupying stalls adjacent to the aborting animal, should have their hind parts, including the tail, hips, and udder, washed thoroughly with an antiseptic solution such as a two per cent. solution of lysol or creolin.

Cattle, after aborting, should preferably be kept by themselves for a period of at least one month, and they should not during this period of time be pastured in the same fields as healthy pregnant cattle, nor allowed in the pasture fields so long as discharges continue to come from the vulva. This is important, because the discharges may infect the grass and water, and which, when thus contaminated, may remain virulent and a possible source of infection for some time. At the end of the isolation period, before allowing aborting cattle to mingle with the other members of the herd, it is advisable again to thoroughly wash off their hind parts and disinfect the stable in which they have been kept. Cows which have aborted should not be bred again until a period of one or two months has elapsed, and not even then if they show any signs of discharges coming from the genitals.

The bull, each time after serving aborting cows, and before serving healthy cows, should have the end and inside of the sheath washed with a mild antiseptic solution, such as a one per cent. solution of lysol or a three per cent. borax solution. In treating the inside of the sheath the antiseptic solution can be injected with an ordinary metal or rubber syringe.

THE USE OF DRUGS.

The internal use of drugs alone appears to be of little real benefit in abortion disease of cattle. From time to time certain agents have been used and were highly praised for a time as a likely cure.

The carbolic acid treatment, which was particularly popular for a time, consisted in administering it daily, in dram doses, or at intervals of several days throughout pregnancy.

Another drug, known as methylene blue, has been advocated as a likely cure. It is given in doses of one or two teaspoonfuls daily in the feed for a period of five or six weeks.

While no serious objection to the use of carbolic acid and methylene blue need be taken, nevertheless their curative value has been over-stated. In fact, the use of these remedies in the hands of those most capable of judging as to their merits has shown them to be of no lasting benefit, and their popularity has greatly diminished.

VACCINE TREATMENT.

More recently the treatment of cows and heifers for abortion is being undertaken by means of special abortion bacterins and vaccines to confer immunity or protection against the infection. The bacterins are composed of killed abortion bacilli in suspension, and are advocated for the treatment of doubtful cases and for infected cows during the first half of the term of pregnancy. The bacterin treatment has unfortunately not as yet proved altogether as satisfactory or successful in conferring immunity or protection as expected. The abortion vaccines are products containing living cultures of the bacilli, and on that account are only recommended for use in herds already infected, and to be administered to heifers and non-pregnant cows from one to two months before breeding. It is not advisable to use the vaccine on pregnant animals nor in herds in which the disease is not present.

The preparation and use of abortion vaccines are as yet largely in the experimental stage, and the evidence at hand so far is only sufficient to recommend their use in affected herds on heifers and non-pregnant cows before breeding as a means of assisting materially in obtaining living calves at full term.

HOW TO OBTAIN VACCINE.

The Health of Animals Branch of the Department of Agriculture at Ottawa will supply qualified veterinary surgeons, with contagious abortion vaccine, free of charge, providing an owner of cattle makes a request that he desires to have his animals vaccinated, and furnishes the name and address of the veterinarian he desires to employ and the number of animals to be treated. On receiving such a request the vaccine will be sent to the veterinary surgeon, with directions as to its use.

Owners desiring to avail themselves of this arrangement may do so by writing to the Veterinary Director-General at Ottawa.

Abortion vaccines are also sold by commercial concerns, and may be obtained through reputable veterinary surgeons and used under their direction.

TREATMENT OF WHITE SCOURS.

Where abortion disease exists in a herd, outbreaks of White Scours may occur among the calves, causing severe losses at times. In these cases the healthy calves should be immediately removed from among the sick ones. The soiled bedding should be frequently removed from the calf pens and replaced with clean bedding. The stalls should be well disinfected from time to time. If veterinary assistance is available it should be obtained for the administration of special remedies such as the serum and bacterin treatment. After the affected calves are a few days old they may be fed on boiled milk to which may be added half a teaspoonful of lysol or formalin morning and evening until relief is afforded.

STERILITY.

In herds where sterility or barrenness prevails to an increasing extent among the females it should be considered as a resulting phase of abortion disease. Where the barren females are only of ordinary beef value, they may be disposed of for slaughter. In the case of valuable cows being affected, the services of a skilled veterinarian should be obtained for the purpose of treating the womb by the Albrechtsen method, and to manipulate the ovaries with the hand to rupture cysts, if present, and to expel retained *corpus luteum*, or the so-called brownish body. This operative treatment of the womb and ovaries by a skilled person results in restoring many valuable cows to breeding usefulness.

SUMMARY OF LEADING POINTS.

1. In purchasing pregnant cattle, make careful enquiries in order to ascertain if the herd from which they are being obtained is free from abortive disease.

2. If doubt exists as to their freedom from this disease, keep the newly obtained females separate until they calve.

3. As soon as a cow aborts remove her to a separate stable.

4. Thoroughly clean and whitewash the stalls in the stable. The bedding and litter removed from the stalls should be burned, together with the aborted fetus and the after-birth.

5. Wash off the hind parts of all the exposed pregnant cows with an antiseptic solution.

6. Cleanse the genital passage of the aborting animal with mild, warm antiseptics. This should be repeated daily until the neck of the womb closes. If the washing of the womb is not desirable, make use of antiseptic powders in capsules.

7. Do not allow cows with retained after-births to remain in stalls adjacent to other pregnant cows.

8. Keep aborting cows separate from the others so long as they are discharging. Wash their hind parts before allowing them to return to the herd.

9. Allow a period of at least one or two months to elapse before returning aborting cows to the bull.

10. Wash the end and inside of the bull's sheath after service of doubtful cows and before service of healthy cows.

11. Do not allow the bull to serve aborting cows which have a discharge from the vulva.

12. Obtain the advice and guidance of a qualified veterinary surgeon as to the use of vaccines or bacterins, combined with the sanitary measures recommended.

13. If calves become affected with White Scours, immediately separate the sick ones from the healthy. Consult a reputable veterinary surgeon for special treatment and as to the use of special serums and bacterins in conjunction with sanitary measures.

14. In the case of valuable cows becoming barren, the services of a skilled veterinarian should be obtained for the purpose of treating the womb and ovaries.

BULLETIN 273] [AUGUST, 1919

Ontario Department of Agriculture

Community Halls

It is well recognized that social as well as economic conditions have much to do with community development and well-being. While in many rural sections a very desirable condition socially exists, there has been recognized for some time the need of proper meeting places or of desirable centres for community gatherings and for organizing community effort. Having these facts in mind, the Legislature at its last session passed the Act Respecting the Establishment of Community Halls and Athletic Fields in Rural Districts, which was introduced by the Minister of Agriculture. This Act provides for giving financial assistance to rural communities for the purposes of erecting community halls, or for providing such accommodation in consolidated schools.

In order to safeguard against the possibility of these halls being unsuitable for the purposes intended, the Act provides regulations, one of which requires that the hall include an auditorium with movable seats, reading room, including a library and kitchenette. The auditorium should have a level floor and platform with space suitable for recitals, dramatic entertainments and the discussion of public questions. It is intended that such a building should be available for all meetings and gatherings of a community nature in the broadest sense of the meaning of these terms and consistent with the regulations made under the Act.

It is also provided that each community hall shall have in connection with it at least three acres of land adjoining the building or in close proximity to it, this land to be used for sports, picnics and outdoor gatherings.

To assist communities undertaking the erection of these halls the plans of four different types of buildings are given in the following pages together with brief specifications. It is not expected that these plans should be entirely followed. It is the intention that they should serve more as a guide and may be modified to suit local conditions. All plans of proposed community halls and athletic fields must be submitted for the approval of the Department. On approval of these plans the Department will prepare blue prints for departmental filing purposes and for the use of the Board of Management. Where any plan given in this circular is adopted, the Department will supply blue prints to the Board of Management.

A Board of Management which constructs a new building or remodels a building now in existence according to plans approved by the Department and provides the required athletic field shall receive through the Municipal Corporation of the township the Government grant, this to be 25 per cent. of the cost of the building, but no grant shall exceed the sum of $2,000. The cost of the building shall be exclusive of the cost of the land for building and grounds.

The Act and the Regulations which are given herewith will supply any further information. Attention is called to the method of applying for the Government grant. After the plans of a proposed hall have been approved, and the building has been constructed in accordance with those plans, the Board of Management shall forward to the Department of Agriculture a certified statement showing all monies received and expenditures made, in connection with constructing the building. Where members of a community contribute to the establishment of a hall by giving their services free in connection with some part of the work of construction, it is suggested that the number of days work represented by such voluntary service, and the amount of wages which otherwise would have been paid for such work, be shown in the financial statement as part of the cost of the building.

An Act respecting the Establishment of Community Halls and Athletic Fields in Rural Districts.

His Majesty, by and with the advice and consent of the Legislative Assembly of the Province of Ontario, enacts as follows:

1. This Act may be cited as *The Community Halls Act, 1919.*

2. In this Act,—

(*a*) "Minister" shall mean Minister of Agriculture;

(*b*) "Regulations" shall mean regulations made under the authority of this Act.

3.—(1) The minister may grant aid to the municipal corporation of a township for the purpose of assisting in providing for a community hall and the establishment and laying out in connection therewith of an athletic field, but such grant shall not exceed an amount equal to twenty-five per cent. of the cost of the building or of that part of the building designed for a community hall and exclusive of the cost of the lands required for building and grounds, nor shall such grant exceed the sum of $2,000 in any one case, but grants may be made for the establishment of more than one community hall and athletic field by the corporation of any one township.

(2) The grant shall be payable out of such sums as may be appropriated by the Legislature for the purpose of aiding in the establishment of community halls.

4. All the property acquired for the purposes of this Act shall, except as hereinafter provided, be vested in the municipal corporation of the township.

5.—(1) The council of a township may by by-law provide for the establishment of a community hall and athletic field in accordance with the provisions of this Act in the township or in any incorporated village adjacent or contiguous thereto, and may acquire by purchase or otherwise real and personal property for that purpose and may enter into an agreement with the council of any adjoining township or village for the joint use of the community hall and athletic field by the inhabitants of the municipalities upon such terms as to contribution to the cost of the hall and athletic field and as to the maintenance thereof as may be agreed upon, but notwithstanding any such agreement the aid to be granted under the Act shall not exceed the amount mentioned in section 3.

(2) The corporation of the township may issue debentures for the purposes of subsection 1 in the manner provided by *The Municipal Act.*

6.—(1) Every community hall and athletic field established by the corporation of a township under this Act shall be under the management and control of a board appointed by the council of the township composed as follows:

(*a*) Two members of the township council; and

(*b*) Five members selected by the council from amongst the officers of the local organizations in the township, not being religious or fraternal organizations, for the use of which hall is established, and in selecting such representatives the council shall have regard to the contribution by each organization to the erection and maintenance of the community hall.

(2) The council may fill any vacancy arising on the board from among the class of representatives in which the vacancy occurs.

(3) The representatives of the township council shall be appointed annually and shall hold office until their successors are appointed, and every other officer of the board shall hold office for two years from the date of his appointment and until his successor is appointed.

7. Any municipal corporation entering into an agreement for the joint use of a community hall and athletic field, and any of the societies or other bodies by which the community hall may be used under the regulations, may make grants out of any moneys in their hands in aid of the erection and maintenance of a community hall and athletic field established under this Act.

8. The Minister shall have power to make grants to the board of trustees of any consolidated school which provides athletic grounds of satisfactory area, and a community hall in or in connection with the school, on the same terms as herein set forth, except that such grounds and community halls shall be managed and conducted under the regulations of the Department of Education, and such property shall be vested in the board of the consolidated school, provided always that the community halls and athletic grounds shall be available for the purposes permitted by the regulations.

9. The Lieutenant-Governor in Council, upon the recommendation of the Minister, may make regulations respecting the terms and conditions upon which aid may be granted under this Act, the uses to which a community hall may be put, and the accommodation which may be provided therein, and generally for the better carrying out of the provisions of this Act.

10. This Act shall come into force and take effect on the day upon which it receives the Royal Assent.

Regulations passed under the Community Halls Act, 1919, and Approved by the Lieutenant-Governor in Council

1. Where it is proposed to establish a community hall and athletic field under this Act the Municipal Council of the township shall appoint a Board of Management in accordance with section 6 of the Act, and such Board shall handle all matters pertaining to the construction of such hall and planning of such grounds, and shall be responsible for any monies collected for these purposes.

2. The site proposed shall be approved by the Minister and plans and specifications for a community hall and athletic field shall be submitted to the Minister of Agriculture for approval before construction is commenced.

3. The site of the community hall shall be determined by the Board, but every hall shall provide the following accommodation: assembly room with movable seats, stage, and other equipment; reading room including library; kitchenette.

4. Every hall erected under this Act shall be available for any public gathering of educational, fraternal, religious or social nature or for the discussion of any public question, and no organization shall be denied use of the building for religious, fraternal or political reasons.

5. The Board shall regulate and control the use of the hall and athletic field and shall have the care and management thereof, and, subject to the Act and these Regulations, shall make such rules as are necessary for the proper conduct of each, and shall have power to fix such charges as are necessary for the purposes of proper maintenance, provided that any person or organization considering themselves aggrieved may have the right of appeal to the Minister of Agriculture.

6. Subject to the regulations of the Board as to hours and discipline, the reading room and library shall be open to all.

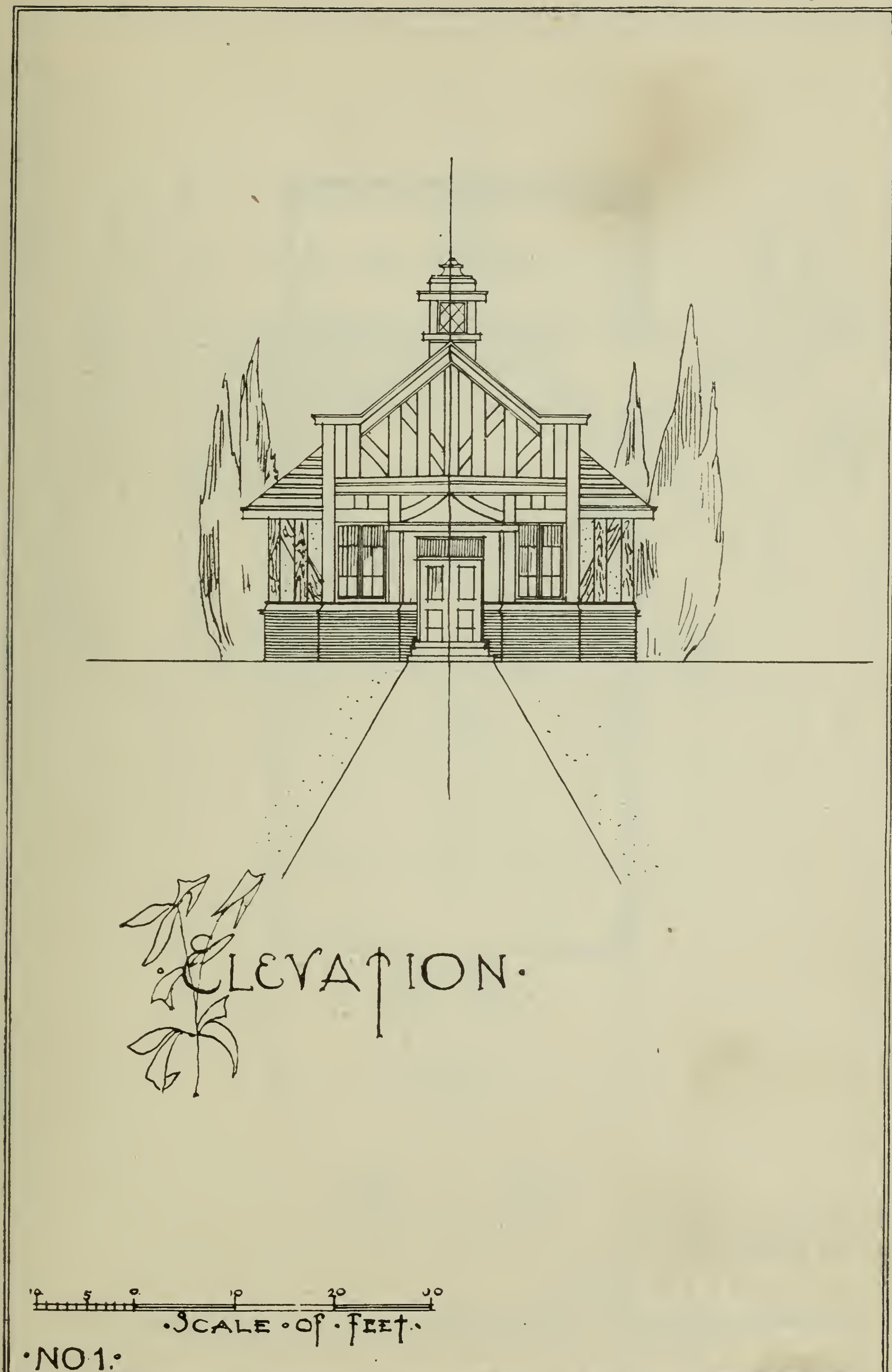
7. The Government grant as provided by the Act shall be paid to the Treasurer of the Township on certificate of such officer as may be designated by the Minister setting forth that the terms of the Act and these Regulations have been complied with.

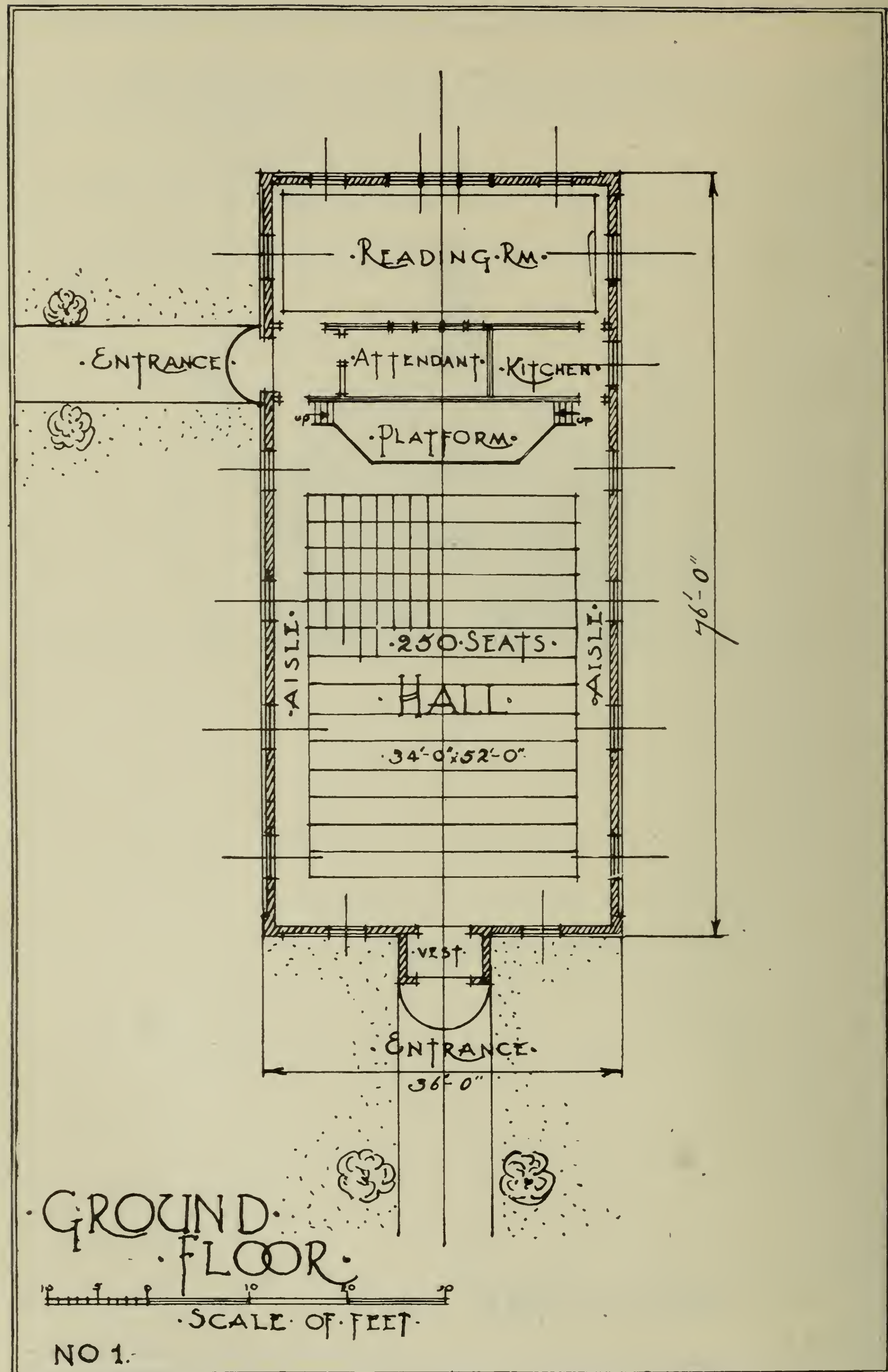
8. The Government grant shall be payable only on the cost of such portion of the building as may be used for the purposes herein enumerated.

9. An athletic field must be provided with each community hall, to be adjacent thereto or within convenient distance, and to be at least three acres in extent, such athletic field to be vested in the township and controlled in the same manner as the hall.

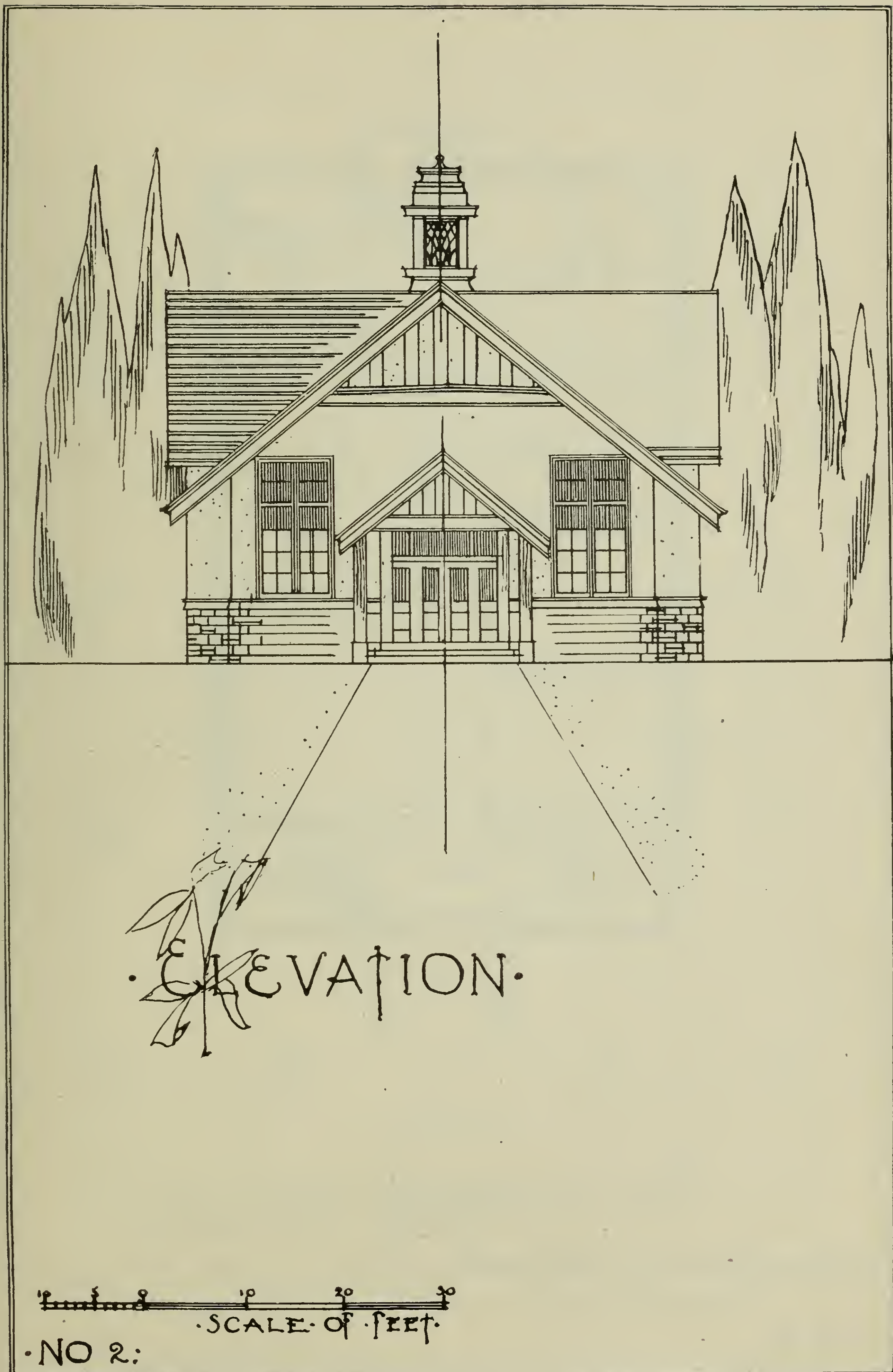
10. Every athletic field shall be available for picnics, sports, school fairs, public meetings and other community gatherings of any kind.

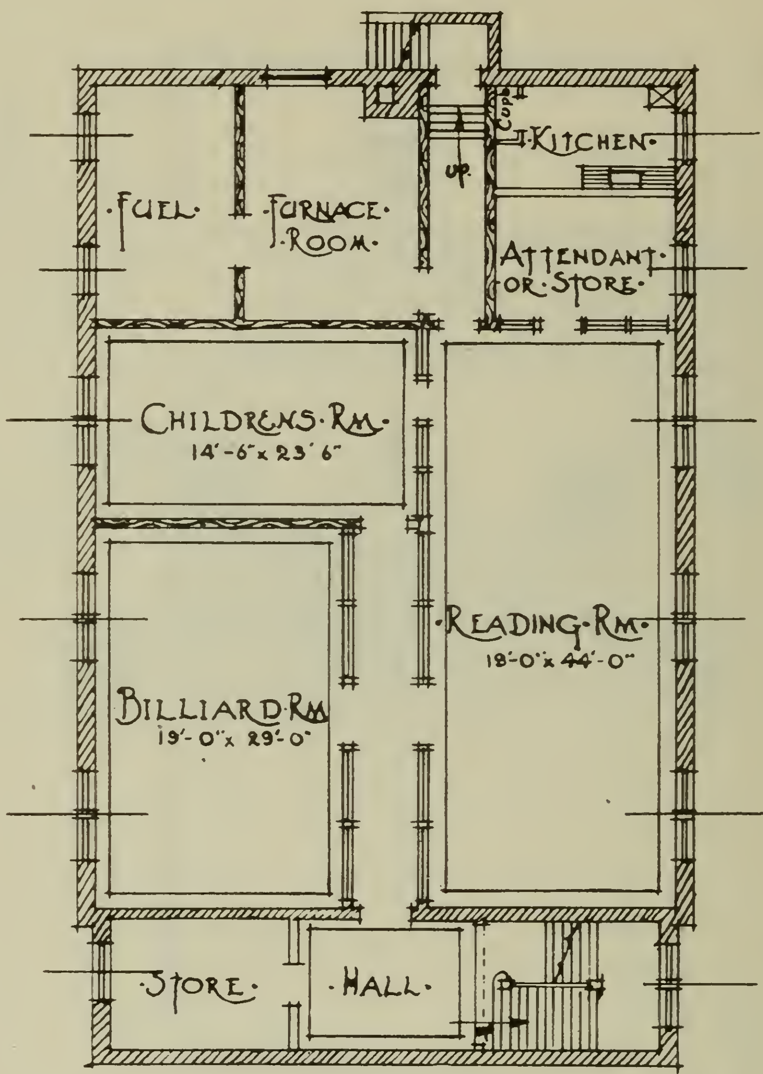
11. The Board appointed in accordance with this Act shall be responsible for the observance of the terms of the Act and of these Regulations.


·ELEVATION·
0 5 10 20 30
·SCALE·OF·FEET·
·NO 1·



READING RM.
ENTRANCE
ATTENDANT
KITCHEN
UP
UP
PLATFORM
250 SEATS
HALL
34'-0" x 52'-0"
AISLE
AISLE
76'-0"
VEST
ENTRANCE
36'-0"
GROUND FLOOR
5
10
20
SCALE OF FEET
NO 1.

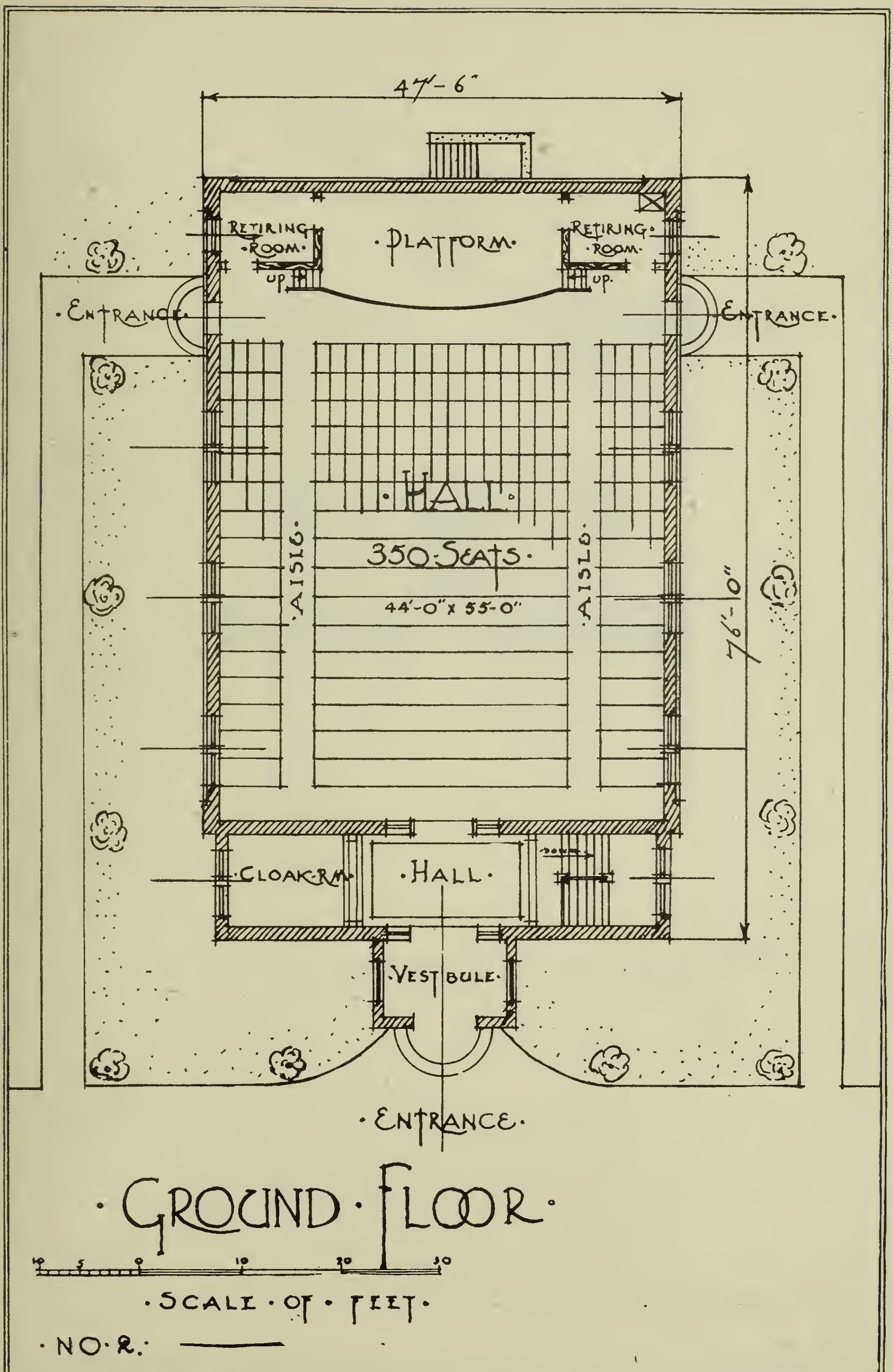

·ELEVATION·
10 5 0 10 20 30
·SCALE·OF·FEET·
·NO 2:

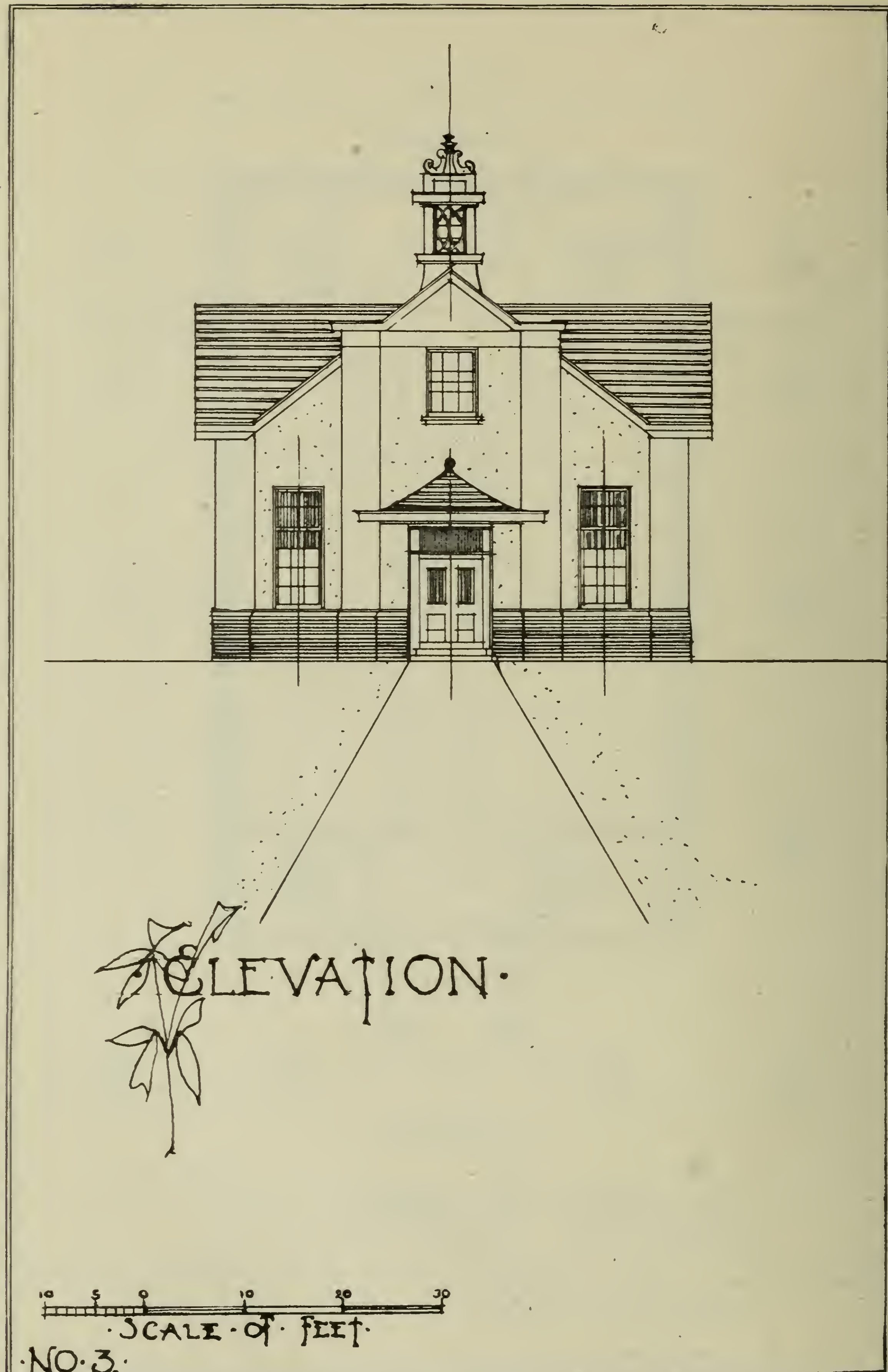


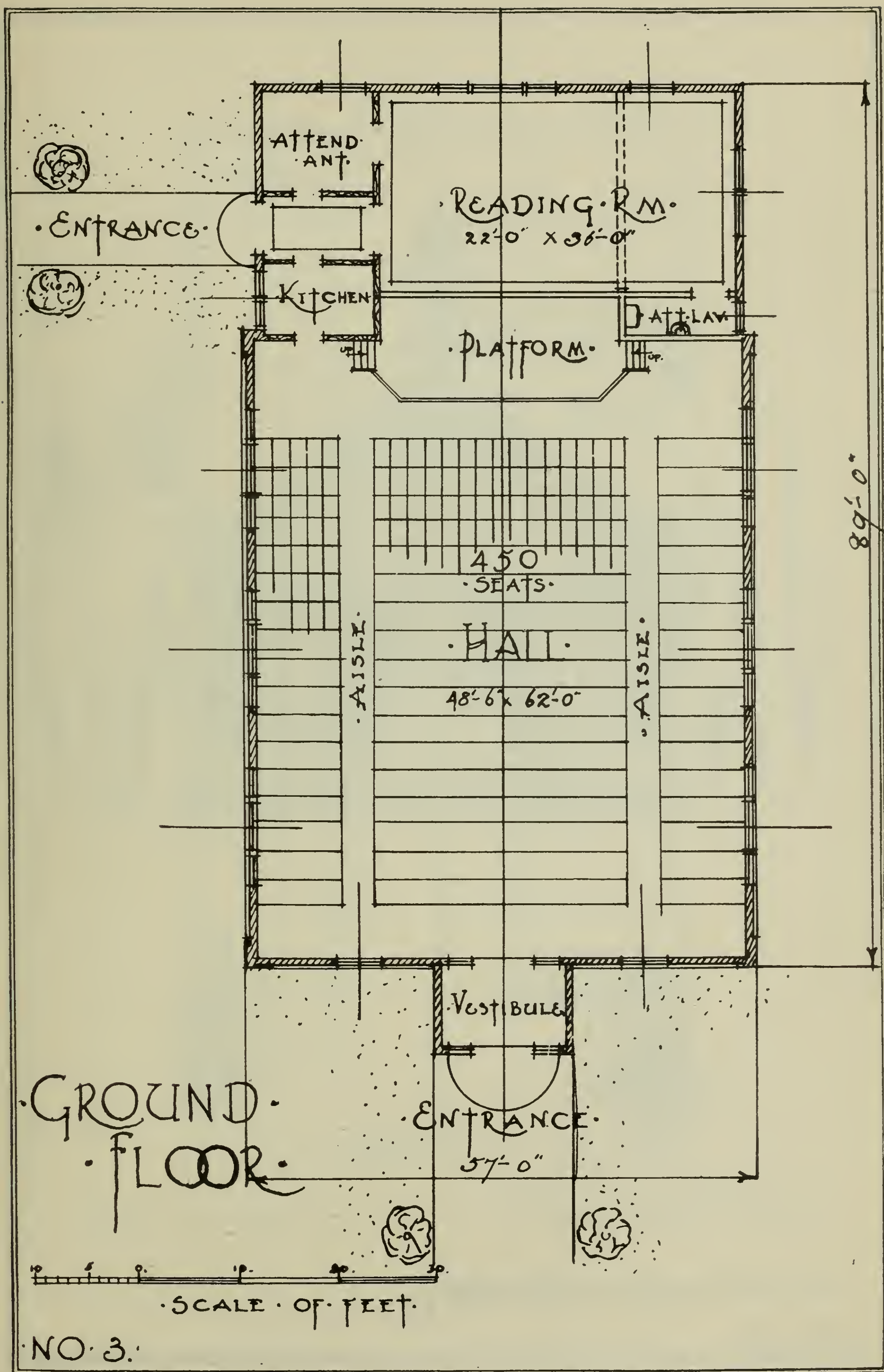
BASEMENT·

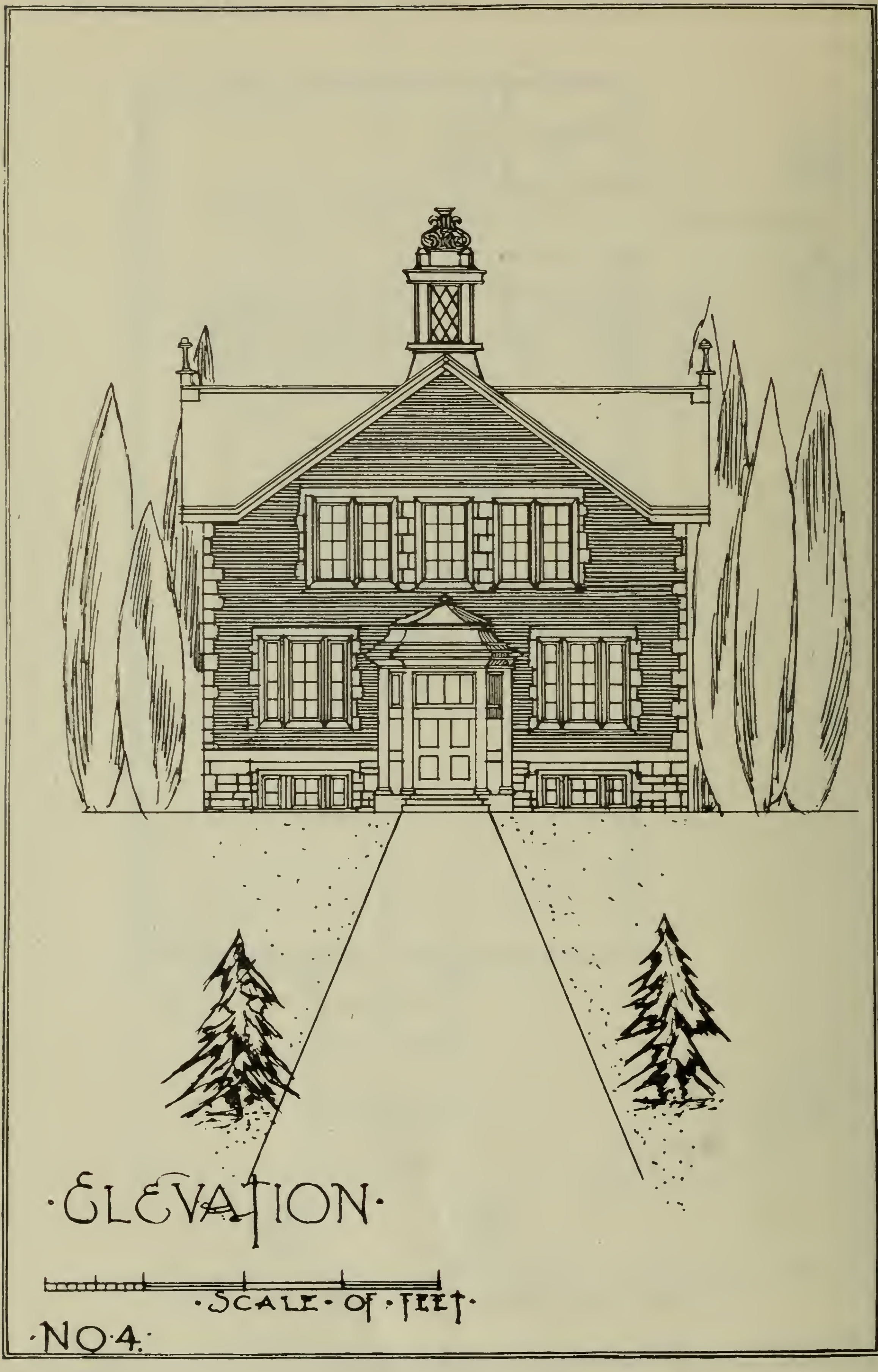
·SCALE·OF·FEET·

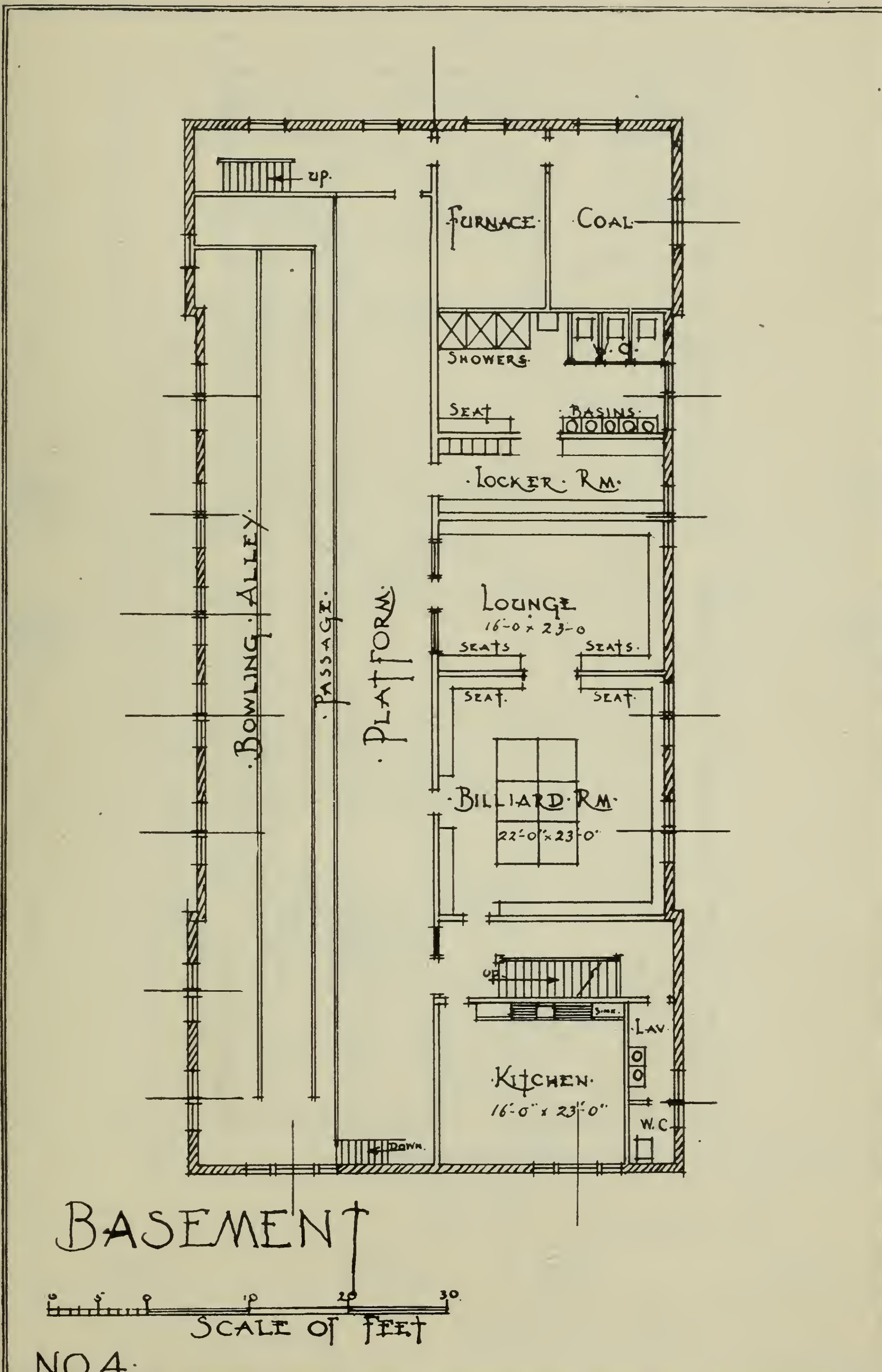
·NO·2·

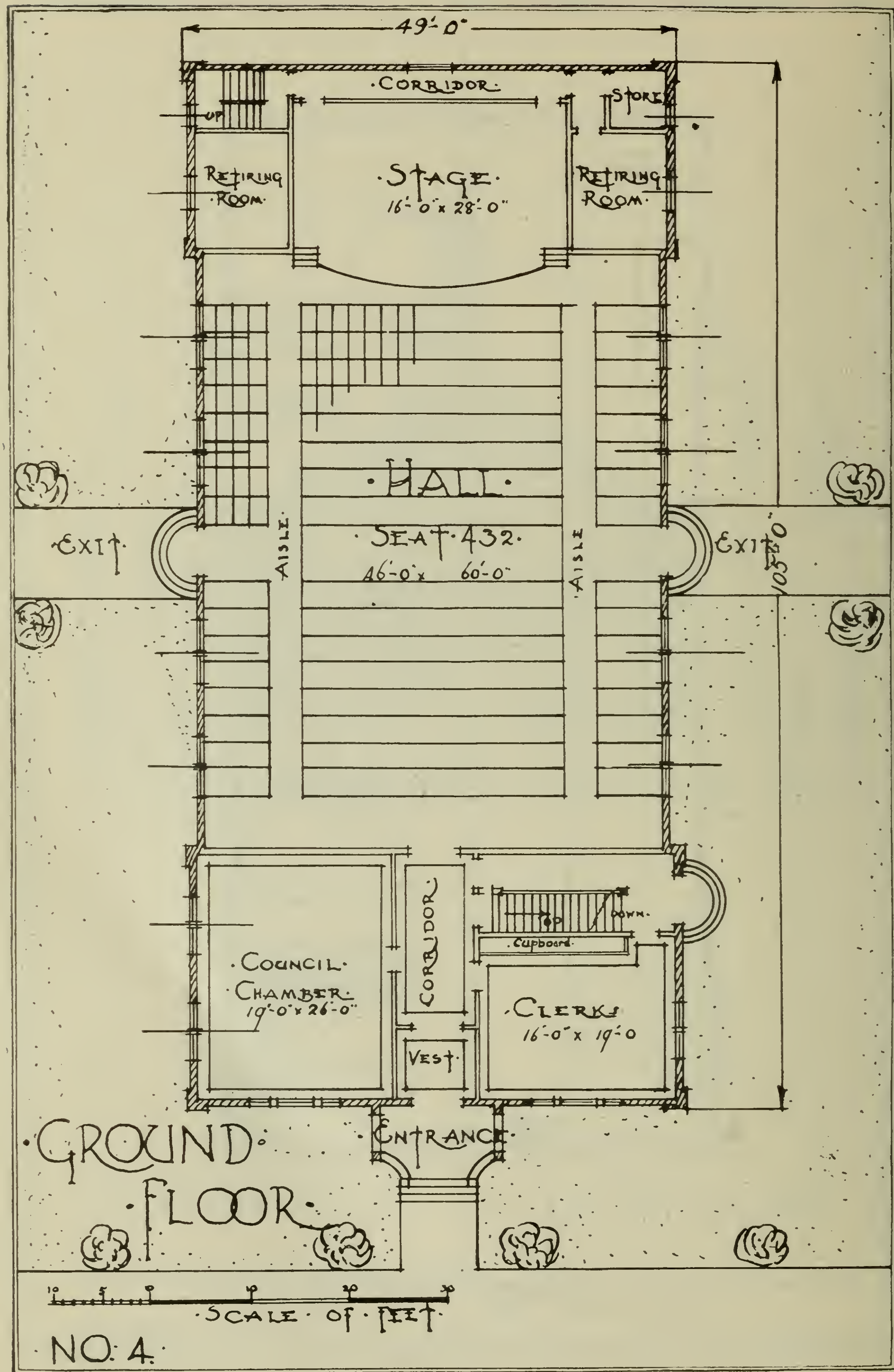

47'-6"
RETIRING ROOM
PLATFORM
RETIRING ROOM
UP
UP
ENTRANCE
ENTRANCE
HALL
350 SEATS
44'-0" x 55'-0"
AISLE
AISLE
76'-10"
CLOAK RM
HALL
DOWN
VESTIBULE
ENTRANCE
GROUND FLOOR
10 5 0 10 20 30
SCALE OF FEET
NO. 2.

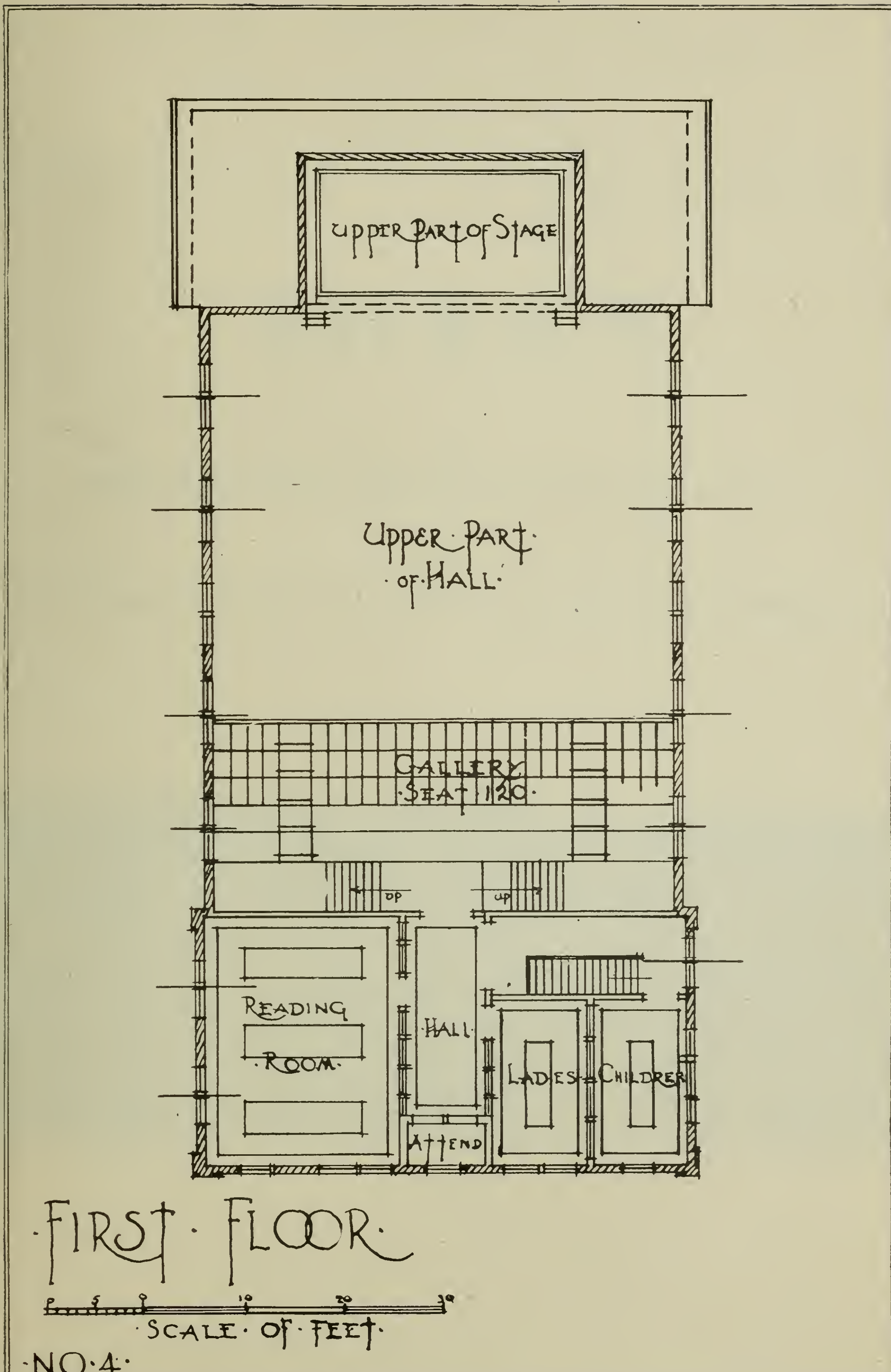

ELEVATION·
10 5 0 10 20 30
·SCALE·OF·FEET·
·NO·3·


ATTEND ANT
ENTRANCE
READING RM.
22'-0" x 36'-0"
KITCHEN
ATT. LAV.
PLATFORM
UP.
UP.
450
SEATS
HALL
48'-6" x 62'-0"
AISLE
AISLE
89'-0"
VESTIBULE
ENTRANCE
57'-0"
GROUND FLOOR
10 5 0 10 20 30
SCALE OF FEET
NO. 3.


·ELEVATION·
·SCALE·OF·FEET·
·NO·4·


UP.
FURNACE
COAL
SHOWERS
W.C.
SEAT
BASINS
LOCKER RM.
BOWLING ALLEY
PASSAGE
PLATFORM
LOUNGE
16-0 x 23-0
SEATS
SEATS
SEAT
SEAT
BILLIARD RM.
22-0 x 23-0
UP
SINK
LAV.
KITCHEN
16-0 x 23-0
W.C.
DOWN
BASEMENT
0 5 10 20 30
SCALE OF FEET
NO. 4.


49'-0"
CORRIDOR
UP
STORE
RETIRING ROOM
STAGE
16'-0" x 28'-0"
RETIRING ROOM
HALL
SEAT 432
46'-0" x 60'-0"
AISLE
AISLE
EXIT
EXIT
105'-0"
COUNCIL CHAMBER
19'-0" x 26'-0"
CORRIDOR
UP
DOWN
Cupboard
CLERKS
16'-0" x 19'-0
VEST
ENTRANCE
GROUND FLOOR
SCALE OF FEET
NO. 4.


UPPER PART OF STAGE
UPPER PART OF HALL
GALLERY SEAT 120
UP
UP
READING ROOM
HALL
ATTEND
LADIES
CHILDREN
FIRST FLOOR
0 5 0 10 20 30
SCALE OF FEET
NO. 4.

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

BULLETIN 274

SHEEP

By

Wade Toole, B.S.A., Professor of Animal Husbandry

and

J. P. Sackville, B.S.A., Associate Professor of Animal Husbandry

At pasture.

TORONTO, ONTARIO, NOVEMBER, 1919

BULLETIN 274] [NOVEMBER, 1919

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

SHEEP

Wade Toole and J. P. Sackville

While sheep raising has from the time of the earliest settlers been a more or less important industry in the province of Ontario, there has always been room for far greater numbers. Records show that the first pure-bred sheep came to this province in 1834 and there were then a considerable number of grades which had been brought in by the settlers. Sheep were among the first live stock brought to Canada, and there were nearly one thousand in what was known as French Canada at the end of the 17th century and at that time Nova Scotia had slightly over 1,000 head. Sheep breeding gradually progressed in the Dominion until 1871 when Canada had 3,155,509 sheep. After this the numbers gradually decreased, and in 1911 they had fallen off by almost 1,000,000, there being then 2,160,600 head. From 1901 to 1911 there were increases in the number of sheep in the Western Provinces amounting to 108,436 and decreases in the Eastern Provinces, including Ontario, of 444,375, or a net decrease in the Dominion of 335,939. The decrease in Ontario alone was 304,268 or 29.08 per cent.

The following table shows the trend of the sheep business in the various provinces of Canada from 1901 to 1911 as well as Ontario's relative position as a sheep-breeding province, as shown by the Dominion census, together with estimates by the Dominion Bureau of Statistics for 1918 and 1919.

Number of Sheep, by Provinces, 1901 and 1911.

Provinces	Sheep		Increase (+) or Decrease (—)		Estimated by Dominion Bureau of Statistics, June 15	
	1901 March 31st	1911 June 1	Amount	Per cent.	1918	1919
Canada	2,510,239	2,174,300	—335,939	—13.38	3,052,748	3,421,958
British Columbia	33,350	39,272	+5,922	+17.76	45,291	44,985
Alberta	87,104	133,592	+46,488	+53.37	332,179	364,498
Saskatchewan	66,048	114,216	+48,168	+72.93	134,177	146,911
Manitoba	29,464	37,322	+7,858	+26.67	136,782	167,170
Ontario	1,046,456	742,188	—304,268	—29.08	972,341	1,101,740
Quebec	654,503	637,088	—17,415	—2.66	959,070	1,007,425
New Brunswick	182,524	158,316	—24,208	—13.26	140,015	212,745
Nova Scotia	285,244	221,074	—64,170	—22.50	259,847	261,529
Prince Edward Island	125,546	91,232	—34,314	—27.33	73,046	114,955

During the period of the Great War, owing to the enhanced prices for wool and mutton, and the need for greater production, the number of sheep increased in all provinces with the exception of Prince Edward Island, and in 1918 had reached 3,052,748 for the Dominion, while the number in Ontario was placed at 972,341.

Ontario has very close to one-third of the sheep and lambs of Canada, and about one-half million are sold or slaughtered off the farms of the province annually. While Ontario had 2,022,735 sheep in 1895, depressed market conditions, fear of losses from the ravages of dogs, and general lack of interest in sheep breeding caused the number to dwindle to the figure of 908,066 in 1916. With prices of wool, lamb and mutton high more interest has been taken in the farm flock and numbers have increased as is shown in the following table:

Sheep and Lambs on Hand in Ontario on July 1.

Statistics compiled by the Ontario Bureau of Industries showing the numbers of sheep and lambs on hand on July 1 of each year, whereas the Dominion census was taken on March 31 for 1901 and on June 1 for 1911.

Year	No.	Year	No.	Year	No.
1882	1,915,303	1895	2,022,735	1908	1,143,898
1883	1,868,784	1896	1,849,348	1909	1,130,667
1884	1,890,733	1897	1.690,350	1910	1,065,101
1885	1,755,605	1898	1,677,014	1911	1,040,245
1886	1,610,949	1899	1,772,604	1912	1,021,848
1887	1,396,161	1900	1,797,213	1913	996,155
1888	1,349,044	1901	1,761,799	1914	922,375
1889	1,344,180	1902	1,715,513	1915	908,095
1890	1,339,695	1903	1,642,627	1916	908,066
1891	1,693,751	1904	1,455,482	1917	956,986
1892	1,850,473	1905	1,324,153	*1918	972,341
1893	1,935,938	1906	1,304,809	*1919	1,101,740
1894	2,015,805	1907	1,106,083		

*On June 15th by Ontario Department of Agriculture in co-operation with the Dominion Bureau of Statistics.

These figures give some idea of the extent of the sheep industry in Ontario. While numbers dwindled for a time there has been a steady improvement in quality, and with better prices and more interest in this branch of the live-stock business numbers should still increase and quality continue to improve. Ontario has in the neighborhood of twenty-five million acres of assessed land with nearly fifteen million acres cleared. With under one million sheep there is less than one sheep for every twenty-five acres of assessed land and less than one to every fifteen acres of cleared land. When we consider that from six to seven sheep can be maintained on what is required to feed one cow there seems to be room for great developments in Ontario's sheep industry.

One of the greatest factors tending to improve the sheep breeding industry in the Province is the work in wool grading and co-operative selling that has been carried on by the Ontario Sheep Breeders Association with the aid of the Live Stock Branch of Ontario Department of Agriculture for the past three seasons. It speaks well for the success of this work that the amount sent to Guelph to be graded each year shows a substantial increase and the number of satisfied producers also continues to grow.

In 1917 the Association charged five cents per fleece for grading and selling the wool. In addition the grower paid freight to Guelph. At the close of the season's business 1 per cent. of the value of the wool was refunded to all shippers.

In 1918 the Association charged 1 cent per pound, and the Canadian Co-operative Wool Growers, Limited, through which the wool was sold, charged 1¼ cents per pound against the wool. Besides this a membership fee of 50 cents was charged for fifteen fleeces or less, and $1 for more than fifteen fleeces. The grower also paid freight to Guelph.

In 1919 the Association charged 1 cent per pound, and the Canadian Co-operative Wool Growers, Limited, 2 cents per pound. Membership fees were the same as in the previous year, and freight to Guelph was paid by the grower. A refund of one-half of one per cent. of the value of the wool was made to all shippers.

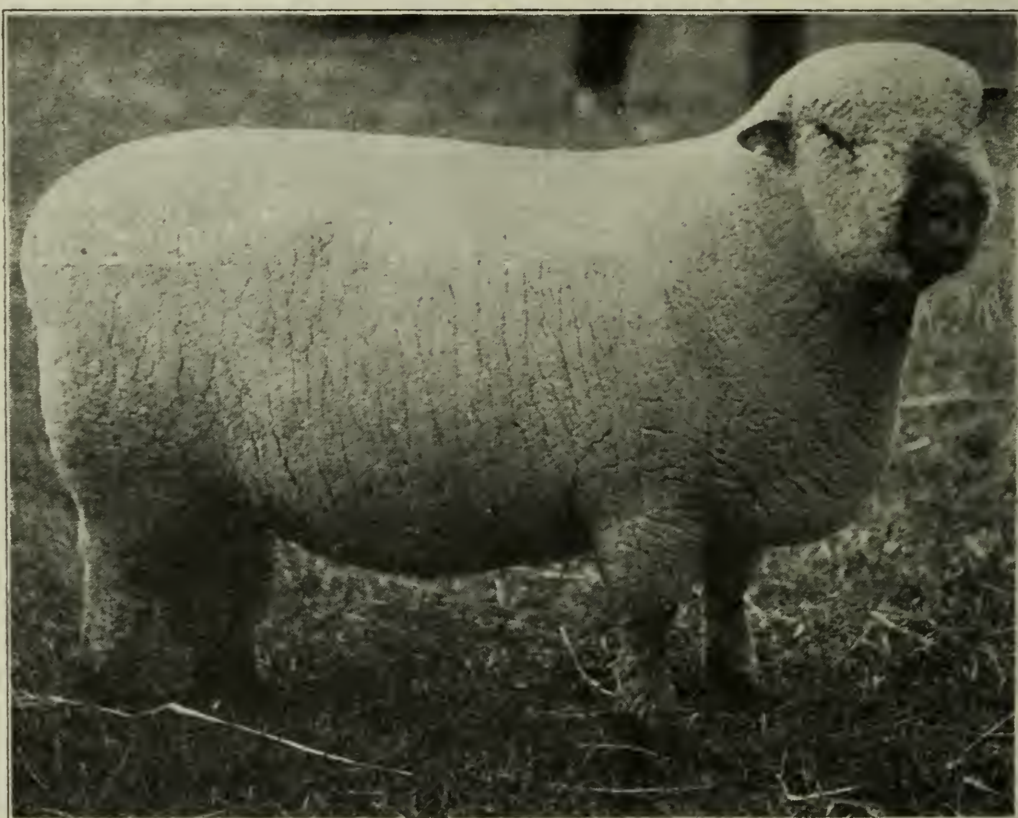
The growth of the business of selling wool co-operatively in the Province is indicated by the following table showing amounts of the various grades handled in each of the three years in which the scheme has been followed:

Grade	Amount handled in 1917	Amount handled in 1918	Amount handled in 1919	Selling price per lb. in 1917	Selling price per lb. in 1918	Selling price per lb. in 1919
	lbs.	lbs.	lbs.	cts.	cts.	cts.
Fine Staple	....	740	....	....	75	....
Fine Medium Staple	....	807	....	....	76	....
Medium Staple	....	281	....	....	73	....
Fine Combing	....	....	385	....	....	70
Fine Clothing	....	573	222	....	70	64
Fine Medium Combing	3,461	8,102	7,492	67	76¼	67
Fine Medium Clothing	....	979	6,581	....	70	62
Medium Combing	82,241	129,518	204,519	66	76¼	67
Medium Clothing	7,184½	24,678	18,173	67	73½	62
Low Medium Combing	64,636	228,281	256,620	63⅛	73¼	60
Low Combing	....	169,297	96,429	....	67	52
Lustre Combing	4,480	....	....	57	....	....
Coarse	93,444	104,820	113,748	57	60¾	45
Rejects						
Burry and Seedy	8,835 (Burry and Seedy, Cotts, Dead)	15,812	13,338	50 (Burry and Seedy, Cotts, Dead)	42	40
Cotts		26,724	22,851		50	35
Dead		5,197	4,615		50	45
Gray and Black	1,351	4,401	3,823	46	41	40
Locks and Pieces	604	163	....	34	....	....
Washed Wool (fine)	....	7,766 (fine and coarse)	3,848	78 (fine and coarse)	95	82
Washed Wool (coarse)	....		2,790		85	65
Tub Washed Wool	....	1,300	....	....	90	....
Tags	4,886	18,769	18,343	26	16½	15
Mohair	....	29	13	....	....	40
Sisal	....	....	1,388	....	....	52
Miscellaneous	....	....	138	....	....	....
Totals	271,122½	748,237	775,316			

CLASSIFICATION OF SHEEP.

With very few exceptions the sheep found on the farms in the Province of Ontario are maintained for the production of mutton, the wool, though of considerable importance, is looked upon as a secondary consideration. The various breeds belonging to this class although varying more or less in type, all possess general characteristics that stamp them as *mutton sheep*. A general classification of the breeds of mutton sheep is made according to fleece, the two classes being commonly known as the *medium wool* breeds and the *coarse or long wool* breeds. The sheep belonging to the medium wool breeds possess somewhat finer and denser wool, while the color of the hair on the face and legs generally varies from a light to a dark brown. Together with good quality of wool, sheep of this class are recognized as possessing pronounced mutton form. The breeds belonging to this class are as follows: Shropshire, Southdown, Oxford Down, Hampshire, Suffolk, Dorset Horn and Cheviot. With the exception of the Dorset Horn and occasionally the Cheviot these breeds are all hornless.

The long or coarse wool breeds are characterized by having a much longer, coarser fleece, lacking as a rule the density found in the medium wool breeds. They are usually somewhat heavier and possibly a little more upstanding and most of the breeds belonging to this class have either white or mottled faces.



Mutton type.

The long or coarse wool class is represented by the following breeds: Leicester. Lincoln, Cotswold and Romney Marsh. These are all hornless.

Characteristics of the Mutton Sheep. In conformation the mutton sheep approaches very closely that of the beef animal—low set, broad, deep and thick with straight, parallel lines and deeply and evenly fleshed. Fullness and rotundity of form, compactness and smoothness coupled with a stylish appearance should be emphasized.

The Wool Breeds. In addition to the mutton breeds already mentioned there is another type or class of sheep known as the *Fine Wool* class. They are bred practically altogether for their wool, which is of the finest quality and suitable for the manufacture of finest grades of cloth. To this class belong the *Merino and Rambouillet.* Having been selected for the production of wool, it is only natural to find that the mutton characteristics common to the other kinds are not found in this particular class. They are fashioned more after the peaked or wedge shape of the dairy cow; carrying less width and fleshing. The best specimens of this class have heavy folds or wrinkles over the neck and shoulder which permit of a greater surface of body, which lends itself to the production of a heavy fleece of wool. Merino and Rambouillet blood has been introduced to a more or less extent into the mutton flocks on the ranges as the instinct to band together in large numbers is a distinct advantage under such conditions and is natural to this particular class, and is not true of the mutton breeds.

The Shropshire.

The native home of the Shropshire is in the counties of Shropshire and Stafford, England. The breed has been developed by the use of Southdown, Leicester and Cotswold blood on the native stock.

Characteristics. In general appearance the Shropshire conforms to what is recognized as excellent mutton type. It is somewhat heavier than the Southdown, rams weighing at maturity about 225 lbs. and ewes about 160 lbs. The head is

A trio of Shropshires.

covered with dense wool, which should completely cover the entire face excepting a small part of the nose. The legs are also well woolled. The color of head and legs is usually a dark brown, being considerably darker than those of the Southdown. There should be an absence of black wool on the head. The wool is reasonably compact, of good quality, medium fine, and should be free from black fibres. It is longer than the Southdown but shorter than the Oxford, being about three and one-half inches in length. The skin should be a bright pink.

As a breed the Shropshire has been very popular in Ontario. Like the Southdown they are very hardy and do well under climatic and feed conditions in this province. The ewes are fairly prolific and the quality of the mutton is good.

The Southdown.

This breed originated in Sussex County, Southeastern England. Southdowns, as we know them at the present time, are the result of improvement of the native stock of Sussex County. This improvement was brought about by selection and careful breeding, until to-day the breed ranks among the first as a mutton sheep.

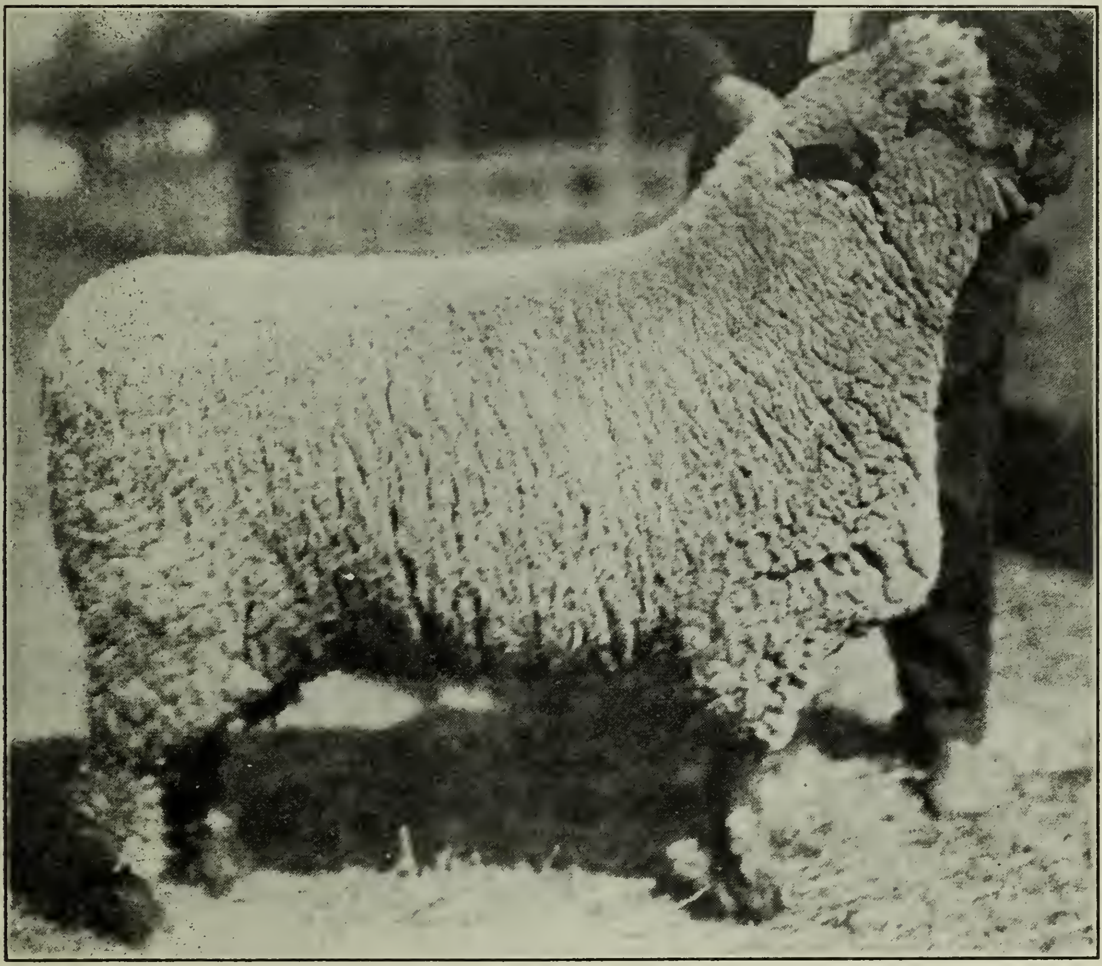
Characteristics. They are the smallest of the down breeds, the mature ram weighing about 175 lbs., the ewe 135 lbs. The shortness of leg, compactness of form and general smoothness of outline give this breed an advantage as they weigh well for their appearance, and what they lack in size is made up, in part at least, by their excellent quality as the mutton of this breed has always held a premier place on the largest markets and with the most discriminating mutton consumers. A blocky, compact, well-rounded-out form is characteristic of the breed, and this, together with the fact that the present day demand is for a light lamb, is a reason for believing that this breed will grow in popularity in Ontario. The head is covered with a cap of wool which should not extend below the eyes. This, as with the wool covering the legs, is a greyish-brown or mouse color. The wool is of fine texture, should be dense all over the body, averaging possibly two and one-half inches in length. Associated with this the skin should be a bright cherry pink.

Southdown ram.

The Oxford Down.

As the name indicates this breed is a native of Oxford County, England, and the foundation was begun by a cross of a Cotswold ram with a Hampshire ewe. From the result of this cross followed by selection a fairly uniform breed of sheep was developed.

Characteristics. In some respects this breed resembles the Shropshire. They have, however, more scale, being the largest of the medium woolled breed. Rams weigh 275 lbs. when fully developed, and 200 lbs. is not uncommon for ewes. The wool covering of the head does not extend below the eyes nor is it as dense as with the Shropshire. The color of the head and legs is usually a uniform dark brown. The ear is inclined to be larger, the face longer, and the entire head lacks the general refinement found in the Shropshire. The fleece is longer and coarser than the other down breeds, but withal is usually of good quality and the sheep shears a heavy satisfactory fleece.



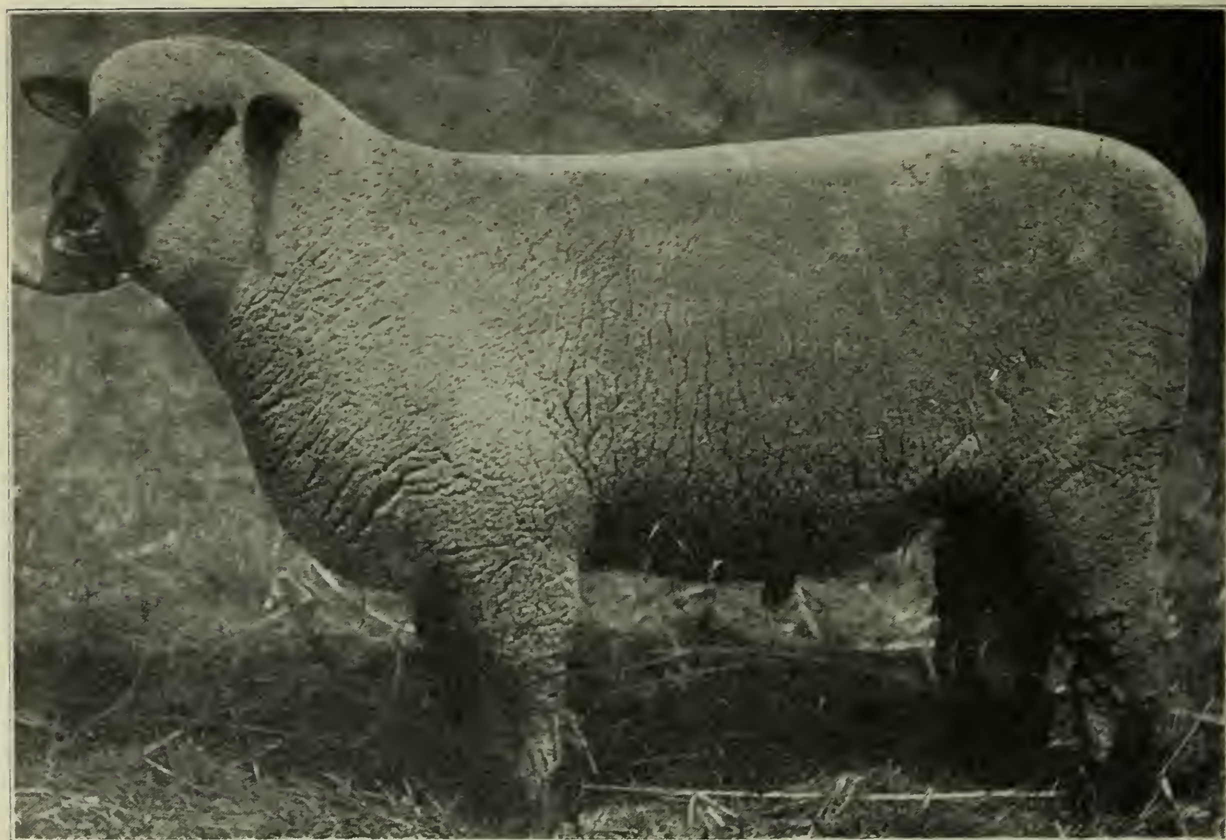
Oxford ram.

The Hampshire Down.

To the county of Hampshire, England, can be traced the foundation of this breed. The original stock differed considerably from Hampshires as we know them to-day. They were inferior sheep possessing horns and lacking in those characteristics that go to make a good mutton sheep. These animals were improved by the use of the blood of the Southdown, and out of this cross, together with rigid selection, developed the present-day Hampshire.

Characteristics. The Hampshire is the second largest of the medium woolled breeds being surpassed only by the Oxford. Mature rams should weigh around 250 lbs. and ewes 190 lbs. The head is woolled to a point just below the eyes and on the cheeks, the color of both head and legs being a dark brown bordering in some cases to black. The ear is long and droops somewhat, the head large and inclined to be rather Roman nosed.

As regards wool the Hampshire shears a fleece of medium length and quality, but lacks the quantity reasonably expected from sheep of their weight. As a mutton producer, however, the breed ranks high, the lambs mature early, their flesh is of excellent quality and they are looked upon with considerable favor where early lambs are required for the market.



Hampshire ram.

A group of Suffolks.

The Suffolk Down.

Originating in the counties of Norfolk and Suffolk, England, this breed has been improved by the use of Southdown and Hampshire rams. The Southdown blood improved the breed in respect to quality and general mutton form, the Hampshire increasing the weight and scale.

Characteristics. The head is fairly long, distinctly black in color and the wool does not cover the head beyond a point behind the ears. The ears are rather large and the same color as the head and legs. In size the Suffolk ranks between the Shropshire and Hampshire, the rams weighing around 230 lbs. and the ewes about 180 lbs.

The Suffolk Down as a mutton sheep ranks high, the infusion of the Southdown blood giving it a high quality of flesh. As a feeder too, the Suffolk has given a good account of itself, the lambs making very satisfactory gains as compared with those of other breeds.

In regard to fleece this breed is only fair, the wool is of good quality, being reasonably fine, but the breed is said to be a comparatively light shearer.

The Dorset Horn.

The counties of Dorset, Somerset and Wiltshire, of Central and Southern England, is the native home of this breed. The general improvement of the breed has been brought about by careful breeding and selection, with the result that the modern Dorset Horn differs considerably from the original stock.

Characteristics. The outstanding feature of this breed is that they are horned (both sexes), those on the male curving backwards and around spirally, while those on the ewe curve downwards and slightly forward. The face and legs are white; the same is true of the hoofs and nose. There is a cap of wool on the head which should not extend below the eyes. This breed does not always exhibit the fullness and compactness of form found in some other breeds of the medium wool class, but the best specimens of the breed conform fairly well to mutton type. In size the Dorset is about the same as the Shropshire, mature rams weighing around 225 lbs., the ewes about 165 lbs.

The chief claim for this breed is that they are well adapted for the production of early lambs, the ewes are said to breed at almost any time of the year, and it is not uncommon in some Dorset flocks for the ewes to raise two crops of lambs in one year. In addition to this they are fairly prolific. The quality of mutton, particularly with young fat lambs, is good, while that from older sheep is classed as fair.

The Cheviot.

That section of country between England and Scotland, known as the Cheviot Hills, is claimed as the original home of this breed. They have been improved by crossing with Leicester, Merino and the Black-faced Highland.

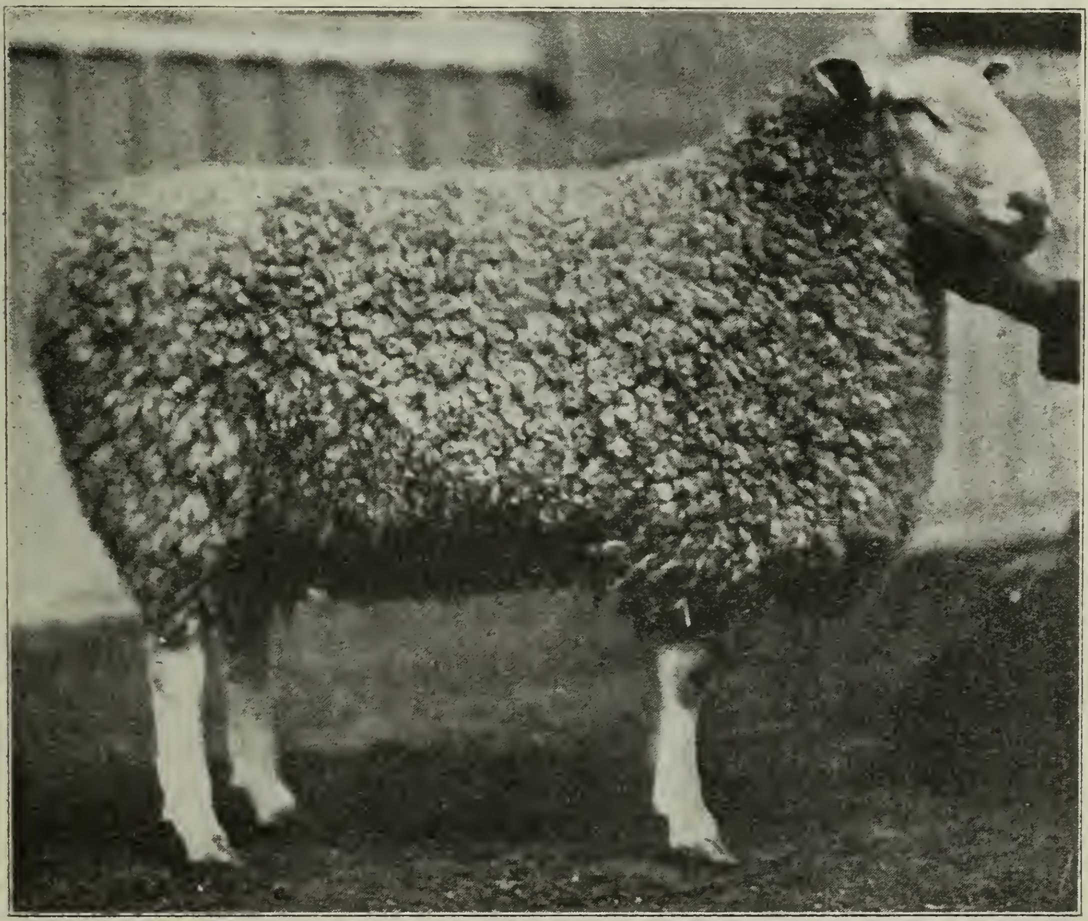
Characteristics.—The head is free of wool, being covered with white hair. The face is inclined to show a Roman nose not unlike the Leicester. It is not uncommon to find horns in the rams. The Cheviot is medium in weight, the rams often reaching 225 lbs. or more, while the ewe will average 160 lbs. The fleece has been said to lack compactness, although within recent years more attention has been given to the question of density of the wool. In its native home the Cheviot is looked upon as an exceptionally good grazing sheep.

Group of Dorsets.

Cheviot ewe and ram.

The Leicester.

This breed derives its name from the county of Leicester, England, where it has been bred since very early times. Much credit is due Robert Bakewell for the improvement of this breed. From a slow-maturing, hard-feeding, coarse, leggy sheep he developed a very superior animal showing excellent mutton qualities. This improvement was brought about by close breeding and careful selection. The breeders of long wool sheep owe much to the Leicester, as this breed has done a great deal in the improvement and development of practically all the sheep of the long wool type.



Leicester ram.

Characteristics. The general impression of the Leicester is that they are inclined to be long in the leg, the fact that their legs are absolutely bare of wool possibly tends to exaggerate this. They are comparatively broad in the back and carry out a full level rump. There is an entire absence of wool on the head, which is covered with short, fine, white hair, the skin often showing a slight bluish tint. A tendency towards a Roman nose is quite common in this breed. Black spots on the head, if not too large or too numerous, are not objectionable. The Leicester shears a real good fleece of long wool. This breed is possibly the smallest of the long wool breeds, rams weighing from 225 to 250 lbs., and the ewes as much as 200 lbs. This breed has a fairly wide distribution over the province, many of the grade flocks showing a predominance of the blood of the Leicester.

The Cotswold.

This breed originated in the County of Gloucester, in Central South-western England. By the use of Leicester rams on the native stock both the quality of the mutton and wool was greatly improved.

Characteristics. The head of the Cotswold has a tendency to be Roman-nosed and is covered with wool that hangs in long ringlets from above the eye, spreading out over the face. The legs are also woolled to below the knees and hocks. The hair on the face and head may be either white or mottled with brown. The wool is comparatively coarse and long, and hangs in locks or ringlets over the body; the

Cotswold ram.

fleece is usually parted down the back, falling away on either side. This is a large breed, mature rams often reaching a weight of 275 lbs. and the ewes from 200 to 230 lbs. The Cotswold is a stylish sheep, possessing a bold, graceful carriage, and this with the characteristic wool covering of the breed gives it a very attractive appearance.

The Lincoln.

This breed has been bred for many years in Lincoln County, England. The native stock lacked many of the good features of the present-day Lincoln, being coarse and slow maturing. The infusion of Leicester blood did much to improve the mutton qualities and to bring the breed into prominence.

Characteristics. Like the Leicester and Cotswold, the Lincoln is inclined to have a Roman nose. The face is usually white, although may have brown spots. A small foretop of wool is found on the head and the wool on the body is com-

Five Lincoln shearling rams.

paratively long and coarse, hangs in ringlets, and is usually parted down the back. The Lincoln shears a very heavy fleece of wool. A weight of from 20 to 25 lbs. of unwashed wool has been known in case of mature rams.

In common with some others of the long wool breeds the Lincoln may be criticized for too great length of leg, but the back is broad and the rump level and full. The Lincoln is the largest of the long wool breeds, 300 lbs. being the standard weight for mature rams, and the ewes weigh close to 275 lbs.

The Romney Marsh or Kent.

Although not widely distributed in Ontario, there have been a few flocks established within recent years. They are native of Kent County, England. This dis-

Kent or Romney Marsh ram.

trict is comparatively flat and moist, and this breed is said to give a good account of themselves under such conditions.

Characteristics. In general appearances this breed resembles the Lincoln, although lacking the extreme size of the Lincoln. The face is white and usually covered with a short cap of wool. They shear a good fleece of averge weight. As already suggested, they are better adapted for grazing on low, flat land, than some of the other breeds, and they are reported as being comparatively free from many of the diseases that affect sheep.

The Corriedale.

Very little is known about this breed in America. They are of New Zealand origin, and were developed by the cross of a Lincoln ram on Merino ewes, the aim being to produce a sheep that would be suitable for range conditions, and at the same time would produce reasonably good mutton and wool. They are considered as being more or less of a general purpose sheep. The wool is a little longer than the Rambouillet, and is more dense and finer, while the lambs from the Corriedale ewes are said to weigh as much as 100 to 150 lbs. when six months old and good enough to top the London market.

The following description adopted by the American Corriedale Association describes the characteristics of this breed:—(*a*) Body large and symmetrical, general appearance to be bold and attractive. (*b*) Head bold and strong, well woolled down to the eyes, but not below, free from horns or scurs, with clear, white face free from any trace of black or brown hairs. (*c*) Neck strong, well set at the shoulders and free from any folds or conspicuous wrinkles. (*d*) Legs strong, set squarely under the sheep and well apart, also free from any trace of black or brown hairs.

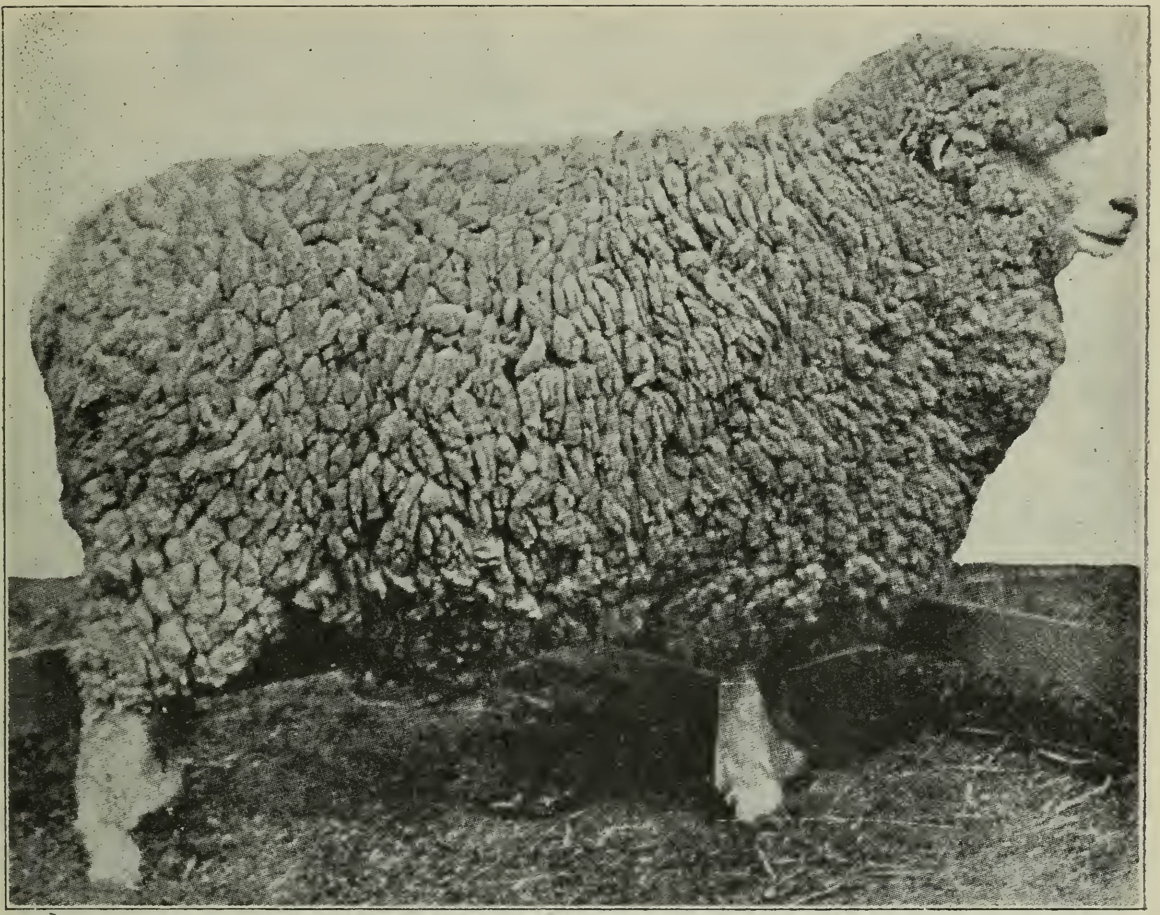
The Rambouillet.

The Rambouillet is really of the same origin as the Merino, although developed in France on a large estate in the village of Rambouillet. The French Government did considerable work in an endeavor to improve the breed, with the result that the Rambouillet is larger, possesses more of the mutton form, and is said to be hardier and has a superior quality of fleece as compared with the stock originally brought over from Spain. The head is large, and in most cases the males have horns the same shape as the Merino; the ewes are hornless. The folds or wrinkles of the skin are common to this breed, although not being so marked as with the Merino. In fact the Rambouillet, as a breed, might be classed midway between the Merino and the recognized mutton breeds.

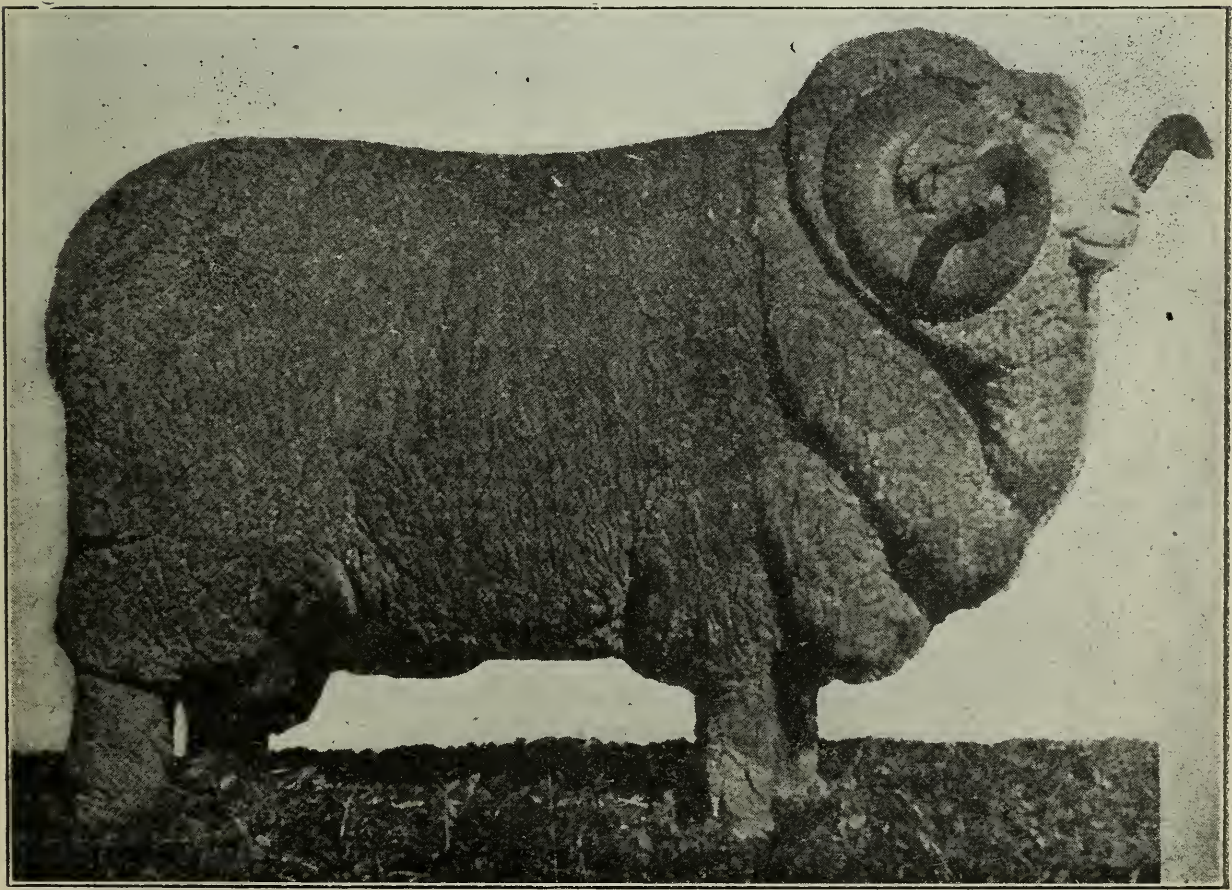
The Merino.

To this particular breed belong three classes differing somewhat in general type, but for our purpose it is not necessary to go into detail, the general characteristics of the breed as a whole being sufficient.

They are of Spanish origin, and as suggested previously the Merino has been bred for production of wool, and for this reason individuals of the breed differ considerably in type as compared with the mutton breeds. The fullness and rotundity of form is lacking, and instead of the fleshing found on other breeds a general, bare, muscular appearance is evident. On parts of the body, especially the neck and shoulders, are to be found folds or wrinkles in the skin, the number of these folds varying with the different classes.



Corriedale ram.



Rambouillet Merino ram.

The head is of medium size, and fairly well covered with wool. The rams possess horns, which are large and have considerable curl to them. The size of the Merino is not great, varying according to the different classes. The wool found on the Merino is of finest quality, the length and size of wool fibre varying with the different classes. In all classes, however, the wool should be dense, the fibre fine, the staple strong and the crimp close.

A special type of Merino has been developed in the United States called the Delaine Merino, a little larger and more compact in form than the other Merinos; a sort of dual-purpose breed, combining wool and mutton qualities.

The Karakule Sheep.

This class of sheep are maintained altogether for the production of the pelt, the lambs being slaughtered when only a few days old and the skins sold on the market as Persian lamb. Very satisfactory results have been attained by crossing the breed with long wool sheep such as the Lincoln, the offspring in most cases being black with a lustrous, tightly-curled fleece and a pelt which commands a compar-

Karakules.

atively high price. Very few flocks are found in Ontario. The business of breeding this particular class of sheep is at the present in the hands of a few men. As a matter of fact it is an industry that demands considerable skill and it is doubtful whether there will be any remarkable development in the business in this province.

The sheep are native of Bokhara, Central Asia, and were first introduced into America in 1908. In appearance Karakule sheep are long of body, medium in size and possess steep rumps, broad tails and long, drooping ears. The wool is long, coarse and hair-like on mature sheep and a light gray to brown in color.

SELECTION AND MATING.

The Ram. In order to make any progress in the development of live stock it is absolutely essential to maintain a good pure-bred sire for use on the herds and flocks. There is no more direct or economical method of improvement. An animal that has been bred and developed from good ancestors for a number of generations is bound to give better results as a sire than a scrub. There is possibly less excuse for the use of a grade ram than is the case with other classes of farm animals. The initial cost of a pure-bred is reasonable, the increase is rapid and the number in the flock comparatively large, which all means the returns from the use of a good ram in the flock are soon apparent. Not only should the ram be a pure-bred, but he should possess all the characteristics that are associated with a good sire, together with proper type and comformation. Unless a sire possesses abundance of vigor and vitality he will prove a disappointment as a breeder. A broad, short head, bright, full eye, large muzzle, thick neck, a deep, full chest, broad and deep in heart girth and a bold, stylish carriage all indicate an animal with plenty of strength and constitutional vigor. He should also conform to the true mutton type, being short and straight in leg supported on strong upright pasterns, full and deep in body, straight in his lines, long and level hindquarters with full, deep thighs. He should possess to a marked degree all the characteristics of the breed which he represents. The fleece, of course, will vary, depending upon the particular breed to which he belongs, but in all breeds it should show density and quality, together with sufficient length consistent with the breed in question. A clear, pink skin is an indication of health and quality and should not be overlooked. There should be no indication of horns or scurs on those breeds that are hornless. In selecting a ram many prefer to choose a twin, believing that the chances for double lambs will be greater than from a single ram.

Age to Breed. There is considerable difference of opinion regarding the age at which a ram should be brought into service. Where comparatively small flocks are maintained there is a tendency to use a ram lamb. Such a ram can be purchased cheaper, and on flocks ranging from half a dozen to twenty, they will give satisfactory results provided they are judiciously handled. On farms where twenty-five or more ewes are to be bred it would be advisable to secure the service of a mature ram. There is the added advantage of purchasing an older ram: the buyer knows exactly what he is getting, which is not always true when buying a lamb. In other words a promising lamb is sometimes disappointing as a mature ram.

Number of Ewes to Ram. Under ordinary conditions of mating, that is to say where hand coupling is not practised, a mature ram will care for a flock of from forty to fifty ewes. As already suggested about half of this number would be sufficient for a lamb approximately eight months old. With the ordinary flock of fifty ewes or less it will be necessary to arrange for a change of ram every two years to prevent too close breeding. Of course, where more than fifty ewes are maintained and more than one ram in service required, it will be possible to retain the sire in the flock for a longer period.

Feeding and Care of Ram. The aim should be to keep the ram in good vigorous condition at all times of the year. A short time before the breeding season commences a light feed of grain once per day might be advisable. During the time the ram is doing service, in the flock a fairly liberal supply of grain should be fed. A ration consisting of two parts oats and one part of bran gives good results. A mature ram can safely be fed from one to three pounds per day, the amount depending largely on the work the ram is doing. This, however, is a matter of the feeder's judgment. In order to retain the vitality of the ram and to get best results it is not wise to let him run with the flock continuously during the breeding season. A satisfactory plan is to allow the ram to run with the ewes during the daytime, shutting him away at night. In this way it is possible to give him two feeds of grain a day and in addition an opportunity is afforded for a rest. The question of mating is discussed more fully in another section. At the conclusion of the breeding season the ram may be allowed to run with the flock. The ration fed to the flock will usually suffice to maintain the ram in proper condition during the winter.

As the ewes approach lambing time it might be advisable to remove the ram from the ewe flock, which will avoid any danger of injuring the in-lamb ewe. When grass comes the ram may be turned to pasture with the flock until later in the summer, at which time it is well to separate him from the ewes; otherwise, as the cool nights in the fall approach, there is danger of the ewes breeding. During the fall, the ram may be allowed to pasture with the male lambs, or if that is not convenient give him the run of a grass paddock in company with some other member of the flock if possible.

The Ewe Flock. Where the object is the production of lamb and wool for the ordinary market a flock of grade ewes will give satisfactory results provided they are of the proper type, the flock culled carefully and mated to a good pure-bred ram. The ewes should show all the characteristics desirable in a mutton sheep, i.e., blockiness and fullness of form, strength and vigor, together with feminine character. The type of fleece already described in discussing the ram should also be looked for in the ewe flock. The importance of selection in order to maintain a high standard and to develop uniformity in the flock is a feature of sheep management that should be carefully observed. In order to cull the flock intelligently it is important that the owner have an intimate knowledge of every member of the flock. It may happen that some of the most useful ewes in the flock may be in thin condition due to nursing two husky lambs all summer; this being true, there is a danger of discarding a desirable ewe. A ewe sound in mouth and udder and a good breeder should be retained in the flock until her period of usefulness is past. However, there are usually a few members of the flock, i.e., those with broken mouths, defective udders, undesirable conformation or non-breeders that should be discarded and their places taken by a few of the choicest ewe lambs. Possibly the best time to do the culling is at the time the lambs are weaned. At that time the flock can be gone over carefully, and it is a favorable time to detect the ewes that have not proven their worth. At this particular time, too, the lamb flock is sufficiently developed, that the ewe lambs to be kept may be intelligently selected.

Fall Management of the Flock. After the lambs have been separated from the flock, the aim should be to prepare the ewes for the subsequent lamb crop. The drain on the ewes during the few months previous to weaning will usually result in the flock being in thin condition, and it is necessary that they receive good care so when the breeding season comes they are in good condition and gaining in flesh. It will be necessary to put the ewes on scant pasture a few days after weaning in order to check the milk flow and give them a chance to dry off. At the same time the flock should be watched carefully for a few days and milked out by hand. Unless this is attended to there is a possibility of udder trouble as it is usually the best producing ewes that require attention. The day after the lambs are weaned the flock should be assembled and each ewe should be milked out. Two days following they should be again gone over. At this time it will be found that some members of the flock will require no more attention; these may be marked with colored chalk. In about three or four days more those not marked will require a third milking out. With the exception of a few of the best milkers the flock will then be safe, but it may be necessary a few days later to again strip out a few of the heaviest milkers.

When the ewes are safely over the weaning process they should be moved to good, fresh pasture, and given an opportunity to regain the flesh lost during the period of nursing the lamb. It is a fact that has long been recognized by sheepmen that ewes in good vigorous condition when mated to the ram will give a much more satisfactory lamb crop than when bred in comparatively thin flesh. "Flushing" is the common term, and is simply conditioning the ewes preparatory for the breeding season. Ewes in such condition will give birth to strong, rugged lambs; there is a tendency for a larger percentage of twins and the ewes are more likely to conceive. Rape pasture has given excellent results for fall feeding of ewes. For best results the flock should have the run of a grass pasture in conjunction with the rape. Care should also be exercised in turning the flock on for the first few days, otherwise bloating may result. Very satisfactory results have been obtained at the Ontario Agricultural College with rape pasture for both ewes and lambs. There is something about the crop that adds tone and bloom to the flock. The 1919 lamb crop was one of the best on record and is largely attributed to the excellent condition of the ewes that were on rape pasture the previous fall. If it is not possible to provide rape pasture a very good substitute would be either fresh spring seeding or the second growth of clover, the aftermath of a hay field. Whatever pasture is used it should be of such a nature that the flock will be well nourished, and when the time comes to turn with the ram they are in real good flesh.

It is desirable that the flock should go into winter quarters free of ticks and lice. For this reason fall dipping should not be overlooked. This should be done before the weather becomes too cold. If possible choose a bright, sunshiny day, and if the work is done in the morning the flock will have time to dry off the same day.

Note. For further information on dipping see section on this subject.

Breeding. The lactation period for the ewe is approximately five months. The most favorable time for the young lambs to be born will depend largely upon such conditions as housing accommodation, feed supply, and when and how the lambs are to be marketed. In pure-bred flocks, especially where exhibiting is practised, it is often desirable to have the lambs come early in order that they may be well developed and show or sell to the best advantage. In such cases the ewes are bred to lamb in February and March.

On the other hand, where the object is to market the lambs in the ordinary way, it is usually better policy to have the lambs come later. Early in April is a pretty satisfactory time to have the lambs arrive. As a rule the weather is then comparatively mild and there is little risk of the youngsters becoming chilled, and they get off to a good start before going to grass. Some prefer to have the ewes lamb on grass as they claim there is less loss, it means little if any grain feed for the ewes, and the lambs go right ahead and make satisfactory growth. There is a little more difficulty in giving the detailed attention to the young lamb and its mother that is necessary while the flock is running out on grass, and it is doubtful if the lamb born later than early in April will reach, that year, the development of the one dropped at that time. However, as already suggested, it is a question that depends to a great extent on local conditions and one that can be left to the judgment of the flock-owner.

Before introducing the ram to the flock, the ewes should be gone over and all dirty wool and dung tags clipped from the hindquarters. This will give the ram a better opportunity to perform service and will result in fewer barren ewes.

In ordinary farm practice the ram may be turned with the flock during the day and taken away during the night. This is much more satisfactory, both for the ewe and ram than allowing them to remain together during the entire breeding season. It might be wise to go even further than this and allow the ram to mix with only part of the flock at a time. The object should be to conserve as far as possible the vitality of the ram, and still make sure that the ewes are receiving attention at the proper time, and to accomplish this without undue time and labor. It sometimes occurs that the ram will have a preference for one or two ewes and will ignore others that require service. In such cases it may be necessary to remove a ewe from the ram after the first service and permit him to devote his attention to other members of the flock. When the ram is first turned with the ewes his breast may be painted with a soluble paint and the marking on the rump of the ewe will indicate those that have been bred. As each ewe is marked showing that she has been served she may be removed and the served ewes kept by themselves, thus permitting the ram to devote his full attention to those ewes that have not been bred. At the end of eighteen days, change the breast marking to another color and this will show those ewes that are taking the second service. In this way it is possible to keep a fairly accurate record of the service of each ewe and to note those that are coming the second time. Many sheep owners have had the misfortune to have in service a ram that did not get the ewes in lamb, this is particularly true in case of a lamb or a recently imported ram. When a number of the ewes are coming back for the second or third service it would look a little suspicious, and in such cases it would be wise to secure the service of another ram that had proven a sure getter.

FEEDS.

In discussing the various feeds used in a ration for sheep, the same factors which affect all live-stock rations must be considered. The animal must get sufficient carbohydrates to supply the fuel material for the body and the energy necessary to keep the vital organs active. It must also have plenty of protein to repair daily body waste, and mineral matter to replace the small, but continuous loss of this material from the body. It must also be remembered that, as a general thing, grinding, cracking or rolling does not materially increase the digestibility of the feed although it may aid in mastication. Soaking and wetting are not practised in sheep feeding very much and will not increase digestibility. Cooking of feed, generally speaking, is not advisable.

It should be remembered that the sheep is a ruminant, and has a digestive tract suited to the digestion of roughages, but that the sheep will not digest coarse roughage such as straw quite as well as will the ox, owing largely to the fact that the food is in a drier condition when passing through the intestines of the sheep than it is in the ox. In feeding sheep it is necessary to use, if possible, some legume roughage to supply protein cheaply and to supply the necessary amount of mineral matter. The clovers and other legumes are particularly rich in protein and mineral matter.

Common salt is essential to the life and health of the sheep. It serves as a spice to whet the appetite, and, while it does not affect the digestibility of feed fed, it stimulates digestion and prevents digestive disturbances. It is necessary to supply the hydrochloric acid of the gastric juice, one of the active juices of the stomach which is a big factor in digestion. Salt must be kept before the sheep at all times.

Water is also essential, and, while not considered a feed, it is a matter which the shepherd cannot neglect. Fresh, clean water should be available at all times. Especially is this true where sheep are being fed on dry feed and are nursing lambs.

Scientists have discovered that there are certain unappreciated factors, sometimes called vitamines, which are necessary to growth and general health in sheep as well as in other animals. These substances are present in such materials as the butter fat of milk, in egg fats, in the corn kernel, in the wheat germ, in the thin leaves of plants, and possibly in some vegetables. So long as the shepherd is feeding sufficient green feed or dried roughage the sheep should do well.

It is not possible to get good results from feeding concentrates alone to a ruminant animal such as a sheep, and growing lambs must have a considerable amount of roughage to properly develop them. They must also get an abundance of succulent feed such as pasture grass, silage and roots. These are beneficial because they stimulate digestion and are laxative in effect and economical in production. With this must go exercise, quietness and regularity. It must also be remembered in feeding sheep that production of wool is important, and a liberal supply of protein is necessary to ensure a good fleece. Good feeding makes far more and better wool.

In selecting feeds for the sheep care must be taken to get sufficient bulk in the ration along with the points already mentioned, and with it a maximum of palatability which is generally obtained by feeding a variety of feeds judiciously mixed.

Concentrates.

Corn. Corn is essentially a fattening feed. It is palatable, and may form the basis of the grain ration for fattening lambs, but will give better results if mixed with other concentrates such as oats or oats and bran. It may compose one-third to one-half the ration, or even more, and a good grain ration for a fattening lamb or sheep is from one pound to one and one-half pounds per day, according to age and size and other feeds fed. Of this amount corn might be used as previously stated. Corn should only be fed along with a protein-rich roughage such as clover hay or with a protein-rich concentrate such as bran.

Gluten Feed. Gluten feed is a corn by-product high in protein content and not very often used in sheep feeding. It may be fed to add protein in a fattening ration, but is not generally used.

Wheat. Wheat is not often used as a sheep feed owing to its value in the market. It has a tendency to become pasty, and to cause digestive disturbances. If used at all it should be mixed in small quantities with other concentrates such as oats and a little oil cake meal, or with some bran.

Wheat Bran. This is one of the best concentrates for growing lambs and for feeding nursing ewes. It has a beneficial laxative effect, and should be fed with feeds rich in lime such as clover hay. Mixed with oats or other grains up to a third or a half of the grain ration it is one of the most reliable feeds.

Wheat Middlings. Middlings are not generally used in sheep feeding, as bran is much better suited to the sheep.

Wheat Screenings. There is a product on the market known as wheat screenings which, with all the black seeds removed, is valuable in mixtures for fattening lambs.

Oats. Oats are the most extensively grown cereal in this country and one of the safest all-round feeds, particularly suited to sheep. Fed either whole or crushed they are palatable, and contain sufficient bulk to make them a desirable and reliable feed. In this country they form the basis of the concentrate rations fed, and are generally given at the rate of from one-half to one and one-quarter pounds per day per sheep. With them may be mixed bran and a little oil-cake or other concentrates as already suggested. They are a good carrier with which to mix other feeds, and are relished by the young lamb and the old sheep alike. Mixed with a little bran or oil-cake meal they are an ideal concentrate ration for the breeding flock and for lambs during growth and fattening. From one-half to one pound per day is enough for the average breeding ewe and from one pound to one pound and a half for the average fattening lamb.

Oat hulls, oat dust, oat middlings and oat bran are not commonly used for sheep feeding.

Barley. Barley is not extensively used in sheep feeding. It is heating in nature and seems to interfere with digestion. It is not suitable for the breeding flock, but may be mixed with other concentrates as part of the ration in fattening lambs. When it is used legume hay should be fed with it.

Brewers' Grains. Dried brewers' grains are a rich protein feed bulky in nature which may be used in small quantities for sheep but are not a very satisfactory feed, and wet grains are not suitable for sheep feeding.

Malt Sprouts. This is a by-product of the malting process which is sometimes used for sheep in a mixture not exceeding one-half pound of the material daily. It is not generally considered a very good sheep feed.

Rye. Rye is a feed which is not very palatable and not considered a suitable sheep concentrate. It might be used in small quantity in a mixture of grains.

Millet Seed. Where it is produced in abundance, millet seed is sometimes ground and fed to stock. It may be used as a small part of the ration for fattening lambs.

Buckwheat. Buckwheat is not considered by shepherds to be valuable as a sheep feed.

Cottonseed Meal. Cottonseed meal has its limitations as a feed. It is more useful in milk production than for anything else. It must not be fed to very young animals, but is sometimes used in a grain mixture for older sheep. Preferably not more than from one-eighth to one-quarter pound of the meal should be fed daily and this mixed with other concentrates.

Linseed Meal. Linseed meal, also known as oil-cake meal, is very rich in protein, has a tonic and laxative effect, and is one of the best feeds available for obtaining rapid growth and high finish. It is often used for fattening lambs and putting sheep in condition for the show yard. About one-fifth of a pound per day mixed with oats or other concentrates is good feeding.

Peas. The Canadian field pea was formerly one of the most reliable crops grown on the Ontario farm. The grain, in small quantity, is an excellent feed. Mixed with oats and bran about one-third of each and fed from one-half pound up to one and one-half pounds per day of the mixture it is excellent for fattening purposes.

Beans. Field beans are generally used for human food. Sheep are about the only class of stock that will eat them readily unless cooked. About a pint per sheep twice per day is sufficient and the sheep seem to relish the beans and do well on them.

Tankage or Meat Meal. Tankage is a by-product of the packing houses and is generally used to supply protein, particularly for pigs. It is essentially a hog feed, but may be used up to ten per cent. in the meal ration of growing and fattening lambs where rapid growth is desired.

Molasses. Owing to the danger of smearing the wool molasses is not considered by sheep men as a very satisfactory feed.

Roughages.

Alfalfa. Of all the hay feeds, alfalfa, cut at the proper stage just as the new shoots are appearing in the axels of the lower leaves, is the best sheep feed. High in protein, palatable, and easily digestible, alfalfa with the leaves on the stalks can not be surpassed as a feed for sheep and lambs. When they are in good condition and getting a reasonable amount of roots and grain they will require from one and one-half up to two and one-half pounds per day, the smaller amount being fed when they are getting plenty of grain, but very little silage or roots. Silage or roots may replace a corresponding amount of dry matter in this roughage.

Red Clover. Although not so heavy a yielder as alfalfa, common red clover, because it will grow in almost any section of Ontario, is possibly the main hay ration for the sheep of the province. It is one of the best roughages for all classes of live-stock, and should be cut just before full bloom to be of most value. However, as it is rather difficult to cure at this stage it is generally left until about one-third of the heads have turned slightly brown. Like alfalfa, it is a good crop for soiling and should be fed much as alfalfa is fed.

Alsike. This hardy clover, generally sown in mixtures, is not as good a feed as red clover, but is much relished by sheep and makes satisfactory roughage. It is better mixed with red clover and some of the grasses.

Sweet Clover. Sweet clover is difficult to cure for hay, and is more suitable for pasture. It is liable to grow coarse, and if the weather is bad most of the leaves are lost in curing. There is considerable waste in feeding it to sheep. However, where well cured if the stalks are fine, it has a feeding value approaching alfalfa.

Pea and Oat Hay. This crop, cut when the oats are in the early milk stage, makes a satisfactory feed for sheep, almost equal to red clover.

Blue Grass. Early cut blue grass makes a very good winter feed especially if it has a little clover mixed through it.

While useful when clovers and other feeds are scarce such hay crops as timothy, red top and orchard grass are too woody, too low in protein, and too unpalatable to make high-class sheep feed. However, they may be used to good advantage when clover has failed.

Straw. Sheep which have to depend on straw for a living generally fail in condition. Wheat straw is quite unsuitable, barley straw is little better, and oat straw has some merit, but is not considered a suitable sheep feed. We are safe in saying that straw from the cereal grains does not make suitable sheep feed.

Pea Straw. In the days when peas were extensively grown and threshed with the flail, pea straw, provided the peas were pulled as soon as ripe and harvested without rain and afterwards flail-threshed, are almost equal to clover hay as a sheep roughage where roots were also available. Machine-threshed pea straw is not nearly as valuable, but the straw from legumes is relished by sheep and may be used to good advantage in their feeding, fed much as is clover hay.

Buckwheat Straw. Buckwheat straw is coarse and woody and although relished by stock is not considered to have very much feeding value. If fed at all it must be given carefully as there is danger of digestive troubles.

Roots, Silage and Other Feeds.

Corn Silage. Corn silage is quite commonly fed to sheep and if well preserved makes a fairly satisfactory succulent feed. It is not quite as valuable as swede turnips, but is eaten with a good deal of relish. Ewes may be fed from 2 to 4 pounds and lambs from 1½ to 3 pounds per day in conjunction with other feeds. Corn silage should not be fed as the sole roughage ration as the sheep are liable to go off feed. Mouldy silage must be avoided.

Swede Turnips. Swede turnips are one of the best succulent feeds for sheep and while they do not produce as much dry matter per acre as corn, may be grown by the Ontario sheep breeder to good advantage. They should not be fed heavily to in-lamb ewes as there is a danger of the lambs becoming large, weak and flabby. They are better pulped. About 3 pounds per day is a good ration for a fattening lamb. In-lamb ewes should not get quite as much, but after they have dropped their lambs they may be safely fed all they will eat.

Mangels. Mangels will yield a greater tonnage per acre than will swede turnips. They are quite suitable for fattening lambs but are not as much relished by sheep as are swedes. They should not be fed to breeding rams as they are liable to produce calculi in the urethra. They may be fed in the same quantity as swede turnips where used.

Soft, or White Turnips. This crop is generally grown for fall feed and is sometimes fed on the ground, being pastured off. The roots have not the same feeding value as swede turnips, but come in handy for fattening lambs or flushing ewes in the fall.

Cabbage. Cabbage is a valuable crop for sheep feeding. No class of stock relish cabbage more than do sheep and a small patch grown in rows from 30 inches to 3 feet apart and from 2 to 3 feet apart in the rows makes one of the finest soiling crops for fall feeding. It may be pastured, too, but is more satisfactory fed as a soiling crop.

Potatoes. Potatoes are generally considered too costly a feed to feed lambs. In a mixture they have been found about equal in value to mangels or sugar beets, but are not generally considered a satisfactory sheep feed.

Beet Pulp. Wet beet pulp, a by-product of the manufacture of sugar from beets, has about half the feeding value of roots and, close to sugar beet factories, has been fed extensively along with clover and alfalfa hay in fattening lambs. Where dried beet pulp is used it should be moistened with two or three times its weight with water. Beet pulp is not a very valuable feed for sheep in this country.

Pastures.

For the general run of the flock a permanent pasture in which there is a good deal of blue grass is the most satisfactory for the summer. This, however, should be supplemented by second growth red clover or alfalfa giving the sheep and lambs a change as frequently as possible. Ideal conditions are those in which the sheep have access to a permanent blue grass pasture and at the same time have the run of a fresh plot of clover or alfalfa. It is necessary to change the flock from time to time from one pasture to another and some such crops, as the two clovers mentioned which will come on and give fresh green feed at several periods during the summer is invaluable. To further supplement this there is nothing which will excel rape. This may be sown in drills at the rate of 1½ pounds per acre and cultivated for a time or it may be sown broadcast at 4 or 5 pounds per acre. It is one of the best fall pastures upon which to turn weaned lambs or upon which to flush ewes.

Annual pastures composed of the spring grains are not very suitable sheep pastures. The clovers, permanent blue grass pasture, and rape are the main standbys of the Ontario sheep breeder.

MANAGEMENT OF THE FLOCK.

Winter Management. The main feature in housing sheep during the winter is that their quarters should be dry, both overhead and underfoot, free from drafts, and well ventilated. Warm buildings are not necessary, but they must be protected from the storms. Provision should be made for abundance of exercise for the breeding flock. Possibly no other factor is more important to the success of the flock during the winter. In order to get a good strong crop of lambs the ewes must have plenty of exercise. A large yard located on the south side of the pen in which the sheep are allowed to run every day that is not stormy will usually afford sufficient exercise. It is not safe as a rule to allow the flock to run in the yard with other stock and for this reason they should have a yard of their own. Many successful sheep men consider the question of exercise of such importance that they arrange to feed their flock at some distance from the pen and in this way make sure that the ewes get sufficient exercise.

The aim should be to have the flock enter winter quarters in as thrifty condition as possible. On this will depend to a considerable extent the cost of maintaining the flock during the winter. Sheep that are carrying a reasonable amount of flesh and are clean of all ticks and lice can be carried through until near lambing time with very little, if any grain provided good quality roughage is available. On the other hand if the ewes are thin it will be necessary to feed considerable grain in order to put them in proper condition for the lambing season. It is much more economical to attain this condition in the autumn by means of good pasture such as rape or clover, than it is to attempt to do it later by grain feeding.

Feeding. As already suggested if the flock come off pasture in proper condition and are not due to lamb until late March or early April they can be maintained for the greater part of the winter on the cheaper, more bulky feeds. Legumes, such as alfalfa and clover hay or well cured pea straw, will prove very satisfactory. Of the three feeds mentioned possibly alfalfa is the best. However, on many Ontario farms this crop is not grown to any great extent and in such cases red clover will give good results. Well saved pea or bean straw is relished by sheep and fills in very well for a change. Even good quality oat straw may be fed in limited quantities. This may be scattered about the sheep yard and the flock allowed to pick through it during the day. This will provide a certain amount of exercise and that portion of the straw not eaten will serve as bedding and keep the yard clean. The hay is better fed in properly constructed racks. This will avoid waste and less tramping of the feed underfoot as sheep do not relish feed that has been once picked over. A full feed of either alfalfa or clover, night and morning, (all the sheep will clean up nicely) together with some oat straw scattered about the yard for them to pick through during the day should provide all the dry roughage necessary. Fine-stemmed, leafy hay is relished by sheep much more than coarse, fibrous or woody material, and when the hay crop is being stored provision should be made to reserve some of the best quality for the sheep. Second cutting of clover is preferred to that usually obtained from the first cutting, this being particularly true in the case of alfalfa. Timothy is an unsatisfactory hay for sheep; it is neither nourishing nor palatable, and if fed to any extent is likely to cause constipation. It has another disadvantage in that the seeds and coarse stems become incorporated into the wool which lowers the selling value of the fleece. If it can possibly be avoided timothy hay should not enter into the ration for sheep.

Succulent Feeds. The value of some succulent feed in the ration is appreciated by all good sheepmen. The chemical analysis of some of these feeds does not show them to be high in feeding value, as most of them contain a high percentage of water. However, the advantage of such feeds is that they have a toning effect on the animals, keeping their digestive systems in proper working order. In addition to this they enhance the feeding value of such feeds as the dry roughages, they are themselves very keenly relished and serve to add variety to the ration.

Of the various succulent feeds possibly roots are the most satisfactory; they are perfectly safe to feed in fairly large quantities and in addition they are keenly relished by sheep. At the Iowa Experimental Station one hundred pounds of roots fed to fattening lambs had a value of between 8 and 9 pounds of grain and approximately 18 pounds of hay, for breeding ewes they would give even a better showing. Of the three common kinds of roots fed on the farm—sugar beets, mangels and turnips—they would rank in actual food value in the order named. There is, however, a danger of feeding sugar beets and mangels to sheep as they tend to develop stone in the bladder in the case of rams or wethers. Turnips may be fed without injury to sheep of all kinds and offer a splendid succulent feed and so are preferred by many shepherds. The amount of roots to be fed will depend largely on the supply available, but the maximum would be about 5 pounds per day or one bushel for a flock of twelve sheep. Feeders generally feed about three pounds per day to ewes getting plenty of clover hay and a little grain. If fed in much larger quantities than this there is a tendency to make the ewes washy and the lambs born from ewes heavily fed on roots are apt to be weak and flabby at birth. Even one to two pounds of roots for each sheep per day will be very beneficial in adding the required succulency to the ration. Sheep are not able to handle whole roots as well as some other animals and they are better fed either pulped or sliced.

Corn silage has been fed to a considerable extent to sheep, and provided it is of good quality, it is an excellent substitute for roots. Silage made from fairly well-matured corn and free from mold or decay may be fed in reasonable quantities and where roots are not available it is the next best succulent feed. Unless the silage is of good quality it should not be fed, as the digestive system of the sheep is easily upset and scours, colic and general digestive disturbances will follow the feeding of inferior silage. As a rule sheep may be fed from two to five pounds of silage a day depending upon the quality of the other roughage being fed.

Amount of Grain to Feed. The aim should be to carry the breeding flock through the winter in a thrifty condition, making as much use as possible of the cheaper, more bulky, succulent feeds. It is not good policy, however, to allow the ewes to become too thin, and it may be necessary to feed some grain in order to maintain them in proper condition. If the fall pasture has been short, or the roughage of poor quality, and the ewes are due to lamb fairly early, a light feed of grain will be beneficial. The amount will depend on the condition of the flock. For ewes that are in fair condition, but require a little toning up one-half pound of grain each per day should be sufficient, in cases where the flock is thin and the aim is to put on flesh, it might be necessary to feed as much as two to two and one-half pounds. A light feed of grain commencing a couple of weeks before lambing, will tend to stimulate the mother's milk flow and build her up generally for the trying period during and after lambing, and it is advisable even if the ewes are in good condition to feed a light ration of grain at this time. If roots or silage is being fed liberally it might be wise to feed a little lighter on the succulent feeds and substitute a little grain. There is no better grain feed for sheep than oats; containing a fairly high percentage of hulls they are a safe feed and in addition they are palatable. Mixed at the rate of two to three parts with one part of bran they make a highly satisfactory feed for sheep at any time. A quarter pound of linseed oil meal may be added to the grain ration a few days before lambing. It will tend to keep the bowels free and open and can be used to advantage.

Summer Management. The flock should be turned to pasture just as soon as the grass has got a fair start. It is often possible to make use of otherwise waste land such as the lanes and fence corners early in the spring before the regular pasture is available. The change from dry winter feeding to pastures should not be too sudden. Allow the flock to run out for a few hours for the first few days, housing them during the night, this allows for a feed of hay and grain twice a day. As the grass becomes more abundant and nourishing, the inside feeding may be gradually lessened until the flock can safely be maintained on pasture alone.

For the regular summer pasture it is desirable that sheep should be kept on land that is comparatively high and dry. Much of the trouble, such as internal parasites, foot rot and nodular disease is caused by pasturing sheep on flat, low land. It is a noticeable fact that the flock will always seek the high land pasture when it can be had. All classes of farm animals do better with a frequent change of pasture, and this is possibly of more importance in the case of sheep than with some other live stock. Here again many of the ailments commonly met with in sheep raising can be greatly lessened by not allowing them to run too long on any one field. On those farms on which there is considerable waste land that is located high and dry, the question of summer pasture is not a serious one. Sheep, of all classes of animals, will possibly give the most satisfactory return from such areas. This, supplemented later in the season by some pasture such as rape, will carry the flock through the summer and fall quite satisfactorily. However, on those farms that are practically all tillable, some provision should be made for suitable pasture for the flock.

An arrangement that has proven very satisfactory is to set aside a portion of the farm that is particularly suitable for sheep and by means of temporary fences provide for a few small fields or paddocks. These various fields may then be sown at different times and a continuous supply of pasture is always at hand. One strip may be sown to rye in late summer which will provide late fall and early spring pasture. After the rye has been eaten off in the spring it may be resown with rape which will come along for midsummer feeding. A mixture of peas and oats seeded with red clover will give a picking through June and the clover will have sufficient growth in the fall to carry the flock for a few weeks. Another field could be put down to a permanent pasture which will always be available between times when the others are not ready. A patch or two of rape could be sown any time during the summer and always makes an acceptable sheep pasture. Where it is not practicable to plan for a succession of crops such as has been outlined, the ordinary pasture may be utilized keeping in mind that a change is desirable and should be provided if at all possible. Cattle and horses, especially the latter, are liable to cause injury to the flock and for this reason sheep will do better with a field to themselves rather than running with other stock unless the range is a fairly large one.

The hot, dry time during the summer is a trying season on the flock and whatever system of pasturage is followed some provision should be made for a supply of fresh pasture at this time. In most seasons the aftermath of the hay fields or the fresh spring seeding may be depended on to furnish this and if available will fit in very well. Rape has always been looked upon as an excellent pasture and a field coming on at this time will serve to maintain the flock in splendid condition over this critical period. It usually takes from six weeks to two months from time of sowing until the crop is ready for use. It should be sown on well-prepared, mellow soil and can be sown in drills the same as turnips at the rate of one and a half to two pounds of seed per acre and the rows cultivated the same as with a root crop. No thinning is necessary. It is frequently sown broadcast at the rate of four to five pounds to the acre and, provided the land is clean, will come along well. It will be necessary to exercise a little care and judgment when first putting the flock on fresh rape pasture to avoid bloating. The sheep should be turned on for a few hours during the middle of the day, when the leaves are dry. The following day they may be left a little longer and the time each day lengthened until at the end of a few days it will be safe to give them the full run. Better results will be obtained from this crop when the flock has a run of a grass field in conjunction with it rather than when forced to pasture on the rape alone.

Feeding Grain to Lambs on Pasture. There is a difference of opinion regarding the need of feeding grain to lambs on grass while running with their mothers. It is true that in case of pure-bred flocks where the lambs are to be exhibited or sold for breeding purposes and the object is to push them along as fast as possible grain feeding is profitable. Under ordinary farm conditions, when the lambs are to be marketed in the fall or early winter as mutton lambs and especially when grain is high in price, there is a question whether or not it is profitable to do much grain feeding. The experience at the College farm is that lambs on good grass will eat very little grain. By arranging for a frequent change on to good fresh rape or grass pasture the lambs will make good growth and it is more economical than depending too much on grain feeding. In cases where the pasture becomes very short and dry, lambs, no doubt, will make good use of a light grain ration. Whether or not it is profitable to feed grain while on grass will depend on such factors as the price of grain, the condition of the pasture and the time of year the lambs are to be marketed. This is a question that can be left to the judgment of the owner. The aim should be to keep the lambs growing every day throughout the growing period, but, as has already been suggested, this is possible by providing plenty of the right kind of pasture.

Weaning the Lambs. As a rule lambs are better taken off the ewes when between four and five months old. By that time the ewes will not have a great deal of milk and it is better for both the lambs and ewes that they be separated. The breeding flock will have an opportunity to gain up in flesh and if the lambs are put on good pasture they will make better gains. If it is possible the separation should be made on a cool day and if they can be put at different ends of the farm it will prevent a good deal of fretting and worrying. It is not advisable to put them together again but to make the first separation final.

A rape pasture with a grass field adjoining makes an ideal pasture for the lambs after weaning. If this is not available second growth fresh clover or fresh spring seeding that has made good growth will make a good substitute. In the case of pure-bred flocks where the male lambs have been kept for breeding purposes it will be necessary to separate them from the ewe lambs.

Marketing Lambs. It is a recognized fact that no class of animals are put on the market in such an unfinished condition as lambs. Not a few lambs are sold at, or shortly after, weaning time before they have had an opportunity of putting on much flesh. Lambs that are maintained on good pasture for some time after weaning will usually be in nice condition to go to market. A feed of from one to two pounds of grain a day to each lamb will do much towards putting on a good finish and unless the pasture is exceptionally good and the lambs in good flesh to commence with grain feeding might be profitably practised. A mixture of equal parts oats and barley (ground) with a little bran added is a satisfactory grain ration for finishing lambs. Where corn is available it can be substituted for the barley.

The bulk of the lamb crop in Ontario is marketed in the fall—October and November. This being true there is usually more or less of a glut in the market at this particular season, and unless the lambs are fairly well finished there is likely to be some discount in the price. Possibly, one season with another, as good returns are obtained by marketing at this time as any. In case the fall market is not satisfactory, the lambs not any too well finished, with grass plentiful and grain reasonable in price it might warrant holding the lambs over until later, say December or even January. At this time lamb is a comparatively scarce commodity on the market, and if offered in prime condition a satisfactory price is likely to be obtained. It is quite possible that for those farmers situated near a good local market the lambs can be disposed of to good advantage quite early in the summer. Many butchers in the towns and cities are anxious to secure a few choice lambs for their trade, and in such cases the lambs can be sold for as good a price or a little better price then than later. No hard and fast rule can be set down as to the most favorable time to market the lambs, the market outlook and the feed situation will determine to a considerable extent the time when the most profit will be realized.

THE LAMBING SEASON.

Provided the flock has been properly handled during the winter, the success or failure of the lamb crop will now depend largely on the detailed attention given during this critical period. It is absolutely necessary for the attendant to be on hand frequently both day and night. The loss of not a few lambs, and in some cases both mother and lambs, can be avoided by prompt action on the part of the one in charge. A week or two before the ewes are due to lamb all the dung locks and dirty, straggling wool on the hindquarters of the sheep should be cut away with the ordinary sheep shears. It will be necessary to handle them carefully at this time otherwise considerable injury might result to the heavy in-lamb ewe. The removal of this superfluous wool will mean that the young lamb will be able to nurse with less difficulty, it will lessen the danger of wool balls in the stomach of the nursing lamb, and the ewe will be much cleaner at lambing time. The ewe about to lamb can be properly cared for to much better advantage when separated from the main flock. Provision should be made for a few small pens on the warmest side of the sheep house for this purpose. A very satisfactory arrangement is to construct temporary gates which may be set up when needed. Any ordinary rough lumber may be used, making the gates 6 feet long by 4 feet high, hinge two of these together and set the first one up in the corner fastening them to the wall with hook and staple. This makes a pen 6 feet square. These may be set up in a row along one side or around the main pen as required. By having four or five of these temporary pens on hand they may be used year after year and are always available when needed.

Under ordinary conditions and in case of normal delivery it is not necessary or wise to interfere with the ewe at the time of parturition. There are cases, however, where the lambs are very large, the passage of the ewe too narrow or the lambs coming in the wrong position, and in such cases the ewe may have difficulty in delivering her lamb. The attendant should always be on hand and ready to give any assistance in such cases. The experienced flock master will know when his help is required, but it is good policy to make reasonably certain that the ewe cannot lamb without some help before taking any action. When the ewe has been straining for some considerable time without any relief, it is a fairly good sign that the case requires investigation. Cleanliness and gentle treatment are two important things to keep in mind at this particular time. The hand and arm of the attendant should be first washed adding a little disinfectant such as carbolic acid or one of the coal tar dips to the water, then smeared with vaseline or linseed oil, and the hand gently inserted into the vagina. The object should be to ascertain whether or not the lamb is coming in the proper position, that is head and front feet first. If the presentations appear normal then it is a question of aiding delivery by gently pulling on the front feet of the lamb. At such times the inside passage of the ewe should be well lubricated with linseed oil which tends to soften the vagina and allow it to stretch. Unless the case is a very severe one it will usually yield to the treatment. Under conditions where the lamb is not coming in the proper position, then the case is a much more difficult one to handle. The lamb may be coming front feet first with the head turned back, or again the hind end may come first, in any case it will be necessary to correct the position of the lamb; it requires considerable patience and very gentle handling to do this in order to prevent injury to both lamb and mother. When the lamb has been put in the right position, the ewe may be able to deliver it herself, but if weak and unable to do so help may be given. A lump of pure hog's lard inserted into the womb of the ewe after difficult parturition will be very beneficial in healing it in case it has been injured in any way. If she is weak and exhausted give a stimulant to revive her. If the case has been a severe one it might be advisable to flush the ewe for two or three days by means of a rubber tube attached to a funnel using some coal tar disinfectant or boracic acid in warm water.

The Young Lamb. Lambs that are born strong will be on their feet and nursing in a short time, and provided the mother has a sufficient supply of milk they are well on the way to a good start. On the other hand weak lambs will require immediate attention. Lambs may be born that at first sight appear lifeless; these may often be revived by prompt action on the part of the attendant. First remove all phlegm from the mouth and nostrils of the lamb, then open its mouth and blow into it to start lung action. Next lay it on its belly and slap it gently on the body just over the heart. Repeat this action several times and unless the lamb is very far gone it will soon show signs of life.

Chilled Lambs. Chilled lambs may be warmed by immersing several times in a bucket containing warm water then drying thoroughly by rubbing with a woollen cloth. Another method is to place the lamb in a box or large basket together with a jug of hot water covered with a cloth then cover the whole with a blanket. A few drops of stimulant in a little warm water administered to the lamb will often have the desired effect.

In case of weak or chilled lambs the aim should be to get it nursing as soon as possible as nothing seems to revive them quicker than the warm milk from the mother. If the lamb is sufficiently strong it may be possible to accomplish this by holding it up to nurse. If too weak for this a little of the mother's milk should be given from a spoon. Once the lamb is strong enough to stand up and suck the greatest difficulty is over. It is well to keep a close watch of both lamb and ewe for the first few days to make sure the lamb is getting a regular supply of milk. This can usually be determined by the condition of the young lamb, as a plump rounded-out appearance is a pretty good indication that it is getting all that is necessary. On the other hand the youngsters may not be able to take all the mother's milk and this will very soon result in a caked, inflamed condition of the udder. This is particularly true in the case of single lambs. They may nurse from one side only and the other half of the udder will give trouble. It may be necessary to hand milk the ewe for a few days until the lambs are able to take it all. For caked udder there is no better treatment than bathing well with hot water, dry thoroughly and apply warm, melted hog's lard. Care should be taken that the young lamb gets the first milk from the mother, this is necessary as the first milk is quite laxative and prevents constipation in the very young lamb. In case of constipation from one-half to a teaspoonful of castor oil will usually avoid any further trouble.

Ewe Disowning Lambs: It not infrequently happens that a ewe may refuse to mother her lamb, or in case of twins she may disown one. This is particularly the case with young ewes with their first lambs. The ewe should be confined in a small pen or tied so she cannot move about and if the lamb is real strong they will often get an opportunity to nurse. In other cases it may be necessary to hold the ewe several times a day to allow the lamb to nurse. With a little time and patience the mother instinct will usually prevail, and she will give little future trouble. A dog tied in or near the pen is claimed by some to give good results in persuading the mother to own her lambs.

Ewes Adopting Lambs. In the case of a ewe having only a single lamb and it dies, it is often desirable to have her raise another belonging to a ewe with two lambs especially if the motherless ewe has a liberal supply of milk and the mother of the other lambs is not raising her pair any too well. This can be accomplished by taking the skin off the dead lamb and placing it over the lamb that is to be adopted. Another method is to smear some of the milk of the foster mother over the lamb she is to take. At the same time it will be necessary to keep the ewe with her adopted lamb in a small enclosure for a few days until she becomes satisfied to own her new charge. It is also advisable to hold the ewe for a few times each day to make sure the lamb is nursing.

Raising the Orphan Lamb. In attempting to raise a lamb on the bottle the aim should be to follow the natural method as far as possible. Ewe's milk is comparatively high in butter fat, running on an average between 8 and 9 per cent., as compared with from 3 to 5 in the case of cow's milk. This being true the milk used for rearing young lambs should be from a cow testing high in fat, and for the first few weeks the same cow's milk should be used at every feed. Regular feeding every three or four hours, both day and night, and a little at a time, from two to three tablespoonsful, is absolutely necessary for best results. The addition of a little brown sugar to the milk has a beneficial, laxative effect. After three or four weeks when the lamb's digestive system has become accustomed to the milk the amount may be increased and the length of time between feeds lengthened until at a month or six weeks a few feeds a day will be sufficient. At no time should the lamb get an overdose of milk, just what it will take each time with a relish. The temperature of the milk is important and during the early stages should not vary above or below 92 degrees Fahrenheit. An ordinary sized bottle with a rubber nipple attached is the most satisfactory method of feeding and care should be taken to keep both bottle and nipple scrupulously clean at all times. Overfeeding, the use of dirty bottle and nipple and feeding at the wrong temperature is the cause of much of the difficulty met with in hand raising lambs. The various troubles and ailments usually met with in young lambs are discussed in another section so it will not be necessary to mention them at this time.

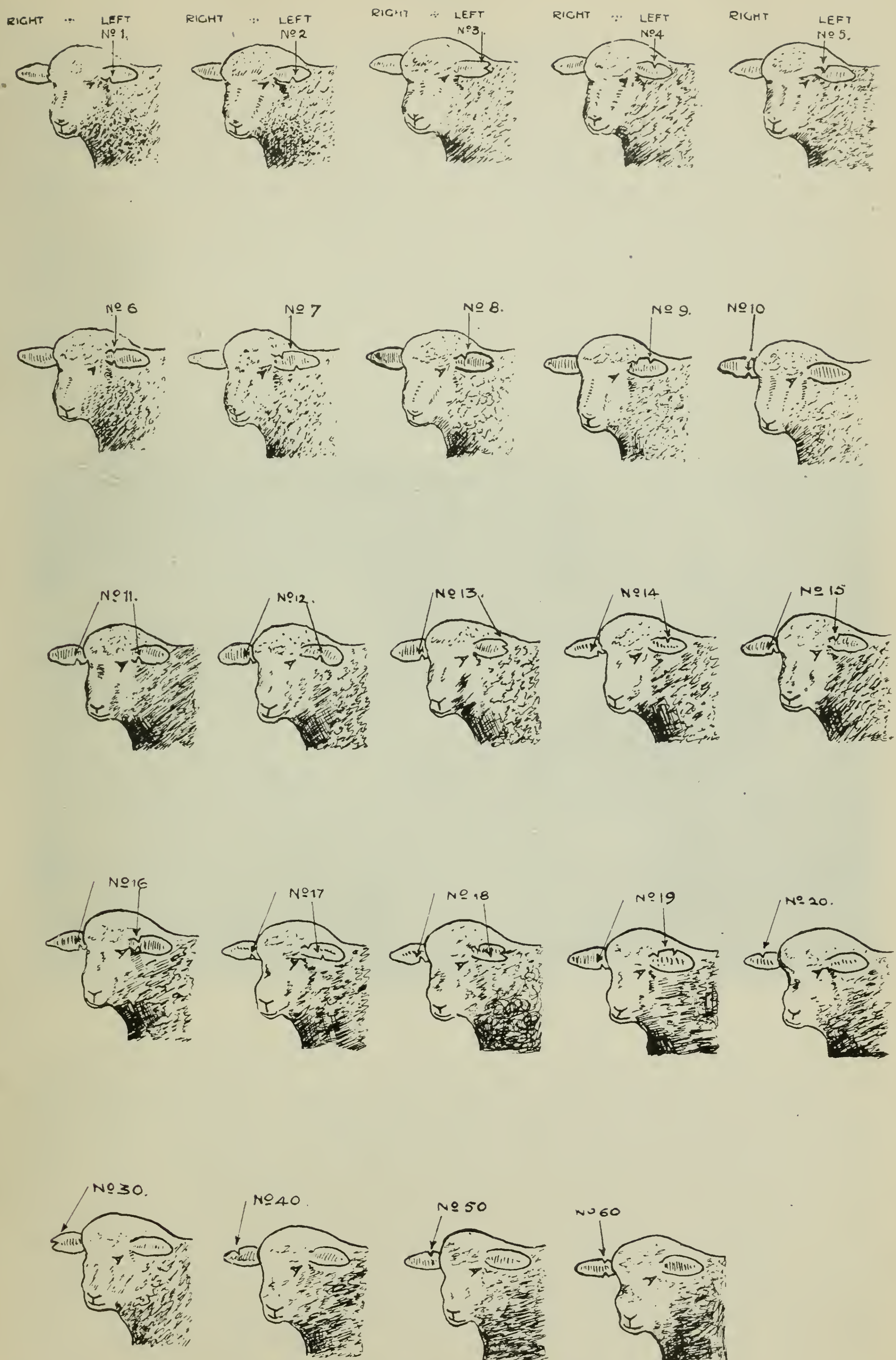
Feeding and Management of the Flock after Lambing. In order to avoid udder trouble and to carry the ewe safely over this trying period immediately following lambing she should be fed carefully for a few days. Good quality hay and a few roots together with a light feed of bran should answer very well. The grain ration may be gradually increased until the mother is receiving her full allowance. A mixture of two to three parts of oats to one of bran fed in conjunction with hay and either roots or silage should maintain a good flow of milk for the young lambs. A little linseed oil meal added will aid in stimulating the milk flow.

Feeding the Young Lambs. It is during the early stages of the young animal's life that it makes the most economical gains; every advantage should be taken of this fact and the feeding and general conditions should be such that rapid growth is possible. By the time the lambs are three or four weeks old they will commence to eat a little grain. Provision should be made for a pen into which the lambs may be fed separate from the ewe. This may be arranged by setting up hurdles in one part of the main pen and the openings into the smaller pen being the proper size so the lambs may enter and yet too small for the sheep to pass through. The same grain mixture suggested for the ewes is quite satisfactory for the lambs. The addition of ¼ to ½ pound of linseed oil meal to the ration of two parts oats and one part of bran will improve it. Fine-stemmed, second cutting of alfalfa or clover hay together with a few roots, will be relished by the lambs and fed along with the grain will mean much in their growth and development. Care should be taken to feed no more than the lambs will clean up and the feed troughs should be kept clean. A little at a time and frequent feeding will give best results.

Ear Marking Lambs. In case of pure-bred flocks it is absolutely necessary to have some system of ear marking the young lambs. The ear labels cannot be put in until the lambs are a few months old, in fact it is advisable to wait until weaning time, the ear is usually strong enough at that time to bear the weight of the tag without drooping. Unless some method of marking is followed it is often difficult to identify the lambs and to keep the breeding records correct. Even in grade flocks it is well worth while to know what each member of the flock is doing as a breeder as this affords a basis upon which to make an intelligent selection.

There are several different systems of marking the lambs, the one outlined here has been used at the Ontario Agricultural College for a number of years and has proven quite satisfactory. A few days after the lambs are born a notch is cut into the ear with a punch, each mark representing a number, in case of twin lambs the same ear mark will do for both. At the time the ear is notched a record is made indicating that a lamb with a certain ear mark belongs to a ewe whose identity is known by the number on her ear label. Later on when the ear labels are to be inserted no difficulty is met with in identifying the lambs in the flock.

This system outlined requires little explanation, commencing with the left ear on the lower outside a notch here is No. 1, half way up the same side is No. 2, a notch on the top of the ear is No. 3, half way down the inside No. 4 and the lower mark in the inside No. 5. Still using the left ear No. 1 and 5 is No. 6 and so on up to 9. No. 10 is indicated by a notch on the outside lower part of the



A satisfactory system of ear marking lambs.

right ear. By using both the right and left ear it runs up to 20. For example 15 would be the lower notch on the outside of the right ear which is 10, this together with the lower mark on the inside of the left ear which is 5, making in all 15. A notch on half way up on the outside of the right ear is 20, corresponding with 2 on the outside of the left ear and so on up to 50: In this way the numbers can be used up to 60, which will be sufficient for any ordinary sized flocks especially as one mark will do for two lambs in case of twins.

Castrating. The importance of docking the lambs and castrating all male lambs not intended for breeding purposes is being appreciated more and more each year. However, a visit to any of the larger market centres in the autumn will reveal the fact that there is still considerable neglect in this regard. Very few farmers would consider marketing their hogs and beef animals entire, and yet on these same farms no thought is given to castrating the lambs. Not only are buck lambs discounted in price, but they will not settle down and feed as contentedly

Proper method of castrating.

as wethers. When the lambs are from ten days to two weeks old is the best time to perform this operation. They are then strong enough to withstand the slight shock, and there will be less danger and suffering than if left later. Collect the lambs to be castrated in a pen by themselves which is well bedded and clean. The operator should make sure that his hands and the castrating knife are clean. The use of a few drops of carbolic acid or other disinfectant in the water is a safe precaution. The lower end of the scrotum should be cut off which will expose the testicles. These should then be drawn out one at a time with the entire cord attached. The cord should not be cut off, but drawn out. The testicle of the young lamb is soft and pulpy and some difficulty may be experienced in pulling the testicle and cord with the fingers. Pinchers may be had which will perform the operation in a satisfactory manner. Another common method is for the operator to grasp the testicle with his teeth, in this way the cord can be drawn out without any danger of breaking. Those who have followed this method for some time are agreed that it is the safest and most satisfactory of any. It is well to apply some disinfectant after the operation. It will hasten healing and prevent any bad effects from dirt getting into the cut.

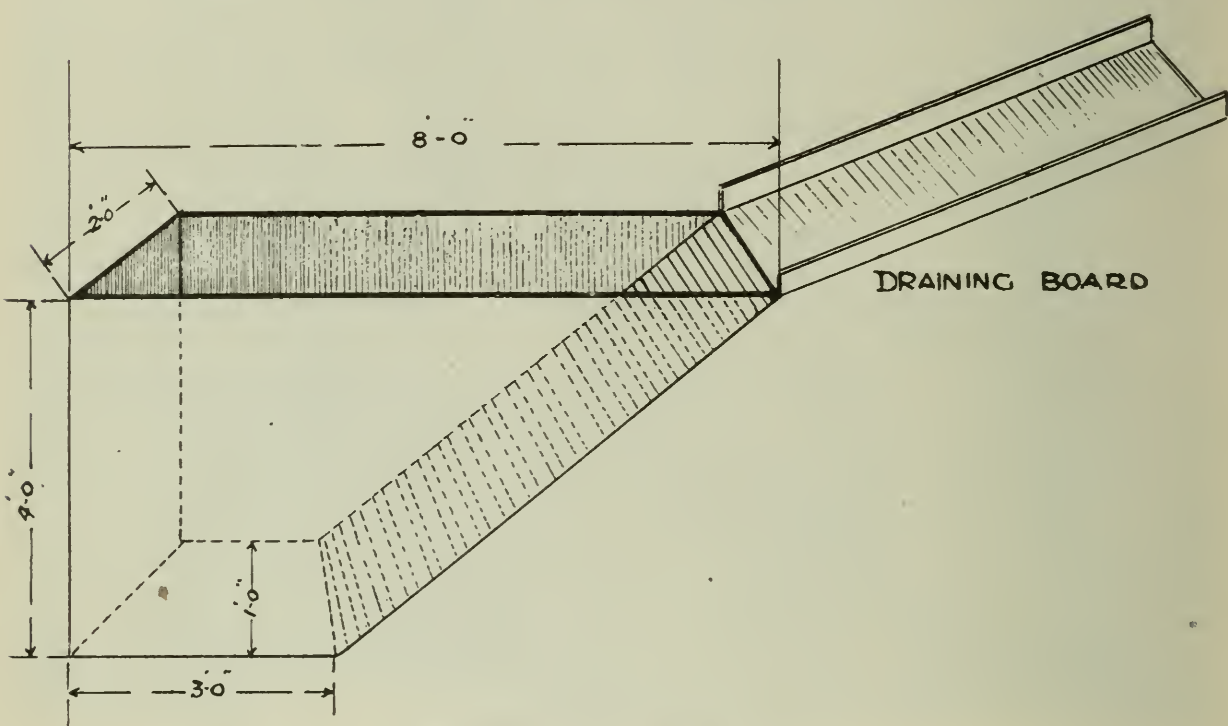
Docking. This is a comparatively simple operation and should never be overlooked. A bunch of lambs that have been docked present a much more attractive, uniform appearance than those left with their tails on. There is less trouble with dung locks and dirty wool collecting on their hindquarters when the tails have been removed. Later on in the season when the weather is very warm and the grass wet there is danger of lambs becoming infested with maggots in the region of the tail, due to the collection of dirty wool. This is greatly minimized when the tails have been removed. The ewe lambs may be docked any time after they

Docking properly done.

are a week old, provided they are strong and nursing well. The shock will not be so severe if done while the lambs are quite young, and any time from one to two weeks after birth is best. In the case of male lambs that have been castrated, it is safer to wait for a week or ten days before docking. The tails may be removed by means of a sharp knife, first find a joint about one and a half inches from the body, then shove the loose skin covering the tail up towards the body so when the tail is removed this loose skin comes down and covers the stub. Now place the knife on the under side of the tail where it is to be removed and with the other hand holding the loose end, the tail can be severed making a clean cut. Special pinchers may be had which, when heated, will remove the tail. These pinchers are quite blunt and the operation is one of searing the tail off rather than cutting. There is probably less danger of bleeding by this method and many prefer the pinchers rather than the knife. In case of severe bleeding following the use of the knife a string tied tightly around the butt of the tail will prevent any great loss of blood. The docking should be done on a comparatively cool morning; there is less danger of bleeding when it is cool, and in addition the lambs may be watched for several hours afterwards, which is not so likely to be done if performed in the evening. It is well to keep in mind that cleanliness in the matter of docking is important, and some good disinfectant applied to the wound will be beneficial. If the docking is done later, when the flies are liable to cause trouble, there is nothing better than ordinary pine tar for this purpose.

DIPPING.

In order to keep the flock in a healthy, vigorous condition throughout the year it is important that they should be kept free from ticks and lice. A good quality of wool cannot be obtained from an infested flock and no amount of feed will make up for the ravages of these pests. After the sheep have been shorn in the spring



Suggestion for a dipping tank.

there is little protection left for the ticks and they will then infest the lambs. A few days after shearing the sheep the young lambs should be dipped. This is absolutely essential if rapid growth and development is to be expected. If a regular dipping vat is not available any ordinary receptacle that is large enough, such as a tub or half barrel will answer very well. Spring dipping of the ewe flock although not as important as fall dipping is advisable and in most cases it is worth while. When the wool has been removed it will take comparatively little dip to do the flock and the increase in the value of the wool and the general thrift of the flock will ordinarily warrant the time and expense.

Before the flock enter winter quarters in the fall they should all receive a thorough dipping. A bright, warm day in October should be chosen and the dipping done in the morning so the wool will have time to dry before night. It is safe to say that fall dipping of the flock should never be neglected. Even in those flocks that are supposed to be clean, it will pay. In case any sheep are to be added to the flock they should always be dipped before being taken in with those that are already clean.

There are several different brands of sheep dip on the market any one of which will give satisfactory results provided directions are carefully followed. The water to be used for dipping should be warmed, and the mixture should be stirred frequently to prevent the heavier dip settling to the bottom. The sheep should remain in the dip for approximately two minutes to allow the wool and skin to become thoroughly saturated.

Unless the flock is a very large one it will not be necessary to build an expensive dipping tank. A large trough or barrel might answer if nothing else is at hand. However, a very satisfactory tank may be built of ordinary tongued and grooved matched lumber. Ordinary lumber may be used and have the inside lined with galvanized iron. Strong galvanized iron alone properly constructed by a tinsmith will make a good vat, although possibly rather expensive. Where comparatively large flocks are to be handled, it might pay to construct a cement vat set part way in the ground with a system of gates and a small pen to handle the flock entering the vat. Whatever tank is used it should be set in the ground so the top of the tank will be about two feet above the ground surface. The size of the tank will depend largely on the number of sheep to be dipped, but for ordinary use the following dimensions will be found fairly suitable; 8 feet long on top, 3 feet at the bottom, (the difference in the width between the bottom and top being due to one end having a slope on which cleats are fastened to allow the sheep to walk out of the vat); a width of 2 feet on top sloping to 1 foot at the bottom and a depth of 4 feet. Provision should be made for a draining platform at the end where the sheep are taken out. This should slope towards the vat and holding the sheep here for a short time after coming out will mean a great saving in the amount of dipping material necessary.

SHEARING.

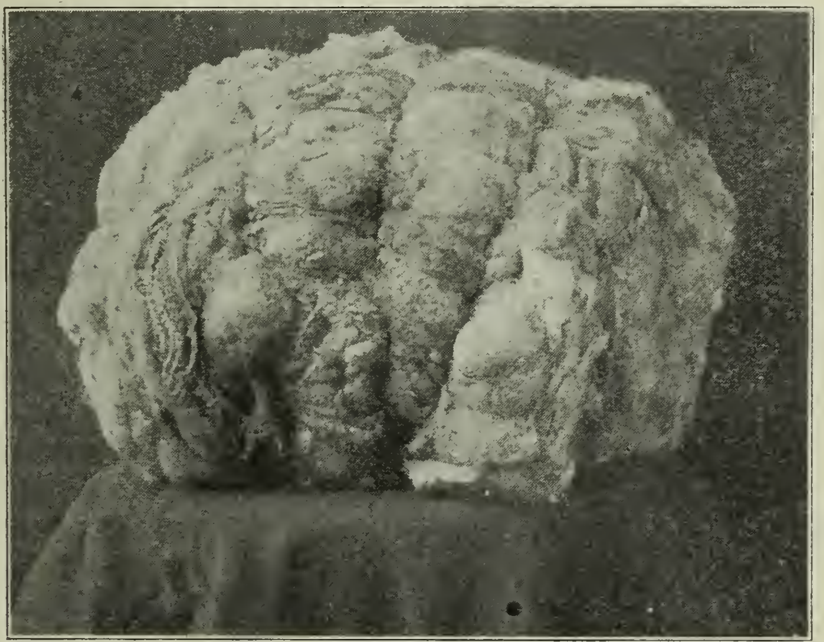
The difference in price between washed and unwashed wool is in favor of the latter. Comparatively little washed wool has been offered on the market during the past ten years, and it is now generally agreed that there is nothing to be gained by washing sheep. Shearing should be done in the spring just as soon as the weather will permit; the old idea of leaving the fleece on until the middle of June is not good flock husbandry. There are several advantages in shearing early; the work is accomplished before the rush of spring and summer work commences, it is a good deal more comfortable for the sheep than leaving it until the warmer weather, this is especially true if the ticks are plentiful and the general health and thrift of the flock will be increased by relieving them of their winter protection just as soon as it is safe. In most districts in Ontario shearing may safely be done early in April. This will depend somewhat, of course, on the time the ewes are to lamb. It is an advantage to shear, if possible, before they lamb as it lessens to a considerable extent the danger from wool balls in the stomach of the young lamb. If the shearing can be done within two weeks of the time the lambs are expected, it will be perfectly safe. If this is impossible it should be done as soon after as it is practicable. For any one owning a reasonable sized flock a sheep shearing machine is a profitable investment. In fact arrangements could be made for a few farmers in one district to buy a machine co-operatively and the expense would not be heavy on any one. Machine shearing is easier on the operator and the sheep, and much cleaner, neater work can be done with them as compared with the ordinary

Hand shearing.

Machine shearing

hand work. The ordinary hand shears in the hands of an experienced man will do a good job, it is true, and if there are only a few sheep in the flock it might not warrant buying a machine. In removing the fleece the aim should be to keep it clean, to prevent the fleece from being torn apart, avoid cutting the sheep, and to make the operation as easy as possible for both shearer and sheep.

The shearing can be done on a clean barn floor or outside on a grass plot. The use of a horse blanket or clean sheet will prevent the wool from becoming dirty and will make it easier for both the sheep and the operator. To commence with, the sheep should be set on its rump and the wool on the neck removed first by separating it on the under side; follow this up by opening the fleece down the belly and shear part way round on both sides of the under side of the body. The sheep may then be turned on one side, the operator holding it by placing one knee on each side of the neck. In this position the upper side may be shorn, then turn over on the opposite side and that portion of the fleece still remaining can be finished. Care should be taken to keep the sheep from struggling and kicking so

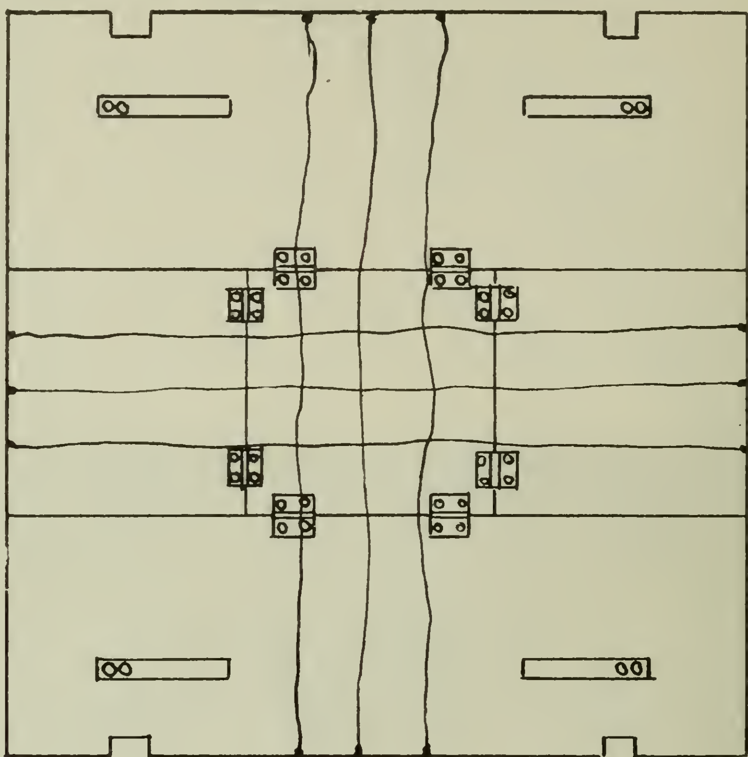


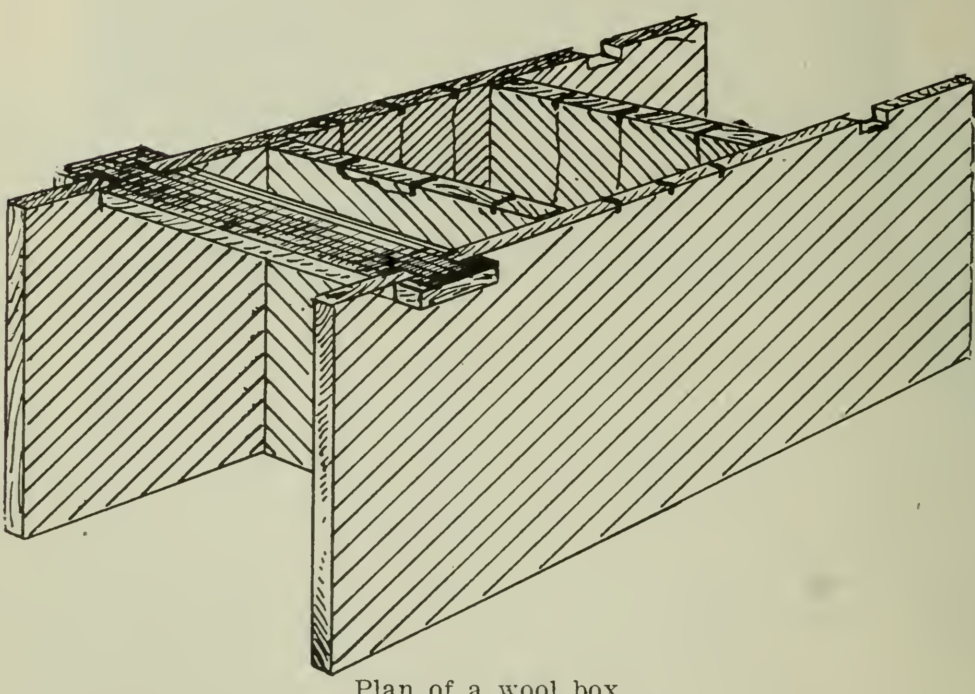
A fleece properly tied.

that the fleece may not be torn apart. Some shearers make a practice of tying the legs of the sheep. This may be advisable if the sheep is very restless, but it is much easier on the animal if the legs are not tied, and under ordinary conditions it is not necessary.

Tying the Fleece. When the fleece has been removed it should be spread out on the blanket with the clipped side down. All dung locks and dirty wool should be cut off and sold separately from the main fleece. To tie the fleece, both outside edges should be folded in leaving a width of about a foot and a half. In this position roll from both ends towards the middle into a compact, neat bundle. The old practice of tying the fleece by twisting the neck piece into a rope should not be followed. That portion of the fleece that has been twisted for this purpose is injured to a considerable extent when the wool is opened up for manufacture. The use of ordinary binder twine is also objectionable as the strands of twine become incorporated into the wool. Such wool cannot be used for making a high class fabric. Paper twine is now available for tying the fleece and is the only string that should be used. If the wool is not marketed immediately it should be stored in a dry place, otherwise considerable damage may result from the effects of dampness.

The use of a wool-box will aid considerably in making a compact, tidy bundle of the fleece. This wool-box is constructed as follows: take three pieces of inch, planed lumber each one foot wide and three feet long; the centre board is cut into





Plan of a wool box.

three pieces each one foot long, by means of eight hinges the five pieces are now fastened together in such a manner as to form a box, that is the centre of the middle board will form the bottom of the box, the two end pieces of this same middle board will go to provide the ends and the two outside boards will be the sides. When the box is set up the two end pieces are held in place by means of a sheet iron spring attached to the side pieces. Two slats dovetailed and arranged so they may be removed each time the box is set up will hold the two side pieces up in their place. To tie the fleece the box is opened up flat and the twine is put in place, being held by cutting three notches on each side, twelve in all. Spread the fleece with the shorn side down, fold in the edges and then bring the sides and ends together to form the box. When fastened the fleece may be tied securely with the string. Now open up the box and the result will be a firm, tidy bundle. A little more time is required to do up the fleece with the wool-box, and in spite of the fact that it does make a much neater fleece many farmers will be content with putting it up by rolling as previously suggested.

TRIMMING THE FEET.

During the winter when the flock is confined to the pens their feet will require trimming to keep them in good condition. Weak pasterns and some of the com-

Before and after trimming.

moner diseases of the feet may be prevented by a little attention in regard to trimming. A strong sharp pocket knife may be used for this or clippers made for the purpose may be purchased. Not only do the toes grow out very long but the sole of the hoof will turn under; both should be pared giving the hoof the proper shape. At the same time all accumulation of dirt should be removed. The paring may be done much easier after the sheep have been running out in the wet grass or snow for some time, as this tends to soften the brittle hoof.

Salt and Water. During the winter when the snow is available and especially where a liberal supply of roots is being fed, the flock will not suffer a great deal if no water is given. At the same time they will drink more or less water if it is to be had, and if at all convenient it will pay to provide it even in the winter. After the ewes have lambed in the spring and during the summer, while on grass, an abundant supply of clean, fresh water should be at hand. Especially during the long, hot days of summer the sheep will drink a liberal supply and the health and comfort of the flock demands that it be available.

Salt should be before the flock at all times during the year. A box or trough. set up in the pen during the winter or in the field while on pasture, in which there is always a supply. will assure the owner that his flock is always well provided with salt.

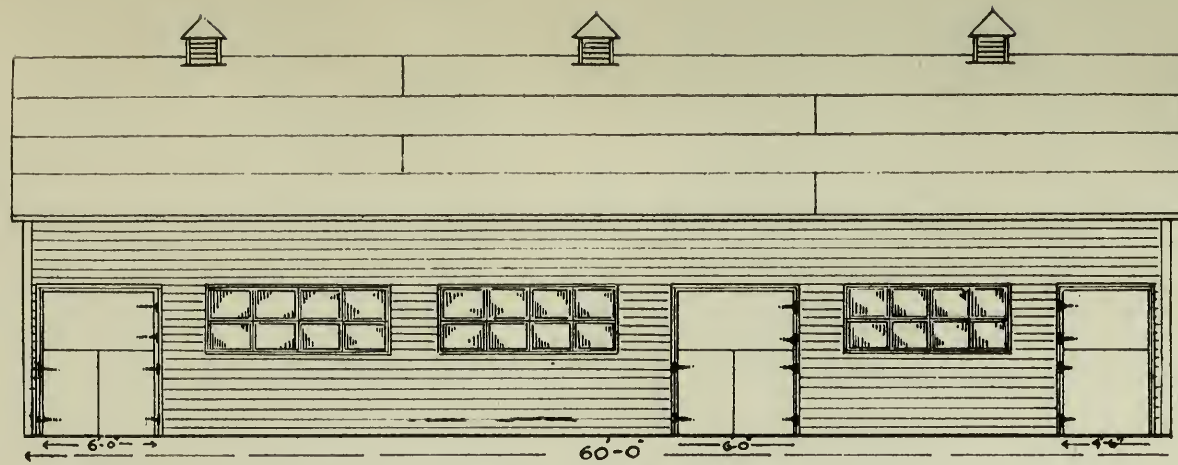
Clippers used for trimming feet.

SHEEP SHEDS, BARNS AND FEED RACKS.

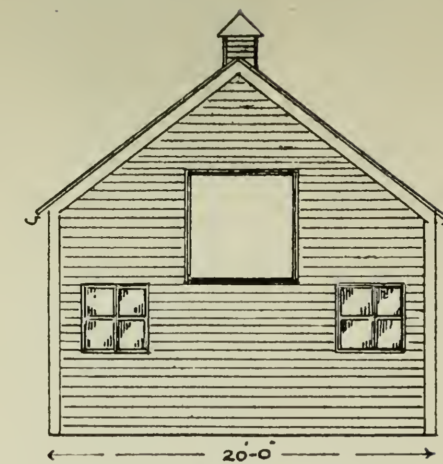
The first thing to consider in the matter of sheep barns is their location. Sheep do better on rather high, dry ground and under no consideration should the buildings be placed anywhere but in a dry, airy place. In Ontario, housing is necessary through the inclement weather of late fall and winter, but buildings should always be placed so that the sheep may get a maximum amount of outdoor exercise, and there should be provision for large outside yards, preferably to the south of the buildings, to which the sheep may have free access on all fine days.

Sheep barns or sheep pens need not be expensive structures. The main points to keep in mind are: good ventilation, which should be accomplished without drafts; plenty of floor space for each sheep; an abundance of sunlight; good drainage; and every convenience in respect to storing of feeds and the handling of the flock. The builder should be careful to plan his building large enough. Crowding is often disastrous. While the smaller breeds will get along with from 12 to 14 square feet per sheep, the larger breeds require up to 18 square feet, and this is not too much space for the man who is planning a sheep barn or sheep pen to allow for each sheep in his flock.

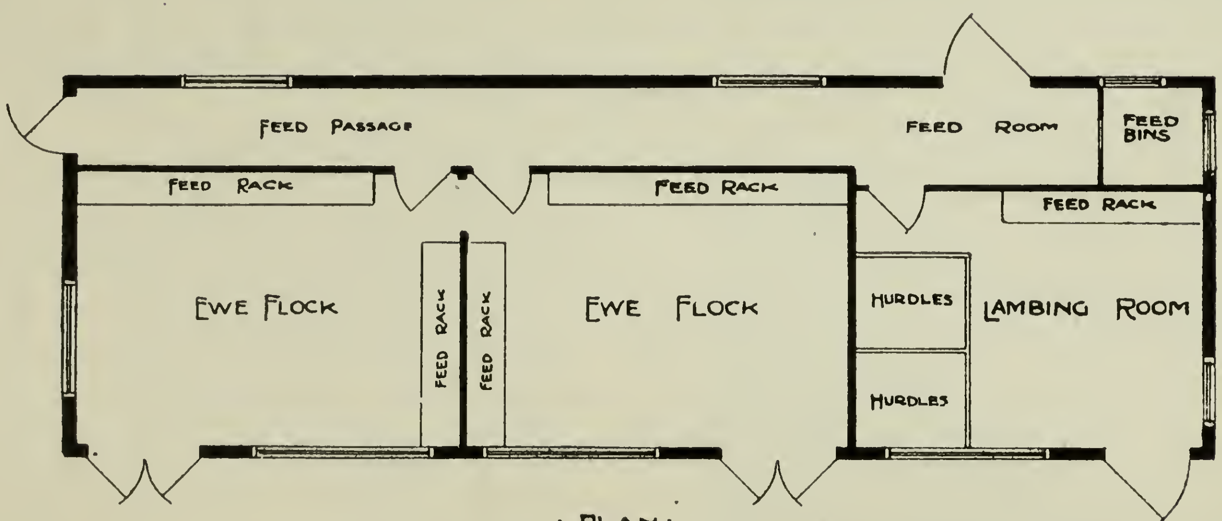
As previously stated the building does not require to be elaborate in design or construction. For foundation walls cement or stone will answer the purpose. Of course, the wall should go below the frost line to solid ground and extend just above the ground. Cement is a little cheaper than stone to construct and is quite as suitable. The barn does not require to be warm. with the exception of that portion which is used as a lambing pen. The building may be studded up and boarded on the inside and outside, the outside having the cracks battened or drop siding used and the inside should be of matched lumber. making a good dead air space and a dry, satisfactory wall. In one corner of the barn should be built a warm extra-lined. lambing pen.



: FRONT ELEVATION :



: SIDE ELEVATION :

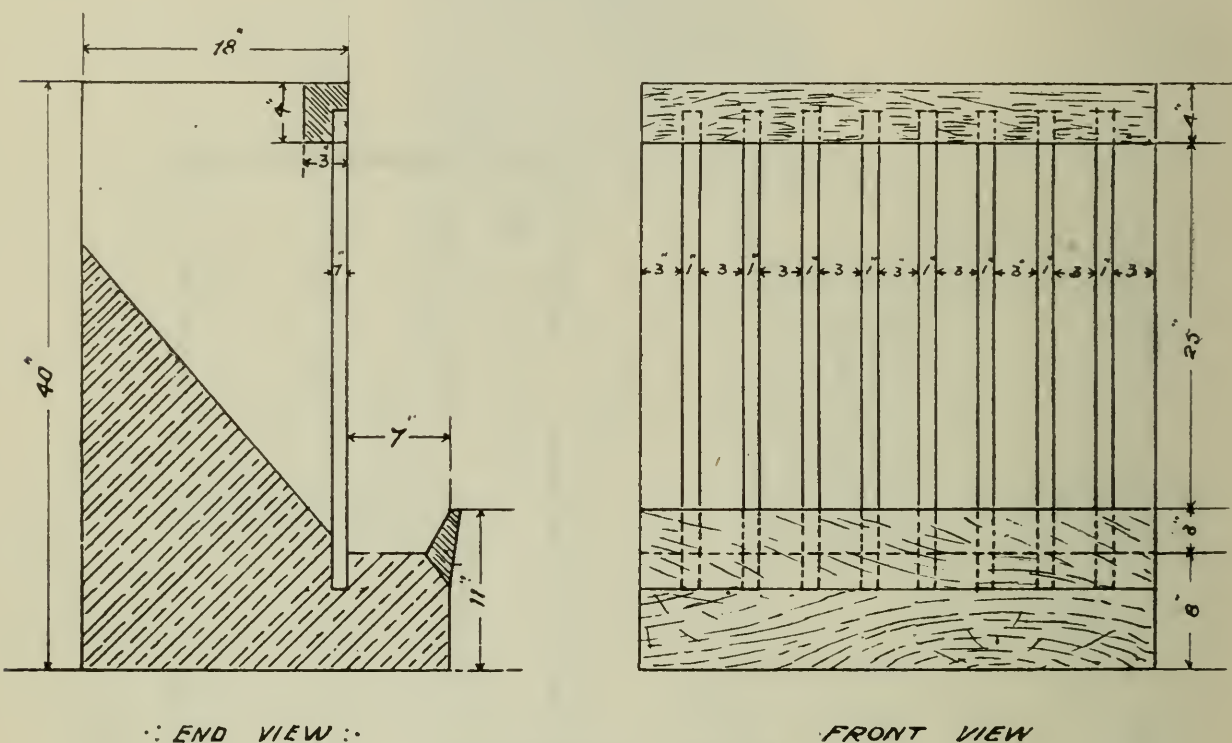


: PLAN :

SUGGESTION for A SHEEP BARN

For partitions it is well to have on hand a number of hurdles which may be used to construct small pens as required, but for the main partitions movable feed racks, such as illustrated, are quite suitable, save space and are altogether desirable. These placed back to back allow the sheep to feed on both sides or they may be used placed against the wall if desired. A trough kept well supplied with clean, fresh water should be provided in each pen.

In planning the building, the shepherd should make provision by which he can keep his ewe and ram lambs in separate pens, and these, of course, separated from the older breeding ewes. In large flocks it is also necessary to plan a pen for older rams. In the breeding ewe pen it is well to provide a number of small hurdles, leaving space about 6 feet square for individual ewes at lambing time. These, of course, are temporary and only require to be used while the lambs are young.



Suggestion for feed rack.

All doors should be built fairly wide to avoid the sheep crowding when going in and out. From 6 to 7 feet is a good width. Large windows, hinged at the bottom and opening in from the top are desirable. Doors are best split in the centre so that either the top or the bottom half may be opened as desired.

To provide for ventilation the Rutherford system or a modification of this system is quite satisfactory. By extending up the outside of the wall a tube of cement or plank about 9 by 18 inches and bringing this down through the wall at the floor and protecting it on the inside by a sheet iron deflector to prevent drafts fresh air inlets may be provided for. These outside boxes should go down into the ground. Then, for outlets, ventilators through the roof coming down through the loft and into the sheep pen at the ceiling are necessary. The outlets should provide double the surface of the inlets and should be built of two-ply tongued and grooved lumber. They may be regulated by a damper.

It is a wise precaution to have plenty of loft room overhead for the storage of hay and feed and to arrange for a root cellar, which may be built under the barn approach with cement walls and with a cement top held together by reinforcing of wire and some such material as old railroad rails. The building should also be provided with bins for grain and a suitable feed room. The accompanying illustrations will give the reader an idea of the type of feed racks and troughs recommended and also of a suitable barn and shed for the handling of a fair sized flock of sheep.

The building, as described, may be too elaborate for some. If so a very satisfactory structure for all purposes with the exception of supplying sufficient protection just at lambing time may be put up of ordinary lumber, one-ply with the cracks battened. The sheep at the Ontario Agricultural College do very well in such a building, and with care at lambing time this type of barn answers all right. It would be well to use lumber planed on one side at least that it may be painted.

DISEASES.

As with all other classes of live stock disease prevention is far more successful than is a cure after any trouble, contagious or non-infectious, gains a foothold in the flock. A sick sheep is not easy to cure, yet with good care many sheep diseases yield to treatment. The best policy, however, is to feed regularly on wholesome feed of the best quality; give plenty of pure drinking water; keep salt before the flock at all times; avoid drafts and hot, ill-ventilated quarters; keep free of ticks and lice; do not crowd; keep dry; and change pastures and runs frequently. These attended to, coupled with the weeding out of old and sickly ewes and the use of a strong, vigorous ram should keep the flock fairly healthy. However, with all known precautions taken some disease is sure to creep into the flock from time to time and it is well to understand a few symptoms and treatments.

Footrot. Footrot is a more or less common contagious or non-contagious disease which requires care and very often rather heroic treatment to eradicate. Low, wet pasture, dirty pens and yards and neglect in trimming feet may bring on the non-contagious type. The contagious form is rarely found in Canadian flocks. Sometimes in new importations a few cases develop.

Lameness, slight at first, gradually becomes more pronounced and sores or cracks are seen between the digits. The cracks later exude pus.

Keep the sheep in a clean, dry place. All hoofs should be examined and pared when necessary to remove any superfluous hoof-growth. Diseased hoofs should be severely pared down until the bottom of the trouble is reached and the feet soaked in a solution of 1 ounce of copper sulphate to 2½ pints water. Isolate diseased sheep. Some shepherds grind the copper sulphate to a fine powder and fill the sores or cracks with the fine powder, forcing it in with the back of a knife blade or some such instrument. We have seen bad cases yield to a treatment of butter of antimony carefully worked into the cracks or sores after severe paring. The shepherd must be careful not to get this material on his hands or on the flesh of the sheep. The writer has seen practically the whole hoof cut away down to the quick and then the butter of antimony applied and the sheep recover after practically growing a new hoof. The attendant must get right to the bottom of the trouble with his paring knife else treatment will be without results.

Grub in Head. This is a large grub which is found in the sinuses of the head of a sheep in whose nostrils the sheep gadfly (*oestrus ovis*) has laid its eggs the previous summer. These eggs hatch in the nostrils and the larvae crawl up and deposit themselves in the sinuses, developing into large grubs.

Not all sheep which have grub in the head show clinical symptoms. The worst sufferers, however, fail in flesh, become weak and thin, and may show giddiness and loss of appetite.

The shepherd should plan to prevent the trouble rather than have to cure it. Sheep should have their noses smeared with pine tar during the months of July, August and September when the fly is most likely to attack them. If time is not available to catch each sheep separately and smear their noses, put tar on the edge of the salt trough or put salt in two-inch augur holes in a log in the pasture and smear the edges of these with tar. Sheep always run to a dusty place with their heads low when the fly attacks. Stirring up the dirt drives off the fly so a plot of plowed ground is a help in the sheep pasture. Trephining the sinuses may be practised to get rid of the grub once lodged in the head. We have heard also of shepherds using turpentine in the nostrils to cause violent sneezing which may dislodge the grub. Prevention is better than cure.

Goitre. Sheep of all ages are subject to this disease and in some seasons heavy losses in the lamb crop occur. It appears as an enlargement of the thyroid gland beneath the throat. It is believed to be hereditary or may be caused by some form of mal-nutrition. In-breeding should be avoided, plenty of exercise given and breeding only from sound, healthy, well-nourished stock practised. Curative treatment avails little.

Sturdy or Gid. Sturdy, Gid or Turnsick is caused by a species of tapeworm which infests dogs, and in a certain stage of its life history becomes encysted in the brain of the sheep. The disease is most common in wet seasons. The head is carried low and the sheep is dull and appears to suffer from defective eyesight. The animal loses control of one or more legs and shows a very peculiar gait and may die at this stage. If it survives it will likely show the symptoms of "turnsick," and will travel in circles until exhausted. The only cure is trephining. This disease is not common in this country.

Catarrh. Sheep suffering from this disease will be noticed sneezing and snuffling. A discharge from the nostrils is accompanied by inflamed eyes, and generally appetite fails. Well nourished sheep, kept in dry quarters free from drafts, rarely take catarrh. When noticed give flaxseed tea three times per day. Steam the head over boiling water to which a little carbolic acid has been added. Some recommend giving 1 dram sweet spirits of nitre and 15 grains powdered digitalis twice a day. Clean, dry, well-ventilated quarters should be the first consideration.

Inflammation of the Lungs. Occasionally a sheep will fall a victim to this trouble due to exposure to cold, wet weather particularly just after shearing. They will be noticed to be dull and off feed, breathing rapidly, coughing and growing weak.

Keep warm and give flaxseed tea and two drams sweet spirits of nitre and some stimulant.

Stretches or Constipation. This trouble, while not very prevalent, is still not uncommon where sheep are confined for long periods on dry feed alone. Stretches is simply a symptom of constipation. The sheep stretch and strain in an effort to defecate. Sheep breeders should plan to have roots, preferably swede turnips, or good sweet silage for their sheep in winter as a preventive of this trouble and should plan where grain is fed without sufficient succulent feed to give at least a third of the grain ration good wheat bran. To relieve constipation give 6 to 8 ounces of raw linseed oil with about 2 drams turpentine. Constipation is sometimes noticed in young lambs. For these there is nothing better than castor oil.

Diarrhœa. Diarrhœa is not a common disorder in sheep. It generally results from bad management or overfeeding on succulent feed. Sudden changes in diet may cause it. Too much green feed, an oversupply of roots or frozen or immature feed are contributing causes.

First remove the cause. Feed regularly. Administer a mild laxative such as castor oil for lambs or raw linseed oil for mature sheep. In bad cases add to the oil a dram of laudanum and the same amount of ginger; this is the dose for a mature sheep. Cut it in two for a lamb of three months. Keep dry and feed carefully.

Colic and Bloat. If spasmodic colic appears due to sudden changes of feed or access to injurious herbs or spoiled feed give a teaspoonful each of laudanum and sweet spirits of nitre dissolved with a teaspoonful of ginger and two teaspoonfuls of baking soda in one-half pint of water. Give an injection of warm water per rectum and a dose of raw linseed oil.

Bloating may occur if sheep are suddenly turned on wet clover or rape when hungry. They should be gradually accustomed to these feeds, and turned on at first only when the feed is dry. Bloat may follow colic. It may be necessary to puncture. For this use a trocar and cannula. If this instrument is not procurable use a pocket knife and puncture on the left side at the most distended point just in front of the hip bone. After puncturing give a dose of 4 to 6 ounces of raw linseed oil.

The Stomach Worm. There are several varieties of stomach worms but they are, as a general thing, less than an inch long. They invade the fourth stomach, are twisted, fine and hair-like. These worms in the stomach produce eggs which pass out with the faeces, hatch in any temperature above 40 degrees Fahrenheit and are taken back in the digestive tract of the lamb or sheep. The eggs hatch in wet places or dirty stagnant water. The worms do most damage in lambs, and usually start soon after the sheep go out on grass.

Lambs infected with this pest show more marked symptoms than do older sheep suffering from the same trouble. They lose flesh, appetite fails, they appear dull, wool becomes dry, and colic with black diarrhœa may develop. As with most diseases the weaker lambs and sheep are those most likely to become severely affected.

Keep the sheep thriving well by good feed and frequent change of pasture. Old pastures upon which sheep have grazed for many years may be infected, and should be plowed up and dressed with an application of lime. Because they are in the fourth stomach of the animal the worms are rather difficult to reach. Gasoline has been used in one-to-three-dram doses, but is more valuable as a preventive than a cure, for it is doubtful whether it ever reaches the fourth stomach in sufficient strength to kill the worms. Turpentine is sometimes used. Kamala may be given once daily in from one-half to one dram doses in thick gruel or raw linseed oil. Bluestone is said to be the best remedy. Dissolve 2 ounces of finely powdered bluestone in a quart of boiling water. Add water until it reaches a gallon. Give a lamb three months old 1 ounce; six months, 1½ ounces; one year 2½ ounces; eighteen months, 3 ounces; two years 3½ ounces.

Tapeworm. Some eight different species of tapeworm are harbored by the sheep, but the most common type found in the Province of Ontario is known as *Toenia expansa.* This species of tapeworm may run from eight or ten feet in length up to eighteen feet, and from about 1-25 of an inch wide at the head to nearly ½-inch at the tail. The entire worm is yellowish white in color and is composed of segments about one-quarter of an inch long.

The experience of the writer has been that lambs suffer more from this trouble than do sheep. In 1918 the lambs in the O. A. C. flock were badly infested, but the ewes were practically free from the trouble. Infested sheep or lambs do not thrive, the skin becomes pale and weakness follows, accompanied by a dry condition of the wool and very often by digestive troubles. The surest symptom is the finding of segments of the worm in droppings. If this trouble is suspected close observation should be given the droppings of the sheep and lambs.

Fast the sheep or lambs twenty-four hours before treatment. Then give one dram oil of male shield fern in three ounces of castor oil to a mature sheep or half the dose for a lamb. Give as a drench by means of a long-necked bottle. Kamala in $1\frac{1}{2}$ dram doses to mature sheep given in thick gruel or treacle and followed by 3 ounces of castor oil in a few hours will expel the worms. Keep sheep in after treatment until all worms are expelled. This will take from 24 to 30 hours. Put out on new pasture, as if any segments of tapeworm are picked up by the sheep or lambs they will develop. The trouble is most common in wet years and on wet pastures.

Intestinal Round Worms and Nodular Disease. There are several species of round worms infecting intestines of sheep the worst of which is that which causes nodular disease or "knotty gut." These are picked up by the young lambs and sheep on pasture. Frequent changing of the flock from one pasture to another. and the growing of rape and such green crops for pasture, are the best preventive measures. Gasoline in one-to-three-dram doses given in milk is used by some shepherds, and turpentine is relied upon by many others. If one sheep or lamb in the flock is known to be affected, it is safe practice to treat the entire flock. A solution such as that recommended for stomach worms may be tried. These treatments are effective with many species, but will not cure nodular disease. This latter may be recognized in post mortem examinations by the knotty condition of the intestines caused by the encysted worms for which, as yet. no remedy has been found. Sheep badly affected become emaciated and very weak.

Maggots. Occasionally the stumps remaining after lambs' tails have been docked late in the season become fly blown and sometimes ewes not kept well trimmed behind suffer from the same trouble through their hind parts becoming wet from urine, etc. Pine tar applied to such places is a good preventive. All sheep should be kept trimmed. Spirits of turpentine will clean the maggots out of such places and after application the spots should be smeared with the tar. Gasoline and lime may also be used to good effect to get rid of maggots.

Lice and Ticks. Sheep are liable to be troubled with lice or ticks, or both. Lice are more feared by the shepherd than are ticks. Both cause loss of flesh. damage and loss to wool and general debility in the flock. Ticks and lice always thrive best on poorly-cared-for sheep and lambs. Sheep, pestered with these parasites, rub and scratch a great deal. Regular dipping in a standard dip just before the sheep go out to pasture in the spring, and on a warm day in the late fall before they go into winter quarters, generally keeps the flock fairly free from the ravages of both these pests. Sheep and lambs should be immersed in the dip for at least one minute.

Scab. Sheep scab is a very contagious disease, and when it appears must be carefully and thoroughly treated. It is caused by a mite which is difficult to see with the naked eye. Infested sheep commence to lose their wool usually on the upper part of the body and around the neck. A flock well fed and cared for is more resistant than one poorly nourished and badly housed. Sheep suffering from scab are very itchy, do considerable rubbing and scabs appear on the body. The insects live under these crusts. Wool drags from the sheep's body and unless treatment is promptly given the disease spreads through the entire flock.

Dipping is the only remedy. Sheep should remain a full two minutes in a dipping tank, the head should be plunged beneath the dip and the material should be thoroughly brushed into the scabby surface. At least two dippings are necessary at intervals from ten to twelve days. In bad cases a third dipping is advisable. Use a standard dip. If possible clip the sheep before dipping. After dipping place the sheep in clean quarters. Disinfect all feed troughs, racks, pen, etc., by applying some good coal-tar product.

Caked Udder, Inflammation of the Udder, Garget. The sheep's udder may become hard and swollen at lambing time and some difficulty may come just after weaning. The shepherd should avoid heavy feeding at and before lambing time and should keep his sheep in a dry, well-ventilated, comfortable place. If not watched, caked udder may develop into inflammation or garget, a disease most common in wet, cold seasons. Ewes suffering from these troubles should be purged with 4 ounces of Epsom salts in a half pint of warm water. Hot fomentations should be applied to the udder. Rubbing is beneficial and water just as hot as can be borne should be applied twice per day for 20 minutes to half an hour at a time. In real severe cases it may be necessary to poultice. After bathing with hot water rub well with lard or some such substance. Feed lightly. Give a bran mash.

Sore teats. Sore teats are generally the result of bad housing of milking ewes in wet, cold weather or are caused by the lambs biting them when the ewe has not enough milk to satisfy her offspring. Apply three times daily vaseline or sweet oil and glycerine or a little melted mutton tallow. Care should be taken to heal sore teats else udder trouble is liable to develop.

Rickets. Rickets sometimes appear in young lambs. They show weakness in the hindquarters, and will reel and fall as they try to walk. May be due to close-in and in-breeding, to poor feeding of the dam during pregnancy, to a lack of mineral or other life-giving ingredient in the feed of the dam, or to undue exposure.

Feed both the lamb and dam well. Do not in-breed too closely. Sell affected lambs as soon as they are big enough for the butcher.

Wool Balls in Stomach. The presence of lice or ticks may cause young lambs to pull their wool and some of this may get into the stomach. Sometimes lambs pull wool from their mothers. All wool should be carefully clipped from around the ewes' udders just before they lamb if they have not already been shorn. Wool taken into the lamb's mouth is very often chewed and swallowed when it forms wool balls in the stomach. The lamb becomes dull and stupid and finally refuses to nurse or eat. A dose of linseed or castor oil will sometimes relieve a lamb of this trouble, but wool balls generally result in death.

Sore Eyes. This trouble may be ophthalmia or it may be due to constitutional disturbance. It is most common in lambs. Eyes should be bathed in warm water and a sulphate of zinc solution dropped into each eye with a dropper. To make the solution dissolve 2 grains of sulphate of zinc in one ounce of water. It is always safer to isolate all sheep and lambs affected, as the disease may be a contagious form. Lambs should not be exposed to storms or drafts. Feed on laxative feed and it is generally advisable to begin treatment by the administration of a mild laxative such as a dose of castor oil. Boracic acid is also used to good advantage in many flocks. If pink eye should develop and scum appear over the eye blow a little burnt alum into it.

Infectious Sore Mouth. Occasionally an outbreak of infectious sore mouth occurs. The sheep cannot eat and soon become thin and emaciated. The edges of their lips, both upper and lower, become sore and scabby. Treatment consists in arresting the spread of the disease by isolating all infected animals and applying to the sores carbolized vaseline or some other cleansing and healing ointment at least once daily until cured.

Calculi. Breeding rams are sometimes bothered with calculi in the urethra. They arch the back, become stiff in the hind quarters and soon become useless. Feeding mangels to breeding rams is liable to cause this trouble and should not be practised. An operation is generally necessary to effect a cure, and all but valuable breeding rams should be slaughtered for mutton when this trouble appears.

Liver Trouble. There are several diseases of the liver which it is not necessary to mention here, but the writer has seen several sheep die due to a clogged condition of the liver which ultimately resulted in its breaking down altogether. The cause seemed to be overfeeding on grain and too little exercise. The sheep go off their feed, show a slight cough and finally weaken and die. Once established no known treatment will effect a cure.

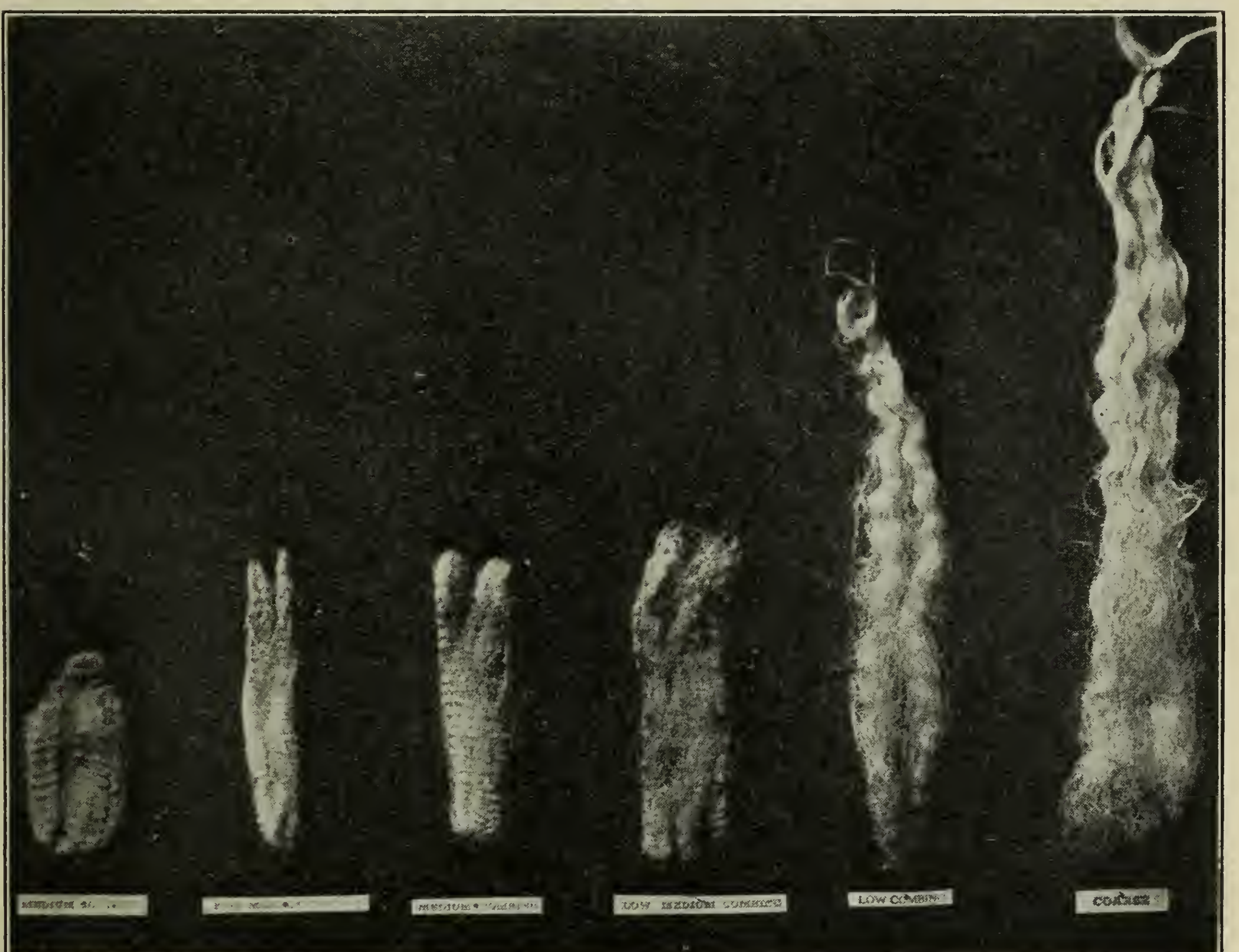
Eversion of the Womb. Occasionally just after a difficult parturition the womb may be protruded. In such cases remove the placenta, wash the womb in a warm two per cent. carbolic acid solution and have an attendant place the ewe on her back and hold her hind quarters about a foot off the ground by grasping the hind legs. Flush out the womb with a pint of lukewarm water in which a little powdered alum has been dissolved and return it to place. The ewe should then be tied for a few days in a narrow stall raised six or eight inches higher behind than in front.

Administering Medicines. In administering medicine to a sheep always give with the sheep standing. Secure a long, slender-necked bottle for drenching. Every shepherd should have a funnel and a graduated measuring glass. Back the sheep into a corner, stand astride of it and with one hand under the lower jaw raise the head just enough that the liquid will run to the throat. Insert the neck of the bottle in the side of the mouth and pour slowly as the sheep swallows. Do not rush the drenching. Give young lambs medicine in the mother's milk.

WOOL.

While it is true that practically all the breeds of sheep kept in Ontario are mutton sheep and the fleece is more or less of a by-product, yet wool selling at over the half-dollar mark per pound the production of a heavy fleece of good quality is a very important feature of sheep husbandry. *Quantity* and *quality* are the essential features of a good fleece. Neither of these can be expected unless the flock is maintained throughout the year in a good condition, and at the same time care taken to keep all foreign matter such as chaff, burs and sand out of the wool. The weight of the fleece depends on the density and length of the wool, and this varies to some extent with the different breeds. A good growth of wool is impossible. no matter what breed. unless the sheep has been well nourished. The growth of wool depends just as much on good feeding and management as does the growth of the animal's body. Quality has reference to strength of fibre, the absence of cotted wool and kemp and a fleece that is free from dirt and chaff. The wool produced during a period of sickness or low condition of the sheep is bound to be weak in fibre. Freedom from cotted wool is dependent upon a regular supply of yoke or grease secreted from the pores of the skin. Here again sickness or low vitality means a scanty supply of yoke, with the result that the wool fibres become interlocked, which is known as a cotted condition. The amount of dirt that collects in the fleece will depend largely on the care exercised in handling the flock.

During the winter more or less chaff and straw is bound to collect in the wool, but by feeding from properly constructed feed racks and avoiding as far as possible having the feed lodge on the necks and backs of the sheep, it is possible to produce wool that will be reasonably clean. As has already been suggested, the amount and quality of the wool produced in any flock will depend very much on the feeding and general management of the flock throughout the entire twelve months of the year and from this standpoint alone it is well worth while to give the proper care and attention at the right time. It may mean the difference of several cents per pound in the selling value, as well as an increase in the weight of the wool.



Grades of wool.

Left to right—Medium clothing, fine medium combing, medium combing, low medium combing, low combing, coarse.

Within the past three years considerable attention has been given to the grading of the Ontario wool clip. In common with any commodity, wool that is marketed after being properly graded will usually command a higher price than that offered without any respect as to quality and values. When wool is sold according to the different grades the farmer that produces a good quality of wool usually gets a premium for it. All cotted and black or gray wool as well as the dung locks are sold separate from the good fleeces. The basis for grading is determined by the length, fineness or coarseness, strength and purity of the wool. It is difficult to say definitely the grade into which the different breeds would be classed. The table given herewith is the result of the grading of approximately three quarters of a million pounds of wool in Ontario this year, and will give a general idea of the grades into which the different breeds are classed. In connection with this table it should be mentioned that many fleeces might be on the border line and could easily have been admitted to a grade higher or one lower.

Breed	Fine Medium Combing	Medium Combing	Low Medium Combing	Low Combing	Fine Medium Clothing	Medium Clothing	Coarse
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Leicester	....	....	15.	39.4	....	....	45.6
Lincoln.........	....	....	.4	1.6	....	....	98.
Cotswold	....	....	....	5.	....	....	95.
Southdown......	8.9	20.9	1.8	....	42.8	25.6	....
Shropshire......	.9	71.6	12.9	....	1.4	13.2	....
Oxford	.4	46.2	49.5	3.1	.6	.2	....
Suffolk	34.4	60.4	....	....	3.1	2.1	....
Hampshire......	5.4	67.5	8.7	....	4.8	13.6	....
Dorset..........	....	74.8	20.	....	....	5.2	....

The illustration showing the different grades of wool is fairly representative, and may be an aid to the farmer as indicating into what class his wool would go.

LEGISLATION FOR THE PROTECTION OF SHEEP.

The Legislature of the Province of Ontario passed an Act in 1918 to impose a tax on dogs and for the protection of sheep. This was amended in 1919, and as it now stands the annual tax on dogs, subject to the provisions of paragraph 9a section 100 of the Municipal Act and of subsection 3 of this Act is $2, and if an owner has more than one dog $4 for each additional dog, and $4 for a bitch if only one and $6 for each additional bitch. Any local municipality may, at any time, increase such tax. Owners of kennels of pure-bred dogs registered in the Canada Kennel Register may, in any year, pay the treasurer of the municipality $10 as a tax upon the kennel for that year, thus exempting them from any further tax for that year.

Any person may kill any dog which is found pursuing, worrying or wounding any sheep, or which is found straying between sunset and sunrise from the premises on which such dog is habitually kept, and no conviction shall be a bar to any action by the owner or possessor of any sheep for the recovery of damages for the injury done to such sheep. Following are extracts from the Act:

Extent of Liability of Owner or Keeper of Dogs.

10.—(1) The owner of any sheep killed or injured by any dog shall be entitled to recover the damage occasioned thereby from the owner of such dog, by an action for damages or by summary proceedings before a justice of the peace, who is hereby authorized to hear and determine such complaint, and proceed thereon in the manner provided by *The Master and Servant Act*, or as nearly as may be, and the said Act, *mutatis mutandis*, shall, except as to the limit of jurisdiction, apply to all proceedings taken under this section and to the enforcing of judgments and to the time and manner of making appeals.

(2) The aggrieved party may recover in such action or proceeding, whether or not the owner of such dog knew that it was vicious or accustomed to worry sheep.

(3) If it appears at the trial that the damage or some part thereof was the joint act of some other dog, and of a dog owned by the person charged, the court, judge or justice may, by the judgment or conviction, apportion the damages among and against the respective owners of the dogs, as far as they are known, in such proportions as may be deemed just.

(4) If it appears at the trial that the damage was occasioned by a dog, the owner of which is known, and a dog the owner of which is unknown, or has not been summoned to appear, the court, judge or justice may determine and adjudge as to the proportion of the damage which, having regard to the evidence adduced as to the strength, ferocity and character of the various dogs shewn to have been engaged in committing such damage, was probably done by the dogs the owners of which have been summoned to appear, and shall determine in respect thereof and apportion the damage which the court, judge or justice determines to have been probably done by the dogs whose owners or keepers have been summoned, amongst the various owners or keepers who have been so summoned.

(5) The like proceedings may thereafter be had against the owners of the dogs which so contributed to the damage.

11. The owner of any dog, to whom notice is given of any injury done by his dog to any sheep, or of his dog having chased or worried any sheep, shall, within forty-eight hours after such notice, cause such dog to be killed; and for every neglect so to do he shall incur a penalty of $2.50 for each dog, and a further penalty of $1.25 for each dog for every forty-eight hours thereafter, until the dog is killed, if it is proved in the proceedings for the recovery of such penalties, that such dog has worried or otherwise injured such sheep, unless the owner proves that it was not in his power to kill the dog.

12. When the owner of any sheep so killed or injured proceeds against the owner of the dog which committed the injury, before a justice of the peace, and is unable on the conviction of the offender, to levy the amount ordered to be paid, for want of sufficient distress, the council of the municipality in which the offender resided at the time of the injury shall order their treasurer to pay to the aggrieved party the full amount ordered to be paid by the justice by the conviction, in addition to the costs of the proceedings before the justice and before the council.

Compensation Where Owner Unknown.

13. Where the owner of any dog killing, injuring, terrifying or worrying sheep is not known, the municipality in which such sheep were so killed, injured, terrified or worried shall be liable for compensation to the full amount of the damage sustained, but no municipality shall be so liable unless application has been made for damages as herein provided within three months after such sheep have been so killed, injured, terrified or worried

14. The amount of damage sustained as aforesaid shall be determined in the following manner:

(1) The council of every local municipality shall appoint one or more competent persons to be known as Sheep Valuers. Within forty-eight hours after the discovery of any damage as mentioned in the preceding section, the owner of the sheep or the clerk of the municipality shall notify a sheep valuer, who shall immediately make full investigation and determine the extent of the damage. The sheep valuer shall make his report in writing, giving in detail the extent of the injury and the amount of damage done, to the clerk of the municipality and shall at the same time forward a copy of such report to the owner of the sheep damaged.

(2) Where the owner of such sheep considers the award inadequate to cover the loss sustained, he may appeal to the Minister of Agriculture who may name a competent arbitrator to make a further investigation and the award of the arbitrator so named shall be final; provided the appeal to the Minister shall be made within one week after the award of the local valuer has been received, and shall be accompanied by a deposit of twenty-five dollars ($25), which shall be forfeited if the award of the local valuer is sustained.

(3) When the amount of damage has been finally determined as aforesaid, the treasurer of the municipality shall forthwith pay over to the owner of the sheep the amount so awarded.

(4) If no sheep valuators are appointed by the municipal council, or the clerk or the sheep valuers do not perform the duties provided for by this section or any of them within the times specified, where the time is specified for the doing thereof, or where no such time is specified, within a reasonable time, the person who has sustained the damage shall have a right of action against the municipal corporation for the amount of the damage, recoverable in any court of competent jurisdiction.

15. After the owner of a sheep has received any money from a municipal corporation under any of the preceding sections, his claim shall thenceforth belong to the municipal corporation, which may enforce the same against the offending party for its own benefit, by any means or form of proceeding that the owner was entitled to take for that purpose, but if the corporation recovers from the offender more than it paid to the owner, besides costs, it shall pay over the excess to the owner.

16. Subject to the provisions of subsection 2 the owner of any sheep killed or injured while running at large upon any highway or unenclosed land, shall have no right to compensation from a municipal corporation.

(2) The council of a township in unorganized territory may by by-law passed with the assent of the municipal electors provide that the corporation shall be liable for compensation to the full amount of the damage sustained by reason of sheep being killed or injured while running at large upon any highway or unenclosed land.

17. Except as herein otherwise provided, *The Ontario Summary Convictions Act* shall apply to prosecutions under this Act.

18. The times and the method of procedure set out in this Act shall be regarded as merely directory and a proceeding which is in substantial conformity with the Act shall not be open to objection on the ground that it is not in strict compliance therewith.

ACKNOWLEDGMENT.

The writers of this Bulletin wish to acknowledge valuable assistance received from the Sheep and Goat Division of the Dominion Department of Agriculture, from the Officers of the Live Stock Branch of the Ontario Department of Agriculture, and from various books and bulletins of reference. They are also indebted to the *Farmers' Advocate*, of London, Ontario, and to the Sheep and Goat Division of the Dominion Department of Agriculture for many photographs.