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NOS. 99 TO 112.

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Ontario Agricultural College and Experimental Farm

GRASSES OF ONTARIO.

BY

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AND

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GRASSES OF ONTARIO.

INTRODUCTION.

No one will question the correctness of the statement, that grasses are amongst the most useful plants grown on the farm; and there is no doubt that farmers should study them carefully and learn all they can about those which are suited to their different localities and to the particular branches of agriculture in which they are respectively engaged.

Ordinary works on botany say very little about grasses, and the great majority of young men know still less about even the most common varieties. Hence Messrs. Harrison and Day have prepared this bulletin and are sending it out in the hope that a considerable number of the young farmers of this province may use it so as to get an exact and thoroughly practical knowledge of those grasses which may be grown in their respective localities.

The popular portions of the bulletin are very simple and can be easily understood by all readers, and the more scientific descriptions introduced in connection with the illustrations, are intended for use in Public and High Schools and for the guidance of young men who may be disposed to study the grasses closely, so as to become familiar with the form, name, and uses of each variety.

Cut 21 has been borrowed from Mr. James Fletcher, entomologist and botanist of the Dominion Experimental Farms, and all the other cuts used are electrotypes made by permission from plates in the possession of the Department of Agriculture, Washington, D.C. The kindness and courtesy of Mr. Fletcher and of the officials of the United States Department of Agriculture are hereby acknowledged.

JAMES MILLS,
President.

Ontario Agricultural College,
Guelph, July, 1895.

A BRIEF DESCRIPTION OF THE PARTS OF GRASSES.

Roots. The roots of grasses are usually *fibrous* ; and the fibres of which they are composed extend downwards into the ground to a greater or less depth. The deeper they go, the better the plant withstands drought and the more it impoverishes the soil. Sometimes the roots, being very numerous and very much branched, bind the soil into a matted turf ; at other times, they creep along beneath the surface (are described as *creeping*) and throw up underground shoots, which root themselves, send up stems, and form new plants. These latter are very difficult to eradicate and are apt to become a nuisance. Hence it is not advisable to grow them, unless they produce an exceptionally large quantity of nutritious food. Couch grass (*Agropyrum repens*) furnishes a good example of this undesirable kind.

Stems. The stems of grasses that rise above the ground are usually hollow and are technically called *culms*. These stems are generally cylindrical, as well as hollow ; but they are sometimes compressed and flattened, as in the case of Canadian Blue Grass (*Poa compressa*) and a few others.

Further, the stems of grasses are divided at intervals by thickened, solid portions called nodes, or joints. These were formerly supposed to strengthen the stem ; but, according to Hackel, their sole function is to lift up stems that have been beaten or trodden down. The leaves, and sometimes the branches, start at these points.

The stem of grasses is divided by Lindley into three parts : (1) The lower part, which is procumbent and produces roots, but is itself distinguished from true roots by bearing scales and sending out, not only roots, but underground branches called *rhizomes*, or *root stocks* ; (2) the stem proper ; and (3) the upper part (where the spikelets are attached) called the *rhachis*.

The stem often has at its base a bulbous formation, which contains a store of food to be used by the plant when specially required; as, for instance, in time of drouth.

The stem may be what is known as *erect*, *ascending*, *bending*, *decumbent* (reclining on the ground but rising at the top), *leafy*, when the leaf sheaths close around it, or *naked*, when there are no leaves on the upper portion.

The *rhachis*, or upper part of the stem, is described as *simple* or *branched*, *round* or *angular*.

Leaves. All leaves of grasses consist of two parts, the *blade* and the *sheath* ; in a few tropical species, a *petiole*, or leaf-stalk, is also found. The upper part of the leaf is called the blade. It is long and narrow, with parallel edges, and is described as *linear*. The lower part, which folds around the stem, is called the *sheath.* It usually extends round so far that the two edges overlap each other; and, as it matures more quickly than the stem, its stiffer tissues serve as a protection to the culm in the earlier stages of its growth.

At the point of union between the blade and the sheath, there is often a small, thin, scale-like, membranous organ, called the *ligule.* It is a prolongation of the sheath; it always lies very close to the stem; and Schlechtendahl has suggested that its function is to keep water from getting in between the sheath and the stem.

The length and breadth of the blade vary considerably. Very narrow blades, such as those of Sheep's Fescue, are described as *awl-shaped;* and comparatively broad ones, as in ribbon grass, are spoken of as *sword-shaped.* In some instances, the apex of the leaf is *acute;* in others, *tapering* or *blunt.*

There is one central rib running down the leaf, called the *mid-nerve* or *mid-rib,* and numerous finer ones running parallel on each side. The extremely strong mid-rib that is found in corn, sorghum, etc., gives especial firmness to the leaf. When there are no strongly marked ribs, the leaf is characterized as *flat;* and its surface may be *smooth, rough, downy,* or *hairy.* The margin is spoken of as *plane, downy, hairy,* or *serrate* (saw-edged).

By the position of the leaves on the stem of grasses, a character is afforded by which they may be easily distinguished from the sedges, a closely related family of grass-like plants. Beginning with any leaf on the stem of a true grass, one will find the next leaf exactly on the opposite side of the stem, and the next directly above the starting point. This arrangement of leaves is technically described as *distichous.* In sedges, however, the arrangement is three-ranked, *i. e.,* it is the third leaf from the first, which is directly above the first.

In the day time, the leaves stand out from the stem, with the upper surface turned upwards; but, at night, they lie quite close to the stem and, according to Hackel, their surfaces are at an angle of 90° from the position which they occupied during the day. These so-called sleep movements are due to the influence of light and are exhibited by many trees, as well as grasses; for example, some mimosas.

Other things being equal, the quality and quantity of the leaves of grasses determine their agricultural value.

Inflorescence, or the Arrangement of the Flowering Parts. The small, individual flowers of grasses are called *spikelets.* These together make up what is known as the Inflorescence; and they are arranged in a dense, compact, or diffuse form.

When the flowers have no pedicels (or stalks) and are closely packed together on the axis, or stem of the plant, they form a *spike,* as in the case of Timothy or Meadow Foxtail (Plate A. Fig. 1).

If the flowers are arranged on distinct, nearly equal pedicels, at intervals on the stem, the flower cluster is called a *raceme* (a somewhat rare form in grasses); but if they are on compound, branching pedicels, as in Blue Grass, they form what botanists speak of as a *panicle.* (Plate A. Fig. 14.)

If the pedicels are arranged in a circle round the stem, as in Red Top, they form what is called a *whorl;* if they are all on one side of the stem, as in Buffalo grass, Gramma grass, the inflorescence is said to be *one-sided* (Plate A. Fig. 7); if the spikelets are arranged cylindrically, as in Timothy, it is described as *cylindrically round;* if they droop, as in Fowl Meadow Grass, *Poa serotina*, (Plate 20), it is represented as *nodding:* and if quite close together, as in Orchard grass (Plate A. Fig. 16), it is spoken of as *crowded.*

The Inflorescence of Grasses,

As indicated in the accompanying illustrations. (Plate A.)

Fig. 1. *Alopecurus pratensis* (meadow foxtail), showing dense spike.
Fig. 2. *Paspalum dilatatum*, showing elongated spike.
Fig. 3. *Hordeum pratense* (wild barley), showing a spike.
Fig. 4. *Agropyrum repens* (couch grass), showing a spike.
Fig. 5. *Elymus condensatus* (giant rye grass), showing a spike.
Fig. 6. *Bouteloua polystachya* (gramma grass), showing a spike.
Fig. 7. *Bouteloua oligiostachya* (gramma grass), showing a spike.
Fig. 8. *Panicum Crus-galli* (barnyard grass), showing a panicle.
Fig. 9. *Agrostis exarata* (variety of red top), showing a panicle.
Fig. 10. *Koeleria cristata* (a prairie grass), showing a panicle.
Fig. 11. *Distichlis maritima* (salt grass), showing a panicle.
Fig. 12. *Bromus secalinus* (chess), showing a panicle.
Fig. 13. *Hierochloa borealis* (Indian hay), showing a panicle.
Fig. 14. *Poa pratensis* (Kentucky blue grass), showing a panicle.
Fig. 16. *Dactylis glomerata* (orchard grass), showing a panicle.

Spikelet. The spikelet consists of three or more scales or bracts, called *glumes.* The first two of these, counting from beneath, are sterile and known as *empty glumes.* Some species, however, have but one of these empty glumes; and, in others, the second is only rudimentarily developed. The next glume above is called the *flowering glume*; and opposite to this, or between it and the axis, is generally placed a smaller and thinner scale, called the *palea* or palet. The midrib of either the glume or the palea is often prolonged beyond the end. This prolongation is called an *awn.* It may arise from the base or from any other part of the glumes or the palea; and it is *straight*, *smooth*, *twisted*, *bent*, or *bristly*, and of every variety of length.

Plate A.

Opposite or inside of the palea, there are often present on the axis two small delicate scales called *lodicules*. These are much swollen with sap during flowering, and serve to open the flower and expose the stamens and pistil. In species in which they are absent, the reproductive organs extend above the glumes.

The peculiarities of the glumes and palea, as the number of nerves, and the texture of these scaly appendages, etc., furnish the chief means of distinguishing the different genera and species.

Dissection of the Flowers of Grasses,

As indicated in the accompanying illustrations. (Plate B).

Fig. 1. *Agrostis vulgaris* (red top), showing two spikelets, one closed, one opened.
Fig. 2. *Agrostis exarata* (variety of red top), showing two spikelets, one closed, one opened.
Fig. 3. *Sporobulus Indicus* (carpet grass), showing two spikelets, one closed, one opened.
Fig. 4. *Calamagrostis Canadensis* (blue joint grass), showing an opened spikelet.
Fig. 5. *Phleum pratense* (timothy), showing two spikelets, one closed, one opened.
Fig. 6. *Muhlenbergia diffusa* (Nimble Will), showing two spikelets, one closed, one opened.
Fig. 7. *Paspalum dilalatum*, showing two spikelets, one closed, one opened.
Fig. 8. *Paspalum lœve*, showing two spikelets, one closed, one opened.
Fig. 9. *Aristida purpurea* (beard grass), showing spikelet.
Fig. 10. *Setaria setosa*, showing two spikelets, one closed, one opened.
Fig. 11. *Setaria glauca* (yellow foxtail), showing two spikelets, one closed, one opened.
Fig. 12. *Alopecurus pratensis* (meadow foxtail), showing two spikelets, one closed, one opened.
Fig. 13. *Holcus linatus* (velvet grass), showing two spikelets, one closed, one opened.
Fig. 14. *Deschampsia caespitosa* (hair grass), showing two spikelets, one closed, one opened.
Fig. 15. *Poa serotina* (fowl meadow grass), showing spikelet and one flower.
Fig. 16. *Bromus erectus* (brome grass), showing spikelet and one flower.
Fig. 17. *Buchloe dactyloides* (buffalo grass), showing male and female spikelets.

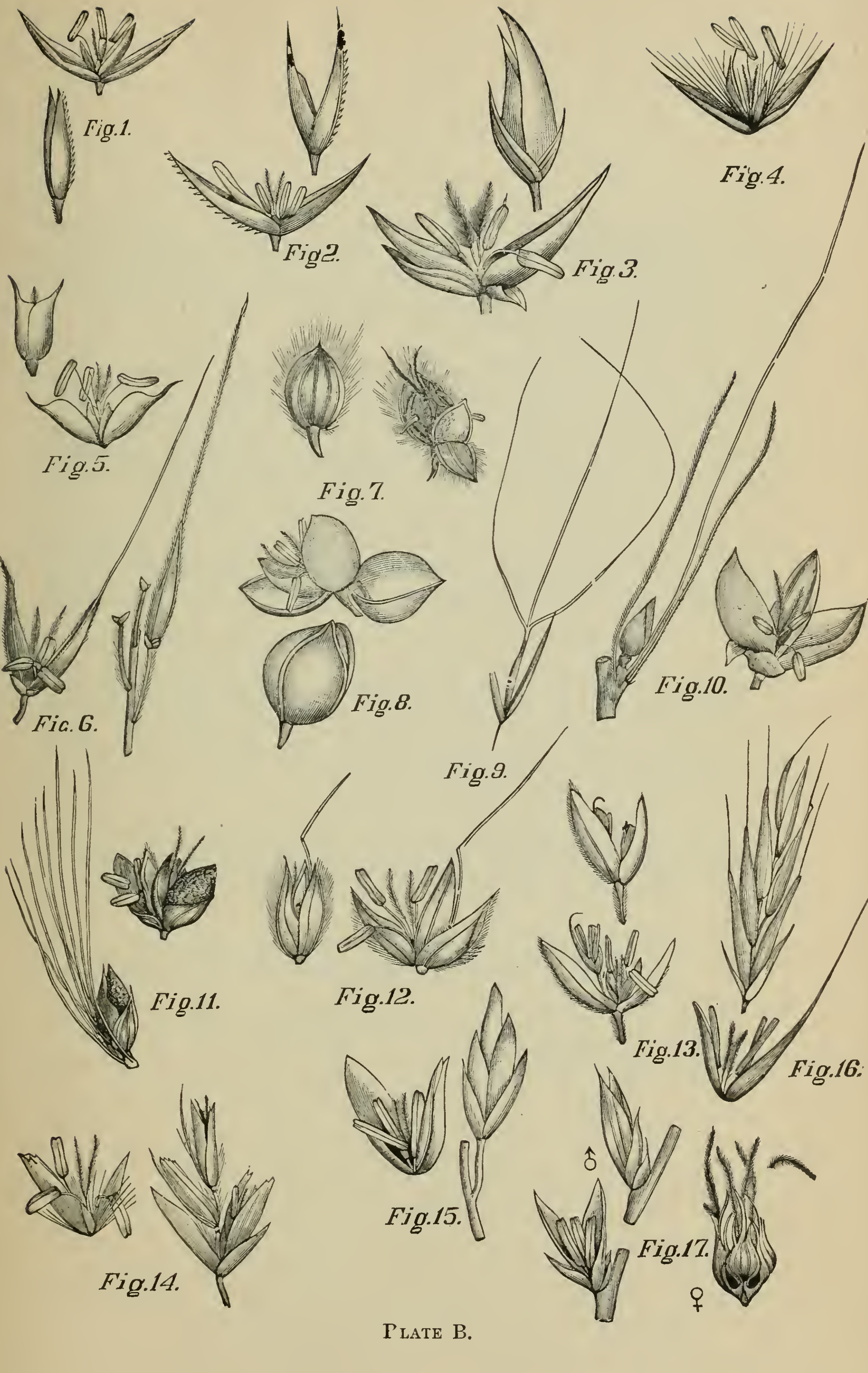
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Fig.15.
Fig.16.
Fig.17.
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Plate B.

Stamens. The reproductive organs of grasses, as of other plants, are called stamens and pistils. Each stamen consists of two parts ; a *filament*, or slender stalk, and (attached to the upper end of the filament) an *anther*, or little sac (usually double) for holding the *pollen*, or fertilizing powder.

In grasses, the filaments are slender and distinct ; and on the tip of each is a narrow anther, attached about the middle. The middle of the anther being the point of attachment, it swings to and fro on the filament. The movement of the anther aids materially in scattering the pollen ; and, because of this movement, the anther in grasses is described as *versatile.* (See Plate B., figures 1 and 4.)

The pollen of grasses is very fine, spherical, and smooth, is discharged in abundance, and scattered by the wind. Cross-fertilization is the rule ; but self-fertilization also takes place, as in the case of wheat.

Pistils. The pistil (or central organ of the flower) usually consists of three parts : the *ovary*, or seed-bearing sac ; above this, one or more *styles*, or stalk-like prolongations ; and on the top of each style, a *stigma*, or the part which receives the pollen. The style is sometimes very short or wanting altogether.

The pistil of grasses has from one to three styles, each surmounted by a stigma ; and the stigmas are usually curved and feathery, giving abundant surface for catching the pollen from the anthers. (Plate B., fig. 12.)

The ovary in grasses is usually round or oval ; the fruit is one-seeded ; the husk, or pericarp, surrounds the seed ; and the palea sometimes adheres to it.

The *embryo*, or young plantlet, lies beneath the skin of the seed, on the front side, at the base.

VERY BRIEF BOTANICAL DESCRIPTION OF GRASSES, FOLLOWED IN EACH CASE BY NOTES ON THEIR AGRICULTURAL VALUE.

Phleum pratense. Linn.—Timothy, Herd's Grass, or Cat's Tail Grass. (Plate 1.)

Roots.—Perennial, fibrous.

Culms.—Tall, erect, and firm.

Leaves.—4 or 5 on stem, rather broad, roughish.

Inflorescence.—Long cylindrical spike; densely many flowered.

Glumes—Empty, The back fringed with hairs and tipped with a short bristle.

Flowering, Five-ribbed, notched on upper part, covered by outer glumes.

Palea.—Short and pointed, with margins delicately fringed.

Stamens.—Long, with feathery stigmas protruding from apex at flowering time.

Flowers, about beginning of July.

Timothy grows best on soils containing considerable humus, but gives very fair yields on a wide range of soils. For hay, it is one of our most valuable grasses, the product being of excellent quality, heavy, easily cured, and saleable at the highest price. But, for pasture, it is not first-class. The bulbs at the bases of the stems expose it to injury from vermin, insects, and close grazing. It also suffers severely from drought; and, under the most favorable conditions, it affords only a scant aftermath.

Timothy yields a liberal crop of seed, which is easily threshed and cleaned. When sown alone, from 10 to 12 lbs. of seed per acre is required.

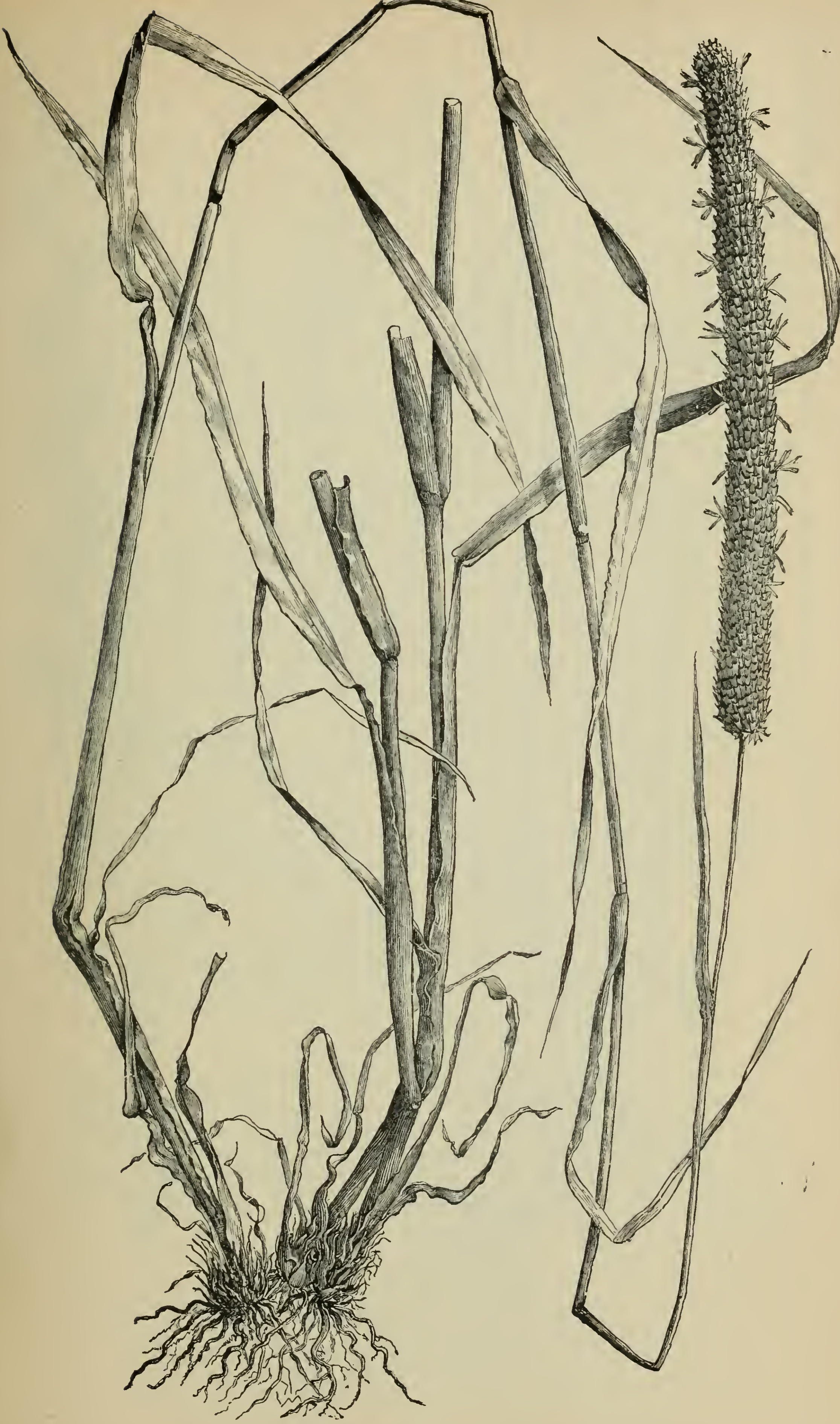


PLATE 1. TIMOTHY (*Phleum pratense*).

Lolium perenne. Linn.—Ray or Rye grass, Perennial Rye Grass, or Darnel. (Plate 2.)

Roots.—Perennial, fibrous, and sometimes producing running shoots.

Culms.—2 to 3 feet high.

Leaves.—Very leafy, flat, narrow, and pointed, dark green in color.

Inflorescence.—Spike like panicle, 6 in. or longer.

Spikelets.—8 to 15 flowered, placed edgewise on stem, and arranged alternately on the axis.

Glumes—Empty, outer one nearly as long as spikelet, or longer; inner one, usually lacking.

Flowering, rounded on back and acutely pointed.

Palea.—Short, 2 keeled (2 ridges.)

In general appearance the panicle resembles couch grass.

Lolium Italicum.—Italian Rye grass, a long awn on the flowering glume, leaves broad and succulent, stem longer but more delicate, and lasting only 2 or 3 years, leaves lighter colored.

Lolium temulentum.—Distinguished from L. perenne by length of outer glume and long awns of flowering glume, has a bad reputation, as the seeds contain a narcotic principle, injurious to man and beast.

Of the rye grasses, Perennial Rye grass is the best known. The name, however, is misleading, since, in this country, it cannot be depended upon to give a crop for more than one year, and is therefore entirely unsuitable for meadows or pastures that are required to stand for several years. It is a grass of good quality; and, on rich lands, it yields a fairly heavy crop of hay not much inferior to timothy.

PLATE 2. *Lolium perenne.* (Perennial Rye Grass.)

Dactylis glomerata. Linn.—Orchard grass, Rough Cock's foot. (Plate 3.)

Roots.—Perennial, fibrous.

Culms.—Stout and rough.

Leaves.—Rough, broadly linear, light green color, slightly hairy, flat and keeled. 5 to 6 in number.

Inflorescence.—Dense, branching panicle, lower part more open owing to length of 3-4 flower stalks, upper part more dense.

Spikelets.—Several flowered, crowded in one sided clusters.

Glumes.—All herbaceous. *Empty*, smaller than flowering.

Flowering, ovate-lanceolate, and rough, with a short awn or point.

Palea.—2 toothed at summit, fringed at base.

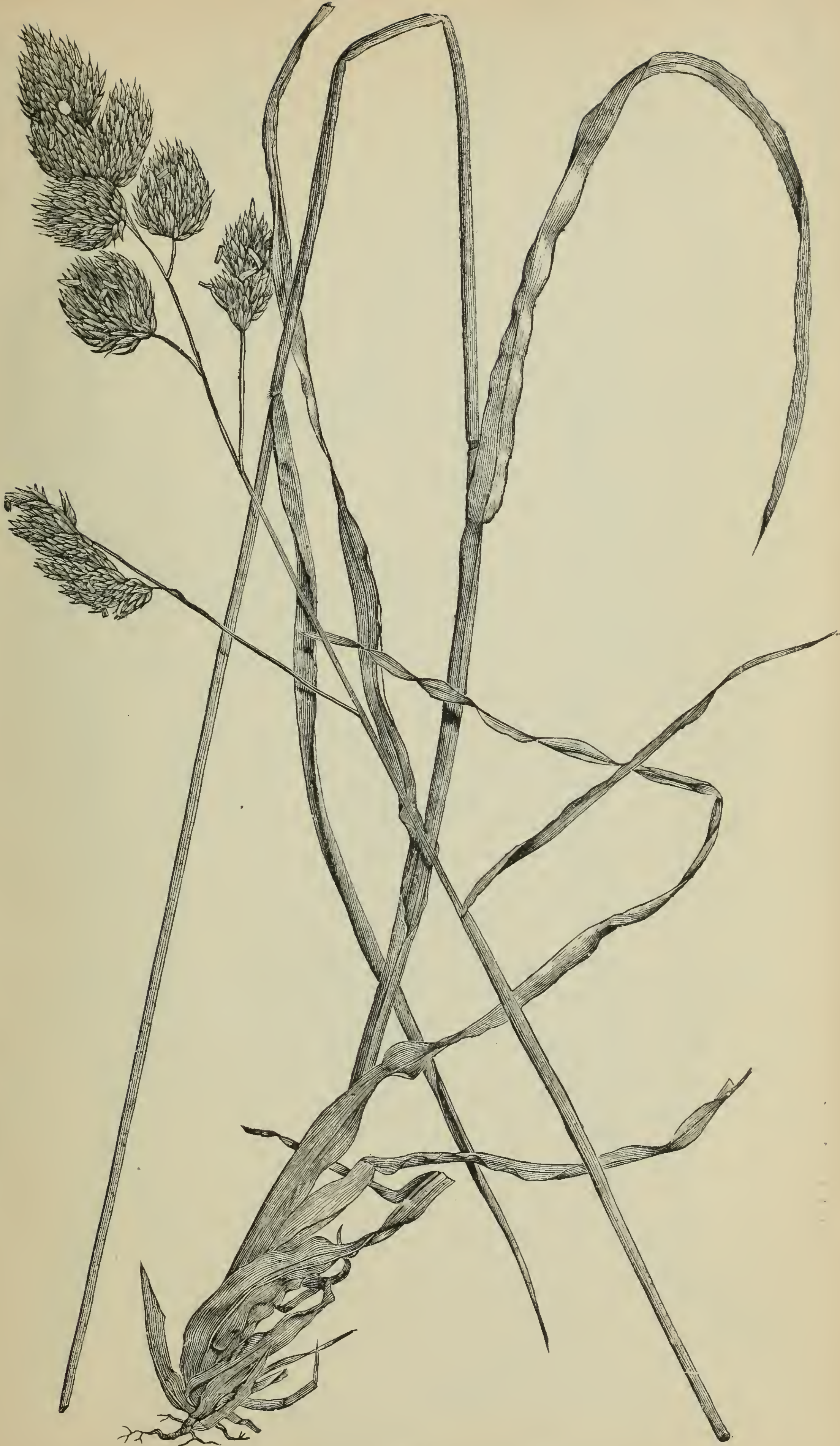
Flowers—July 1-14.

Grows in dense tufts, and is very rank growing and hardy.

Orchard Grass is a very hardy perennial. It grows on almost any cultivated soil, but prefers a rich loam, and thrives in shaded locations better than any other cultivated grass. It has a tendency to grow in tufts and to crowd out other grasses, but is nevertheless one of the most valuable varieties for pasture, as it grows early and late in the season, and remains green throughout the longest droughts. It also furnishes a good aftermath, and bears very close grazing. In the management of an Orchard grass pasture, it is a good plan to mow those parts which have not been closely cropped. When this is done, a fine growth of aftermath may be expected.

For hay, Orchard grass is not so highly esteemed as Timothy ; and when intended for this purpose, it should be cut in early bloom, or even before blooming.

When sown alone, about 24 lbs. of seed per acre should be used.



[2—99] PLATE 3. *Dactylis glomerata*, (Orchard Grass.)

Festuca elatior. Linn.—Taller or Meadow Fescue, English Blue Grass, Evergreen Grass, Randall Grass. (Plate 4.)

Roots.—Perennial, fibrous, and deep.

Culms.—Smooth and erect.

Leaves.—Flat, broadish, long, and abundant.

Inflorescence.—Narrow, contracted before and after flowering, short branches, somewhat one sided.

Spikelet.—Crowded, 5 to 10 flowered.

Glumes.—*Empty*, shorter than flowering.

Flowering, 5 nerved, blunt, with rough awn at apex.

Palea.—Acute, green rib along each side, with hairy nerves.

Flowers—About end of June.

Grows in clumps or tufts, very variable.

Variety—*F. praetensis.* 1-3 ft. high, simpler or closer panicle of smaller spikelets, very liable to have ergot.

Tall Fescue and Meadow Fescue are really different varieties, but they are so similar in general characters that they may be treated as one. Meadow Fescue is somewhat earlier than Tall Fescue, and does not yield such a heavy crop. These two grasses are hardy perennials, grow on a great variety of soils, and are consequently suitable for all pasture mixtures. They yield a fairly heavy hay crop of good quality, but their chief use is for pasture.

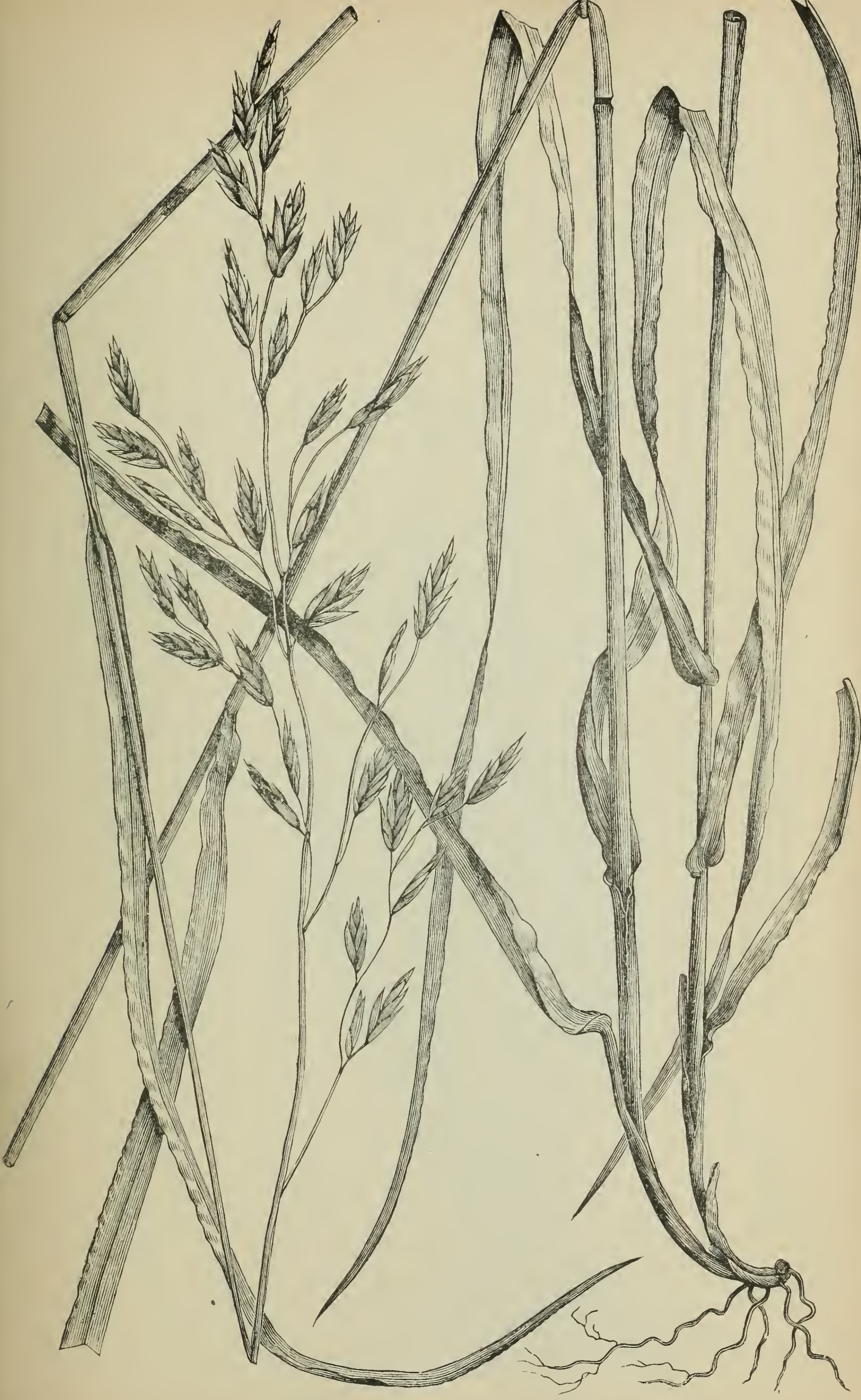


PLATE 4. *Festuca elatior*, (Meadow Fescue.)

Festuca ovina. Linn.—Sheep's Fescue, Pine Bunch Grass.
(Plate 5.)

Roots.—Perennial, deep, fibrous.

Culm.—Smooth and slender, 1-1½ ft. high.

Leaves.—Mostly radical, very narrow and convolute, growing in dense tufts from the root, awl shaped, and dark in color.

Inflorescence.—One-sided, short and more or less compound panicle, open in flowering, 2-4 in. long.

Spikelet.—3-8 flowered.

Glumes—*Outer*, acute and narrow , upper, 3 ribbed ; lower, 1 ribbed.

Flowering, lanceolate and roughish with short rough awn.

Palea.—Two teeth at summit, green ribs in margin.

Flowers— June 20-30.

There are many varieties of this grass, which do well even in very sandy soils.

Sheep's Fescue is a small variety with very fine leaves. It has little value unless for rocky pastures. There is another variety, called Hard Fescue, which is rather more valuable than the above, though neither of them is at all suitable for hay.

PLATE 5. *Festuca ovina*, (Sheep's Fescue.)

Arrhenatherum avenaceum. R. & S.—Oat grass, tall oat grass, evergreen grass, meadow oat grass, false oat grass, tall meadow oat grass, grass of the Andes, French rye grass. (Plate 6.)

Root.—Perennial.

Culms.—Erect, rather stout, 2-4 ft. high, of dark green tint.

Leaves.—Broad and flat, about 4 or 5, rough on upper surface, gradually pointed. Ligule conspicuous and hairy on back; short hair on upper surface of blade and on other parts.

Inflorescence.—Elongated, loose, 6-10 in. long, drooping, branches unequal.

Spikelet.—Two-flowered with rudimentary third flower, middle flower perfect, lowest flower staminate only, on short stalks.

Glumes.—Glume of lowest flower bearing a long bent awn below middle of back.

Outer, thin and transparent; *flowering*, green, 7-nerved.

Palea.—Linear, thin, and transparent, 2-nerved and 2-toothed.

Flowers—July 7-20.

Grows in loose tufts.

Tall Oat grass is a very hardy perennial. It grows early and late in the season, and will withstand long periods of drought. Though somewhat bitter, stock eat it well, and it is therefore a suitable grass for permanent pastures, especially on poor lands. For hay, it should be cut as soon as it blossoms. If allowed to stand a very short time after it blooms, it becomes woody and makes very poor hay. It yields a good aftermath, and though not highly esteemed in Great Britain, it is deservedly popular in districts where the rainfall is comparatively slight.

In addition to the above, there is a Yellow Oat grass which is sometimes included in mixtures. It is a light cropper and is not likely to prove valuable in this country.

The seed of Tall Oat grass weighs about 14 lbs. to the bushel, in the chaff, and when sown alone, about two bushels per acre is required.

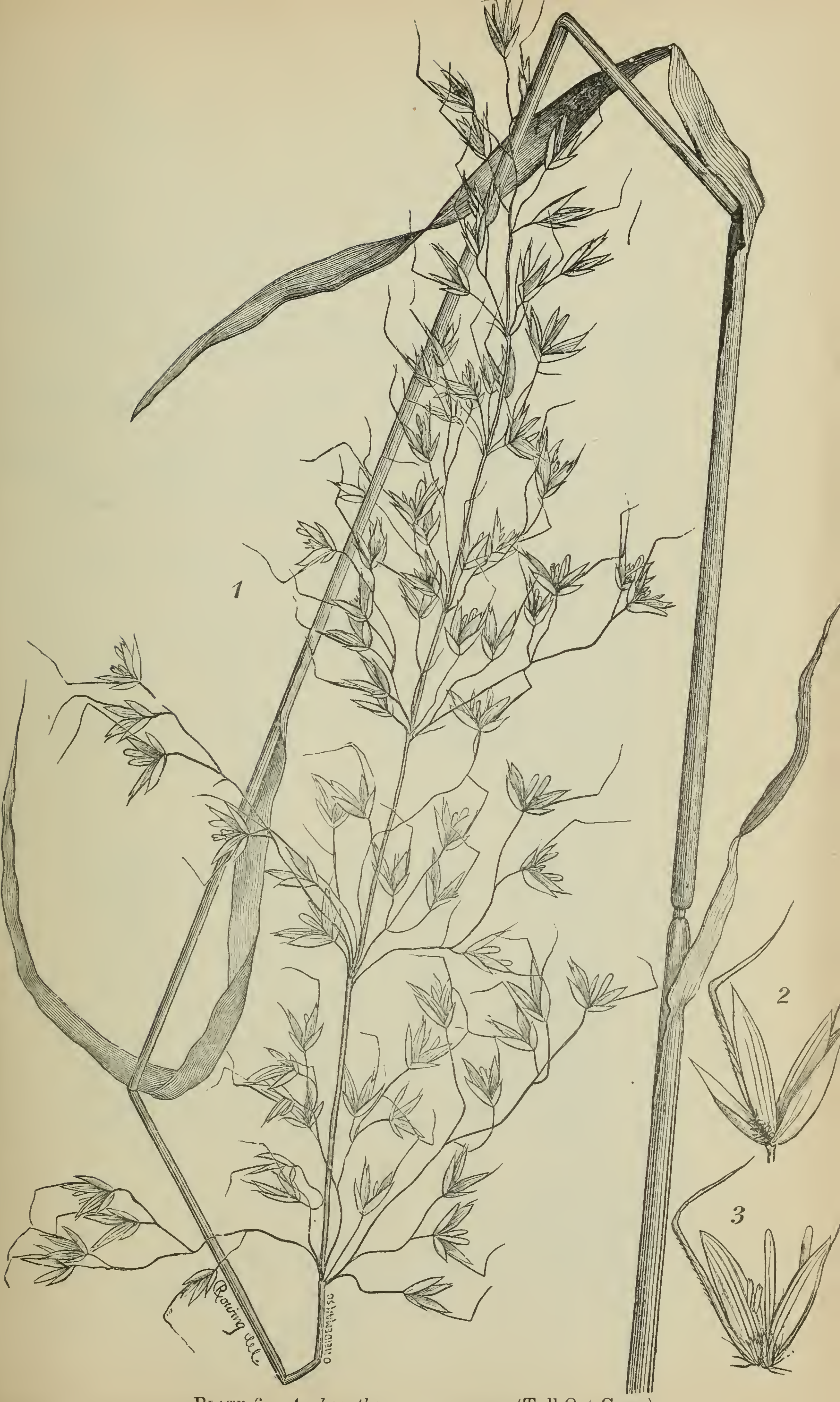


PLATE 6. *Arrhenatherum avenaceum*, (Tall Oat Grass).

Poa pratensis. Linn.—June grass, spear grass, Kentucky Blue grass, Blue grass,—English grass, smooth stalked meadow grass, Green grass. (Plate 7.)

Roots.—Perennial running root stock.

Culms.—Stems smooth, ligule short and blunt, 1½ to 2 ft. high.

Leaves.—Abundance of long radical leaves, rather narrow and pointed.

Inflorescence.—Short, pyramidal, branches mostly in fives, loose spreading, 2·4 in.

Spikelet.—3-5 flowered, crowded, ovate, mostly on short stalks.

Glumes.—*Empty*, unequal, the first narrow and one-nerved, the second broader and three-nerved.

Flowering, hairy on margin and keel, five-nerved tuft of cobwebby hairs at base.

Palea.—Short, *two-toothed.*

Flowers in June.

There are a number of varieties of this grass, differing in agricultural importance. The chief merit of the grass lies in the abundance of the soft radical leaves.

It is one of the best known of our native grasses, and is most commonly called June grass. It is also one of the earliest grasses, and furnishes pasture of exceptionally nutritious character during the early part of the season, but does not withstand the summer droughts so well as many other grasses. As it usually finds its way into permanent pastures when the soil is suitable, it is seldom necessary to include it in seed mixtures for this purpose. It is an excellent grass for lawns, its running rootstocks and fine leaves forming a tough, velvety sward. Compared with timothy, its hay value is rather low.

Plate 7. *Poa pratensis* (Kentucky Blue grass).

Poa compressa. Linn.—Wire grass, English Blue grass, Smaller Blue grass, Creeping Poa, Canadian Blue grass. (Plate 8)

Roots.—Running rootstock, perennial.

Culms.—Hard and much flattened, 1-18 in. long, frequently bent at lower joints and then ascending.

Leaves.—Short, scanty, smooth. Bluish green in color, ligule small

Inflorescence.—Dense and narrow, somewhat one-sided, 1-3 in. long, simple and contracted.

Spikelet.—Sessile, small, 4-6 flowered.

Glumes.—*Outer*, unequal, 3-ribbed.

Flowering, 5-ribbed.

Palea.—Two-nerved, nerves rough, with short hairs.

Flowers—July 1-10.

Low habit of growth, flattened or compressed stems, contracted panicle, less creeping roots, furnish characters by which it is easy to distinguish it from Kentucky Blue grass.

Poa compressa is of little value for hay, owing to its small growth. What pasturage it affords is nutritious, and it will grow on very poor soil, such as sand, gravel, or hard clay.

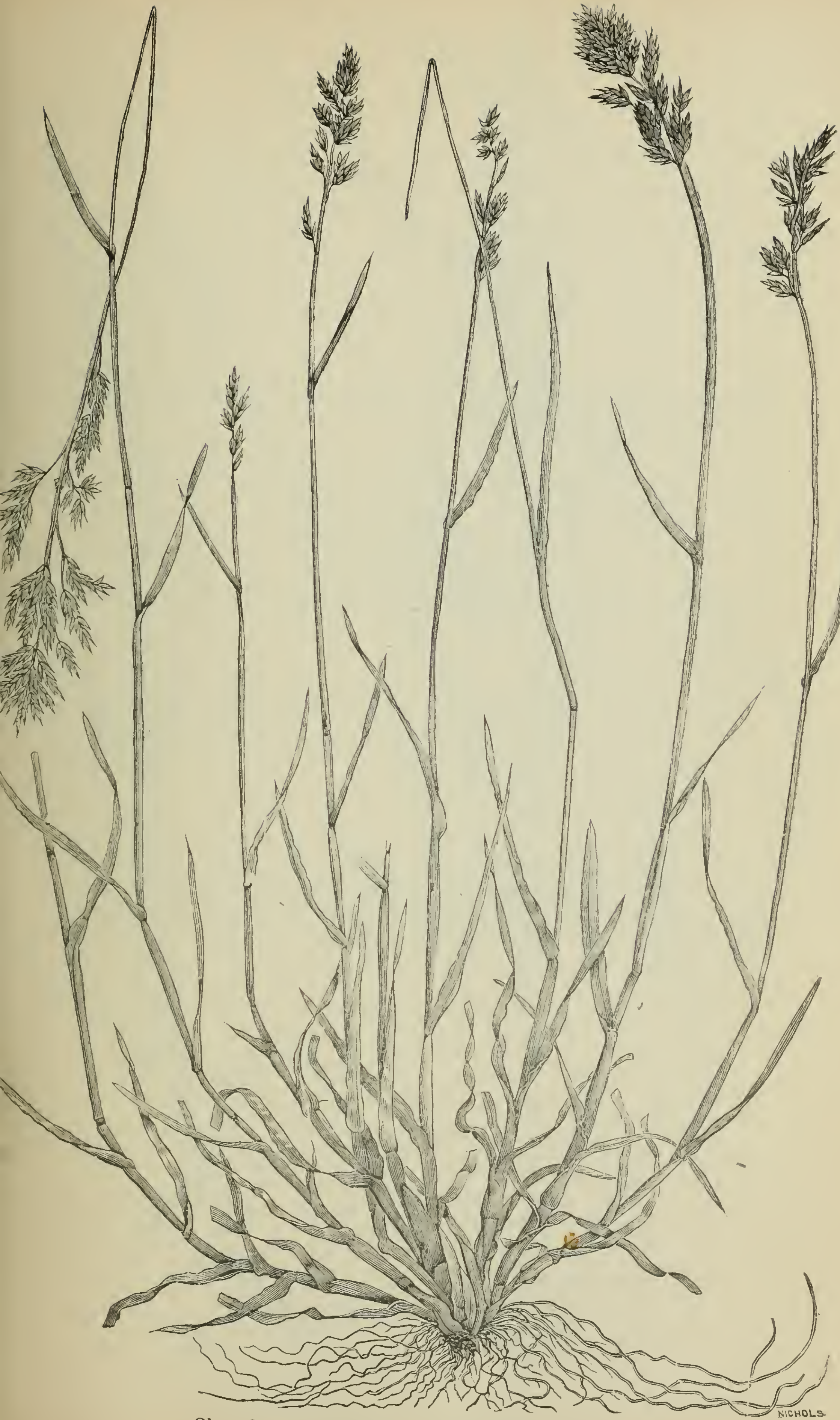


Plate 8. *Poa compressa* (Canadian Blue Grass.)

Agrostis vulgaris. With.—Rep Top, Bent Grass, Fine Bent, Fine Top. (Plate 9.)

Roots.—Perennial, creeping, interlacing and forming a dense sod.

Culms.—Tufted, and slender. Ligule short.

Leaves.—4 or 5, flat, narrow, and roughish.

Inflorescence.—Spreading after flowering, panicle with whorled Branches.

Spikelet.—1-flowered.

Glumes.—*Empty*, equal, and longer than the flowering glume.

Flowering, very thin, awned on back, 3-5 nerved.

Palea.—Thin, minute, or none.

Flowers—July 1-10.

Red Top is a fairly hardy perennial, and is best adapted to rather low lands. It is most suitable for pasture mixtures or for lawns, though for the latter purpose probably *Agrostis canina* (Rhode Island Bent Grass) would be more suitable. It is not of much value for hay.

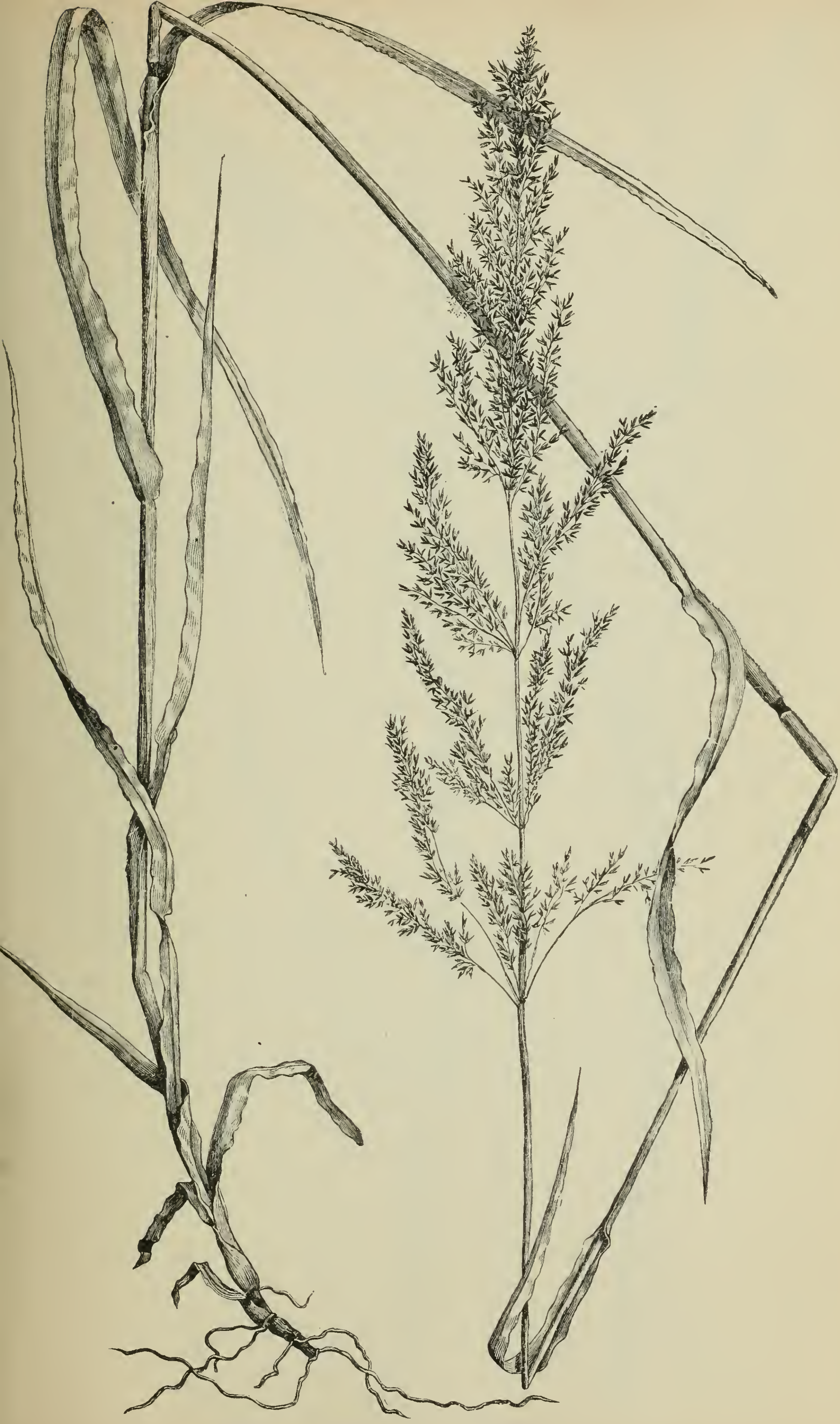


Plate 9. *Agrostis vulgaris* (Red Top.)

Alopecurus pratensis. Linn.—Meadow Foxtail, English Foxtail. (Plate 10.)

Roots.—Perennial, Fibrous, and creeping.

Culms.—Upright, smooth, 2 in. high.

Leaves.—Upper leaf much shorter than its inflated sheath, 4 or 5 at even distance, rather broad and flat.

Inflorescence.—Stout, 1-2½ in. long, cylindrical spike. Awn conspicuously projecting.

Glumes.—*Lower*, acute, awnless, and hairy ;

Flowering, obtuse, awn rising from near the base, half its length twisted.

Palea.—None.

Flowers—June 7-20.

Resembles Timothy, but culm and leaves are shorter ; spikes shorter, broader, and softer ; plant less firm and rough.

Meadow Foxtail is a very early, hardy grass of good quality, used in mixtures for permanent pastures. It requires a rich soil in order to give satisfactory results, and takes several years to become established. It makes hay of good quality, but yields too light a crop and takes too long to become established, to be a profitable grass for this purpose.

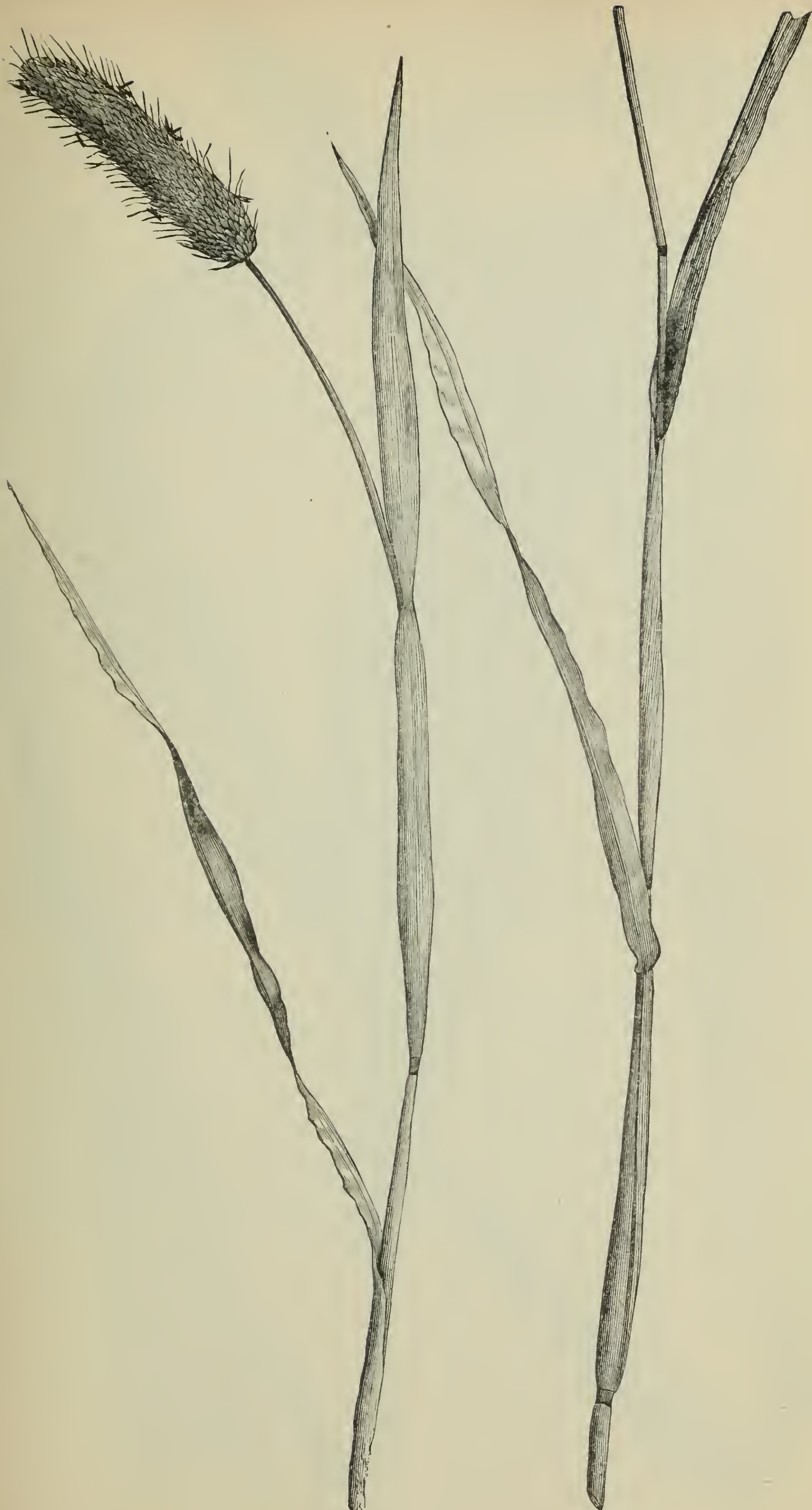


Plate 10. *Alopecurus pratensis* (Meadow Foxtail.)

Setaria Italica. Kunth.—Italian Millet, Golden Millet, Leaf Tail Millet, Bengal Grass, Hungarian Grass. (Plate 11).

Roots.—Annual.

Culms.—Erect, 2-3 ft. high.

Leaves.—Long, broad, and flat.

Inflorescence.—Spike-like panicle, nodding, yellowish or purple.

Glumes.—*Empty*, 3, the lower one small, the second smaller than the third ;

Flowering, hardened.

Palea.—Thin.

Stamens.—Sometimes 4 in number.

The terms "Hungarian Grass" and "Millet" are so variably applied that they lead to hopeless confusion. There are a great many varieties in this family, and among the more valuable for cultivation may be mentioned Salzer's Dakota, Golden, Golden Wonder, and Pearl.

Millet requires a rich, warm soil. It forms a valuable "catch crop," that is, it may be sown late in the season to replace a crop that has failed. It should not be sown until the weather becomes warm, usually during June, though it may be sown much later. In preparing the soil, fine tilth is necessary. The quantity of seed used varies considerably, but about 40 lbs. per acre will be found satisfactory in most cases. When cut in early bloom, millet makes a fair substitute for hay. If allowed to stand until the seeds have formed, it draws much more heavily upon the soil, and the seeds are generally believed to have an injurious effect upon the kidneys of the animals to which they are fed.

[3—99] PLATE 11. *Setaria Italica.*

Authoxanthum odoratum. Linn.—Sweet Vernal Grass, Sweet Scented Vernal Grass, Vernal Grass. (Plate 12.)

Roots.—Perennial, fibrous.

Culms.—Slender, 1 to 1½ ft. high.

Leaves.—Hairy, flat and pointed, scant foliage.

Inflorescence.— Spike-like, but having many very short, dense branches 2·3 in. long, narrow and close.

Spikelets.—3-flowered, only the terminal one perfect, brown or tinged with green.

Glumes.—*Empty* glumes in two pairs, hairy, two-lobed and awned on back.

Flowering, small, smooth, and awnless.

Palea.—Short, three-nerved.

Flowers about end of June.

A low, sweet smelling perennial, the scent arising from a product called cumarin. In Europe the scent is extracted and manufactured into perfume.

Odor appears when dry. It is used in grass *mixtures* in Great Britain, but does not appear to thrive in our climate.

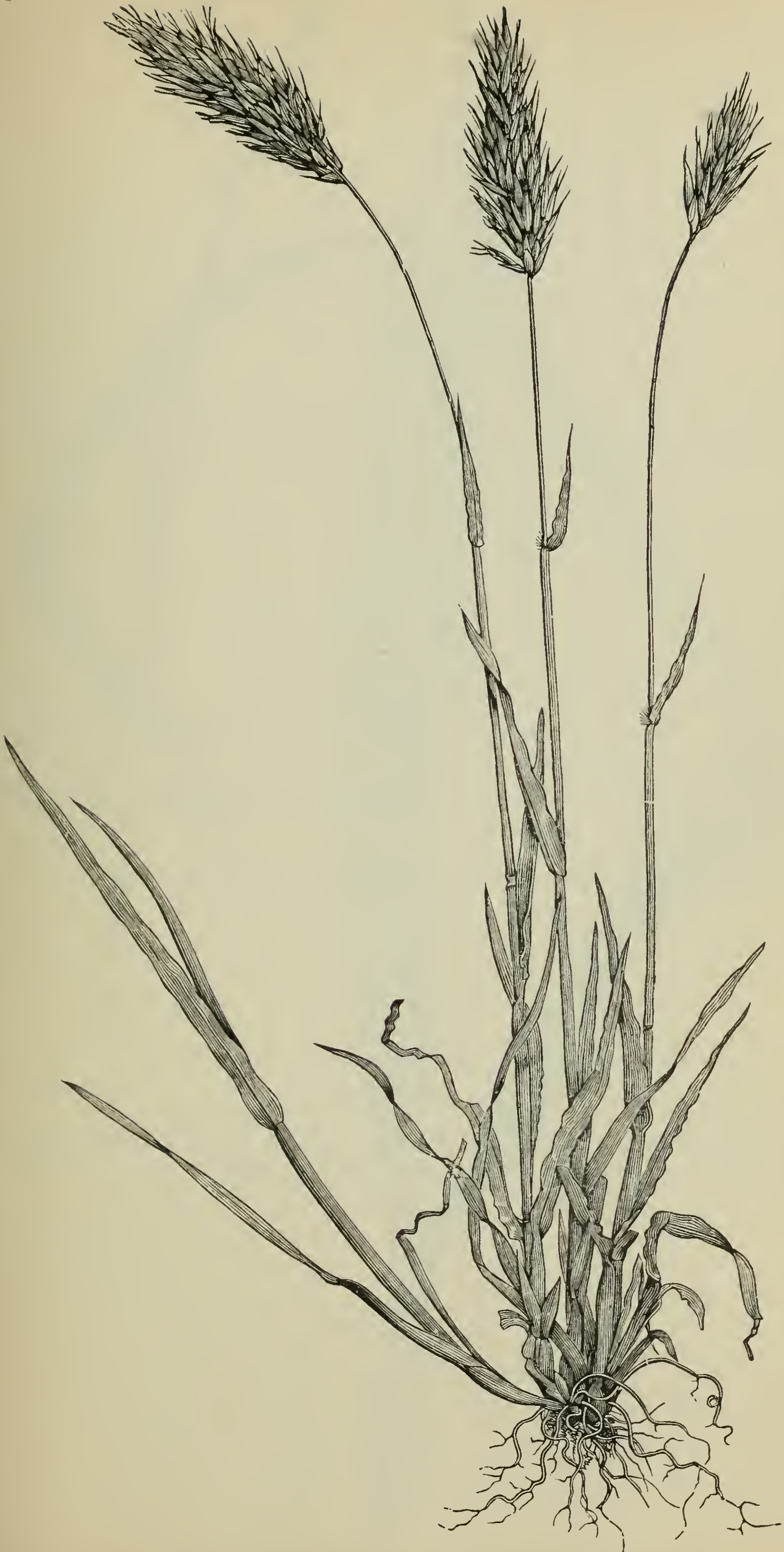


Plate 12. *Anthoxanthum odoratum* (Sweet Vernal.)

Elymus Virginicus. Lynn.—Wild Rye gra3s, Lyme grass, Terrell grass. (Plate 13.)

Roots.—Fibrous, perennial.

Culm.—Stout, 2-3 ft. high.

Leaves.—Leafy, 10-15 in. long, broad and rough.

Inflorescence.—Erect and rigid, 4-5 in. long.

Spikelet.—2-3 at each joint, all alike, and fertile.

Glumes.—*Empty*, lanceolate, very thick and coarse, strongly nerved, and bristle pointed ;

Flowering, shorter than above, thick, rounded on back, and having stiff awn.

Palea.—Shorter than its glume, 2-keeled, oblong, and blunt.

Flowers—July 10-20.

Abounds in marshes and along streams.

By the time it blooms the lower leaves are dead.

This grass is not suitable for seed mixtures on cultivated lands, but furnishes some food for stock in marshy places.

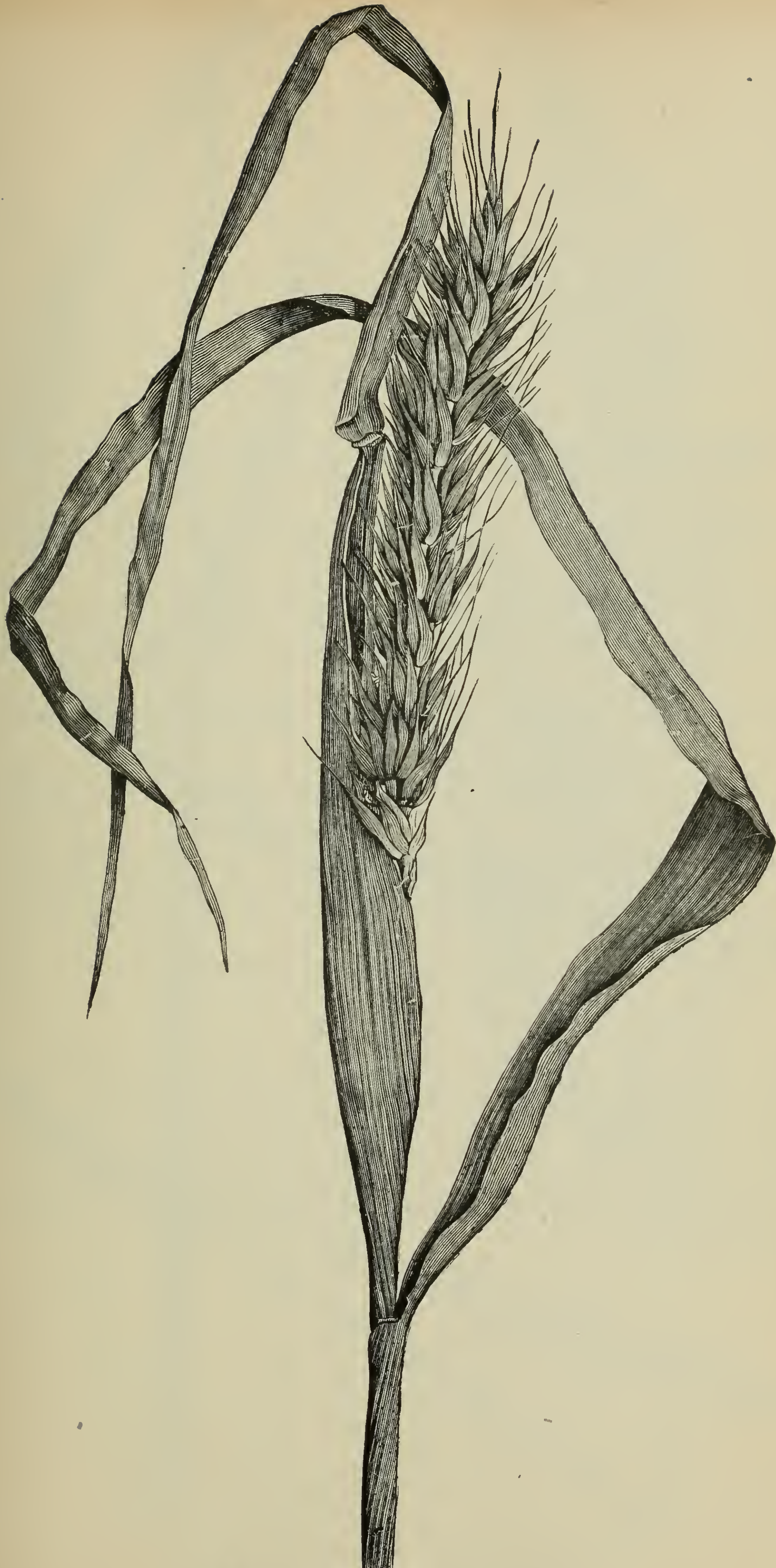


PLATE 13. *Elymus Virginicus* (Wild Rye.)

Deuxia Canadensis.—Beauv. (*Calamagrostis Canadensis*). Blue Joint, Small reed-grass, Sand grass. (Plate 14.)

Roots.—Perennial, creeping root stocks, spreads from underground stems.

Culm.—Stout, tall, erect, and smooth, up to 4 ft. high.

Leaves.—Flat when fresh, slightly hairy, 1 ft. long, long ligule, very leafy.

Inflorescence.—Open panicle, spreading, especially when flowering, purple tinged, 4-8 in. long.

Spikelet.—1-flowered, with a short hairy pedicel, supposed to be a rudimentary flower.

Glumes.—*Empty*, lanceolate and acute;

Flowering, delicately awned, having silky white tuft of hairs at base.

Palea.—Slim, smaller than its glume, and transparent.

Flowers—July 1-14.

Canadian Blue Joint is a valuable grass for low lands that cannot be drained, and grows on land that is too wet for red top. It is commonly found in "beaver meadows" and marshes, but may also be grown on cultivated land. It remains green after the seeds are ripe, and is relished by stock in all stages of its growth, affording a large amount of nutritious pasturage, and a fairly heavy crop of palatable hay.

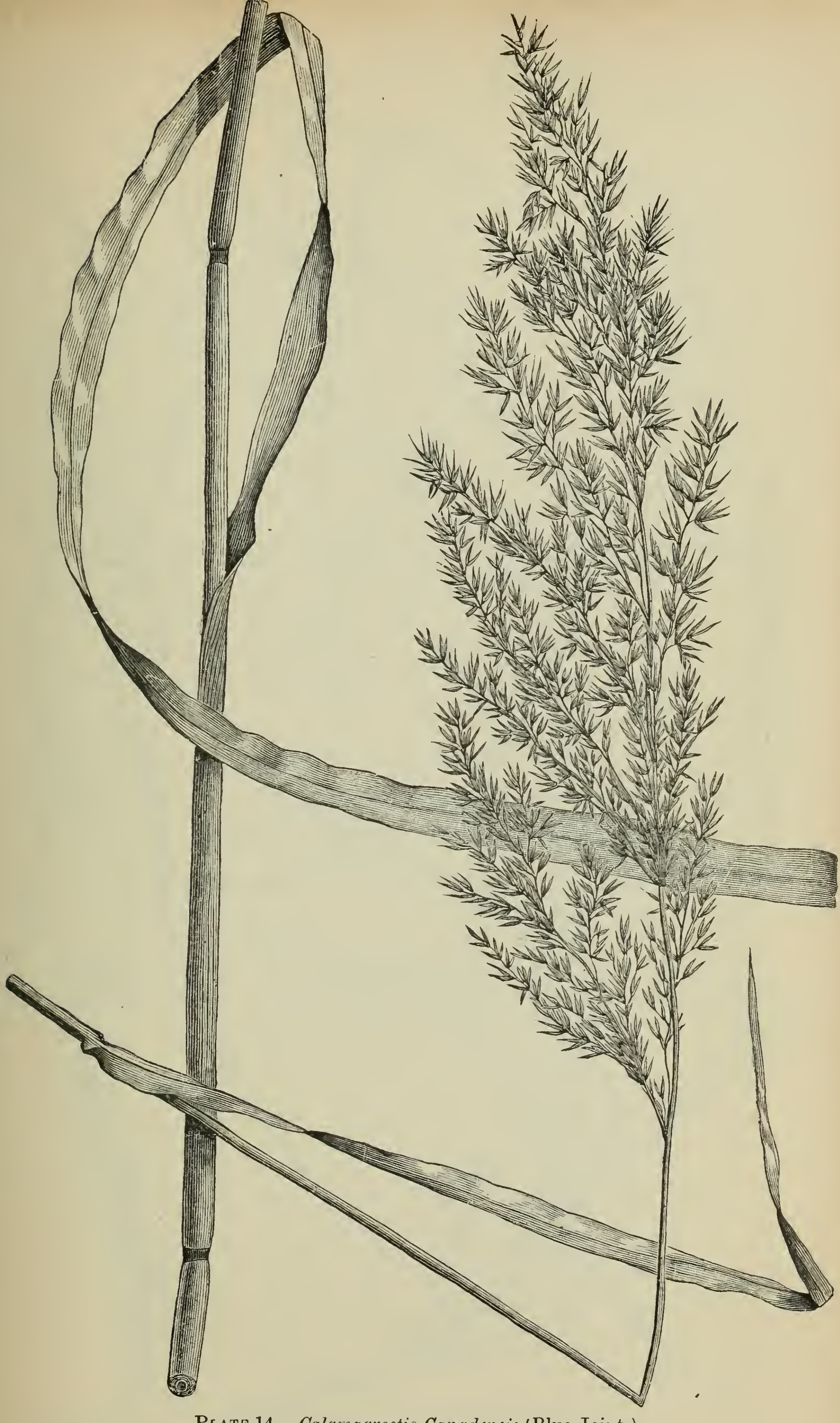


Plate 14. *Calamagrostis Canadensis* (Blue Joint)

Muhlenbergia Mexicana. Trin.—Drop Seed Grass, Wood Grass, Knot Root Grass. (Plate 15.)

Roots.—Scaly, creeping, perennial.

Culms.—Upright, much branched, 2-3 ft. high.

Leaves. –Numerous, flat.

Inflorescence.—Contracted, densely flowered panicle.

Glumes.—*Lower*, awnless, sharp pointed, unequal.

Flowering, three-nerved, acute, hairy at base.

Palea.—Very acute, smaller than its glume.

Flowers—about end of July.

This species is very serviceable in binding sand, with its strong creeping rhizomes. On rich land, it yields from 2 to 3 tons per acre of very fair hay, and affords considerable pasturage.

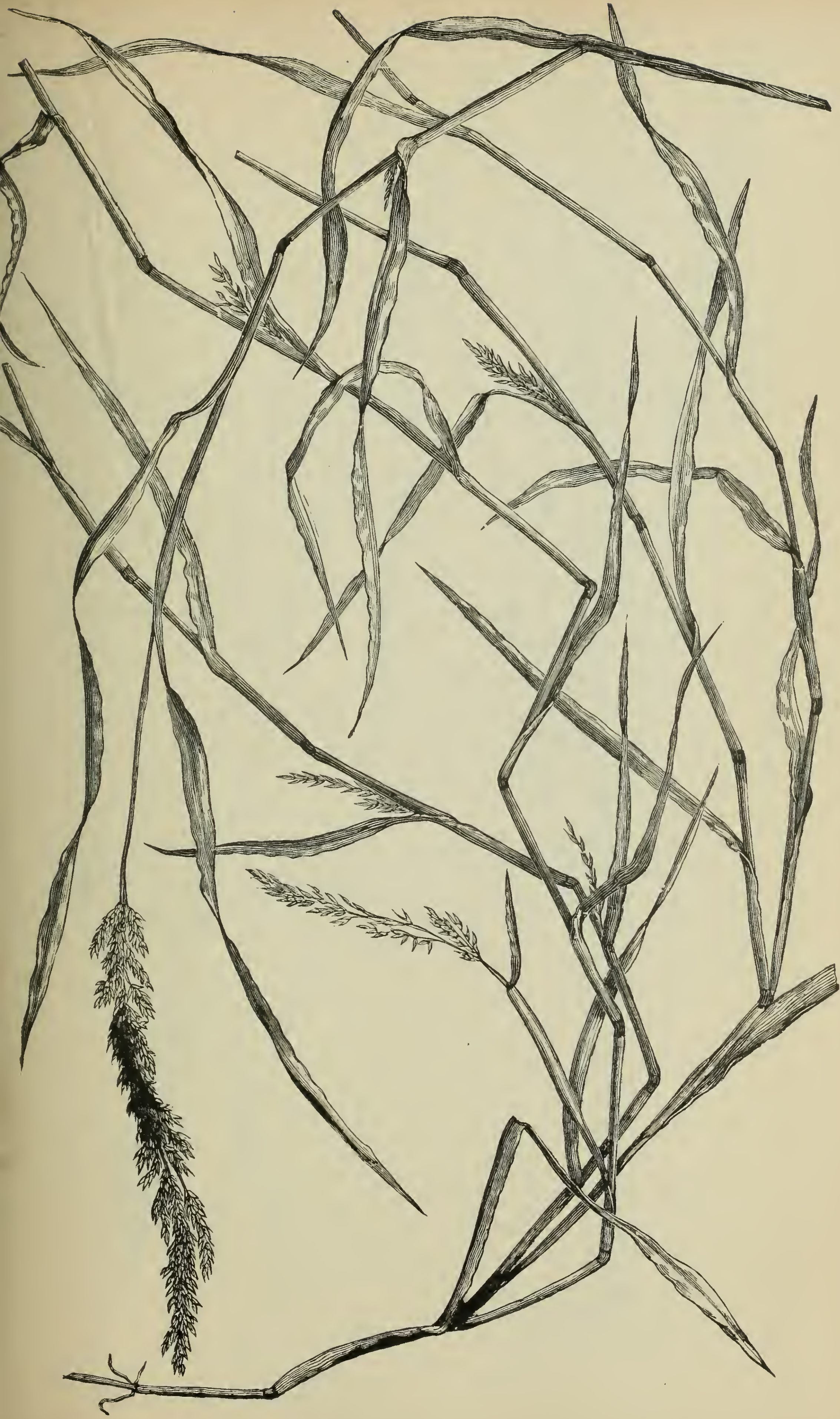


PLATE 15. *Muhlenbergia Mexicana* (Satin Grass)

Muhlenbergia glomerata. Trin.—Spiked Muhlenbergia, Muhlenberg's Grass, Satin Grass, Wild Timothy. (Plate 16)

Roots.—Hard and knotty with numerous firm scales.

Culms.—Upright, stiffly erect, hard, somewhat compressed, sparingly branched, 1-3 ft. high.

Leaves.—Blades linear, 2-4 in. long, rough.

Inflorescence.—2-3 in. long, narrow, contracted, clustered spike, becoming looser below.

Glumes.—*Empty*, awned, nearly equal.

Flowering, twice length of the empty.

Palea.—Two-nerved, acute, and short pointed.

Flowers—about end of July.

This grass is frequently called "Wild Timothy" from the fact that the heads slightly resemble those of Timothy. It is noted for its late period of flowering. On low lands it yields considerable pasturage and hay of no mean quality.

Plate 16. *Muhlenbergia glomerata* (Wild Timothy.)

Muhlenbergia sylvatica. Torr. and Gray.—Bearded Satin Grass. (Plate 17.)

Roots.—Perennial, fibrous, scaly rootstock.

Culms.—Ascending, much branched, and spreading, 2-4 ft. high.

Leaves.—Leafy, flat, rather broad, and sharp pointed.

Inflorescence.—Dense, many flowered panicle, purplish color.

Glumes.—*Empty*, almost equal, bristle pointed, nearly as long as flowering ;

Flowering, awn twice or thrice length of spikelet.

Palea.—Two-nerved, rough at apex.

Resembles *Muhlenbergia Mexicana*, but panicle is looser and bears a bristly awn. On low rich land it is rather a heavier cropper than M. Mexicana.

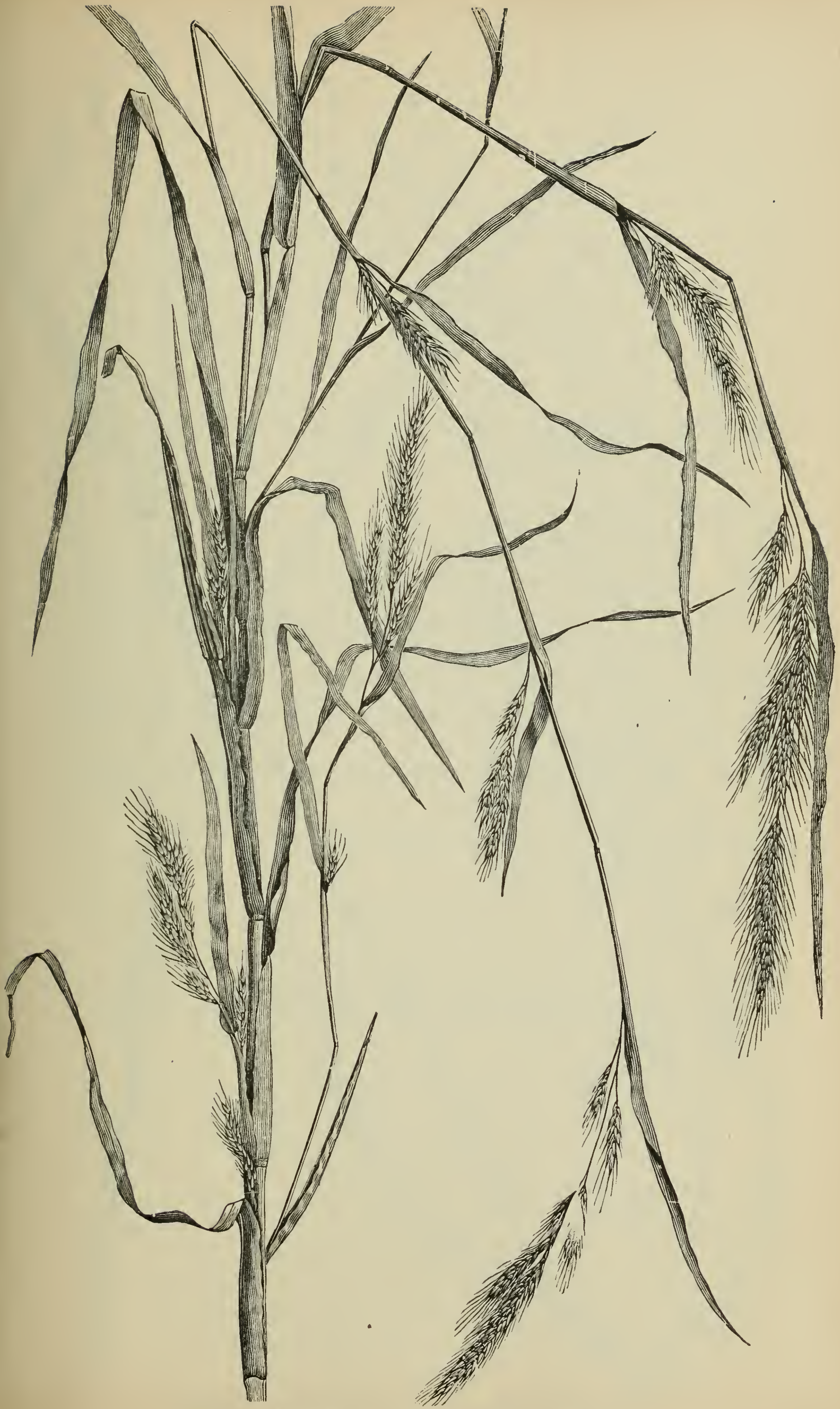


Plate 17. *Muhlenbergia sylvatica*, (Bearded Satin Grass.)

Glyceria Canadensis. Trin.—Rattlesnake Grass, Tall quaking grass. (Plate 18.)

Roots.—Perennial.

Culms.—Stout, 2-3 ft. high, smooth.

Leaves.—Long, lower ones longer and broader than the upper ones.

Inflorescence.—Panicle, 8-9 inches long, large, spreading; branches slender, long, and branching, mostly in threes.

Spikelets.—Oblong, 6-8 flowered, flattened.

Glumes.—*Empty*, 2, unequal, shorter than the flowering glumes—one to three nerved;

Flowering, smooth, blunt apex, 5-9 nerves, prominent and parallel.

Palea.—Shorter than its glume, and two-nerved.

Flowers—in July.

Grows in tufts in wet places and along river banks. Forms good pasturage in wet meadows and makes fair hay. Also is a fine ornamental grass.

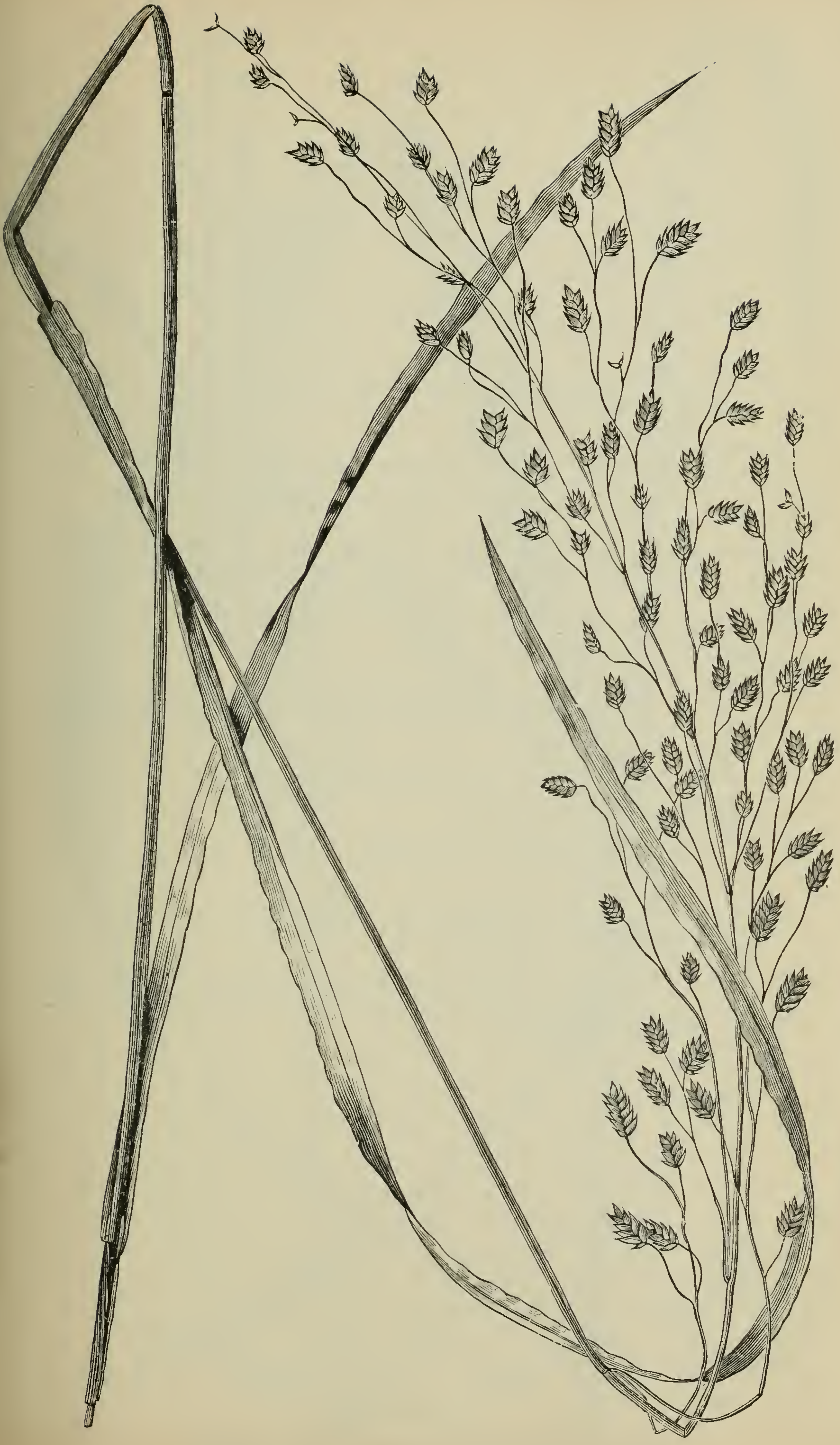


PLATE 18. *Glyceria Canadensis* (**Rattlesnake Grass.**)

Phalaris arundinacea. Linn.—Reed canary grass, Ribbon grass. (Plate 19.)

Roots.—Perennial, fibrous, strong, and creeping.

Culms.—Stout, smooth, and leafy, from 2-5 feet high.

Leaves.—6-10 in. long, 1½ in. wide, flat, lanceolate; margins rougher than surface; ligule short and rounded above.

Inflorescence.—Long, dense spike, 3-6 in. long.

Spikelet.—One-flowered and fertile.

Glumes.—*Empty*, 4, the third and fourth being reduced to hairy rudiments; 2nd and 3rd obscured, nerved and hairy on back.

Flowering, one-nerved and awnless.

Palea.—Rounded, one-nerved.

Flowers—about end of June.

The ribbon grass of gardens, the leaves striped with white, is a variety of *Phalaris arundinacea*.

Suitable only for pasture on wet, swampy land. In the early stages of its growth it is eaten rapidly by stock, but becomes very woody when mature.

[4—99] Plate 19. *Phalaris arundinacea* (Reed Canary Grass)

Poa serotina, Ehrh.—False Red Top, Fowl meadow grass, Duck grass, Swamp wire grass. (Plate 20.)

Roots.—Perennial, running rootstock.

Culms.—Tufted, erect, slender, 2-3 feet high.

Leaves.—Narrowly linear, soft and smooth.

Inflorescence.—Elongated panicle, tinged with dull purple, slender, and nodding, branches in fives.

Spikelet.—2-4 flowered, short stalked.

Glumes.—*Outer*, $\frac{1}{8}$ in. long, sharp pointed, rough on keel ;

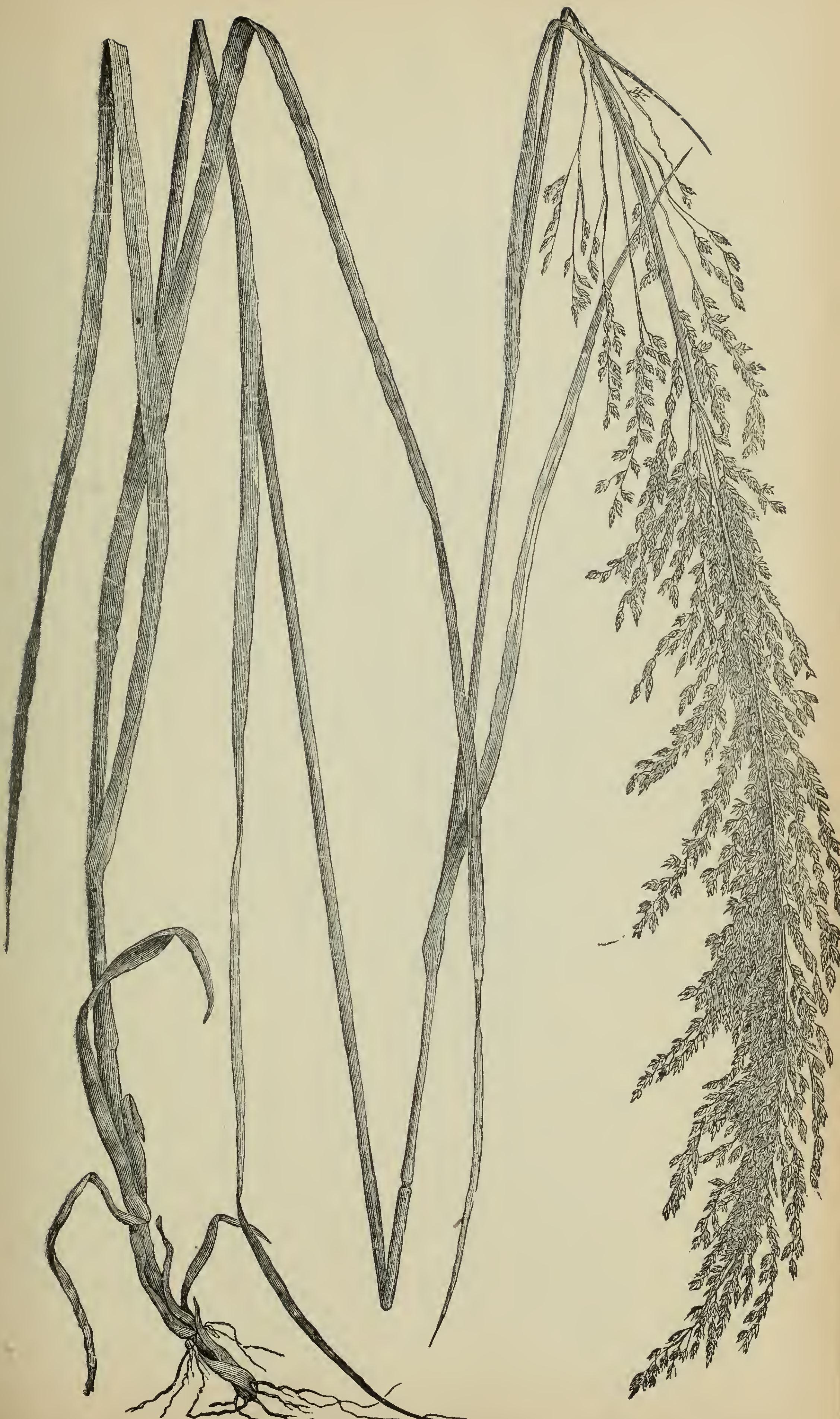
Flowering, very obscurely nerved, cobwebby at base, obtuse or blunt.

Palea.—Acute.

Flowers—July 1-12.

Stems remain green after seed is ripe.

Poa serotina has attracted considerable attention as a grass that will grow on very moist lands, or on lands that are occasionally flooded. Stock eat it readily, and when cut it makes hay of fair quality. It is perhaps worthy of more extended trial in mixtures for low, rich lands.



Plate

Hierochloe borealis. Roem and Schultes.—Vanilla or Seneca grass, Holy grass, Indian Hay. (Plate 21.)

Roots.—Creeping, perennial.

Culms.—Erect, round, smooth, 1-2 ft. high.

Leaves.—Short blades, flat, broad, lanceolate, rough on upper surface; long sheaths.

Inflorescence.—Somewhat one-sided, spreading, pyramidal panicle, 2·5 in. long.

Spikelets.—Chestnut colored, ovate, and glossy, three-flowered.

Glumes—*Outer*, equal, broad, acute, smooth.

Flowering, 5-ribbed, hairy.

Palea.—Two-nerved.

Stamens.—3 in the barren and 2 in fertile florets.

Flowers—May 15-30.

The plants when dry have a vanilla like odor, whence the first name; sometimes strewn before church doors on holy days, and used by Indians for making mats and baskets. In some places it has become a weed.

PLATE 21. *Hierochloe borealis* (Indian Hay).

Panicum Crus-galli. Linn.—Barnyard grass, Barn grass, Cock's foot, Large Crowfoot grass. (Plate 22.)

Roots.—Annual, fibrous.

Culms.—Thick, stout, branching from base.

Leaves.—Very numerous, rather broad and flat, smooth but rough margined.

Inflorescence.—1-3 in. long, crowded spikelets in dense panicle.

Glumes—*Outer*, 3, the first, broad and short, 3-nerved; the second and third, smooth, downy, the 2nd, 5-nerved, the 3rd, 2-nerved and awned.

Flowering, thin and transparent, smooth.

Palea.—Small and polished.

Flowers in August.

It grows in low rich land, and in the neighborhood of barns and dwellings. It is of very little agricultural value.

Plate 22. (*Panicum Crus-galli.* Barnyard Grass).

Agropyrum repens. Beauv.—Couch, Quitch, Quick, Quack, Quake, Scutch, Twitch, Dutch, Dog, Wheat, Durfa, Devil's Grass. (Plate 23.)

Roots.—Perennial, creeping extensively, penetrating deeply into the ground, jointed rootstock.

Culms.—1-3 ft. high.

Leaves.—Flat, roughish above; upper ones broader than those springing from root.

Inflorescence.—Close, narrow spike.

Spikelet.—4-8 flowered, slightly notched stem, smooth.

Glumes—*Empty*, equal and opposite, 1-3 nerved.

Flowering, similar, pointed or awned, and with rounded back.

Palea.—Nearly as long as its glume, two marginal, green nerves.

Flowers—July 5-20.

Whatever value Couch Grass may have for pasture, its habit of taking and keeping possession of the soil renders it extremely objectionable. It flourishes best in loamy or humus soils, from which it is especially difficult to eradicate.

To destroy this grass, the cultivation should be such as to prevent its appearing above the surface. Hoed crops of various kinds, or a bare fallow, on which buckwheat may be sown and ploughed under, will be found useful. A well manured and carefully cultivated rape crop is especially effective as a means of destroying this grass.

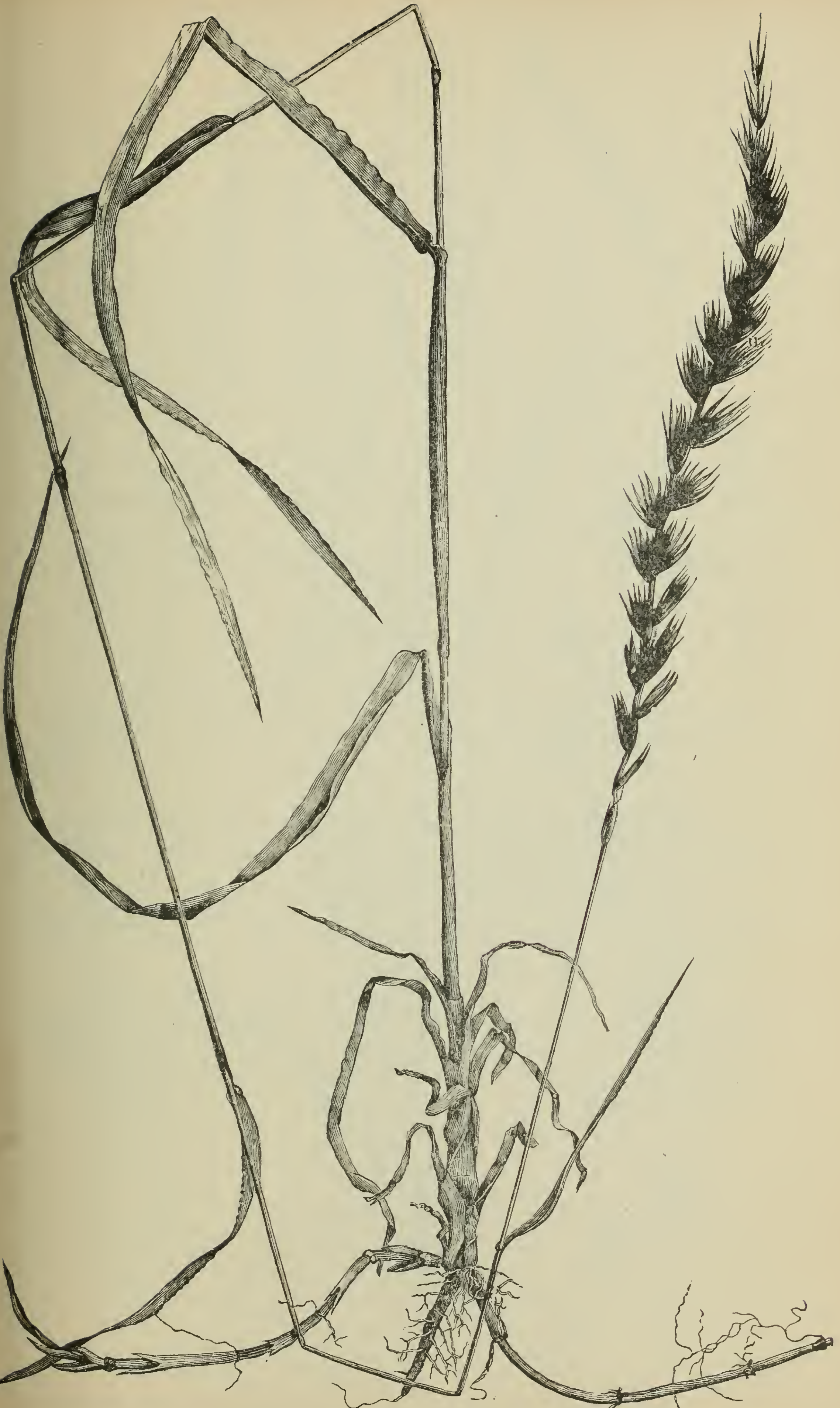


PLATE 23. *Agropyrum repens* (Couch Grass.)

Bromus secalinus. Linn.—Chess, Cheat. (Plate 24.)

Roots.—Annual, fibrous.

Culms.—Simple, round, erect, and smooth, about 3 ft. high.

Leaves.—Broadish, flat, pointed, ribbed, rough on edges and under surface, downy above.

Inflorescence.—Spreading, drooping, little branched, diffuse panicle.

Spikelets.—Oblong-ovate, 7-10 flowered.

Glumes—Empty, unequal, acute, and awnless ;

Flowering, shorter than palet, short awn or awnless.

Palea.—Two keeled, grain adhering to palea, strongly nerved, the nerves fringed with bristles.

Flowers—July 1-10.

" The idea that chess is degenerated wheat is erroneous and entirely without foundation. Chess seed will produce chess and only chess."

Chess is most commonly found among wheat and rye. The flour obtained from it is dark colored and narcotic. Care in the selection of seed grain and careful cultivation tending to prevent the maturing of these seeds are the chief remedies.

To the same order belong the brome grasses of which there are many varieties. Perhaps the best known is *Bromus inermis* (Awnless Brome Grass), which is highly spoken of in some parts of the United States, but which is not sufficiently well known in Ontario to be pronounced upon.

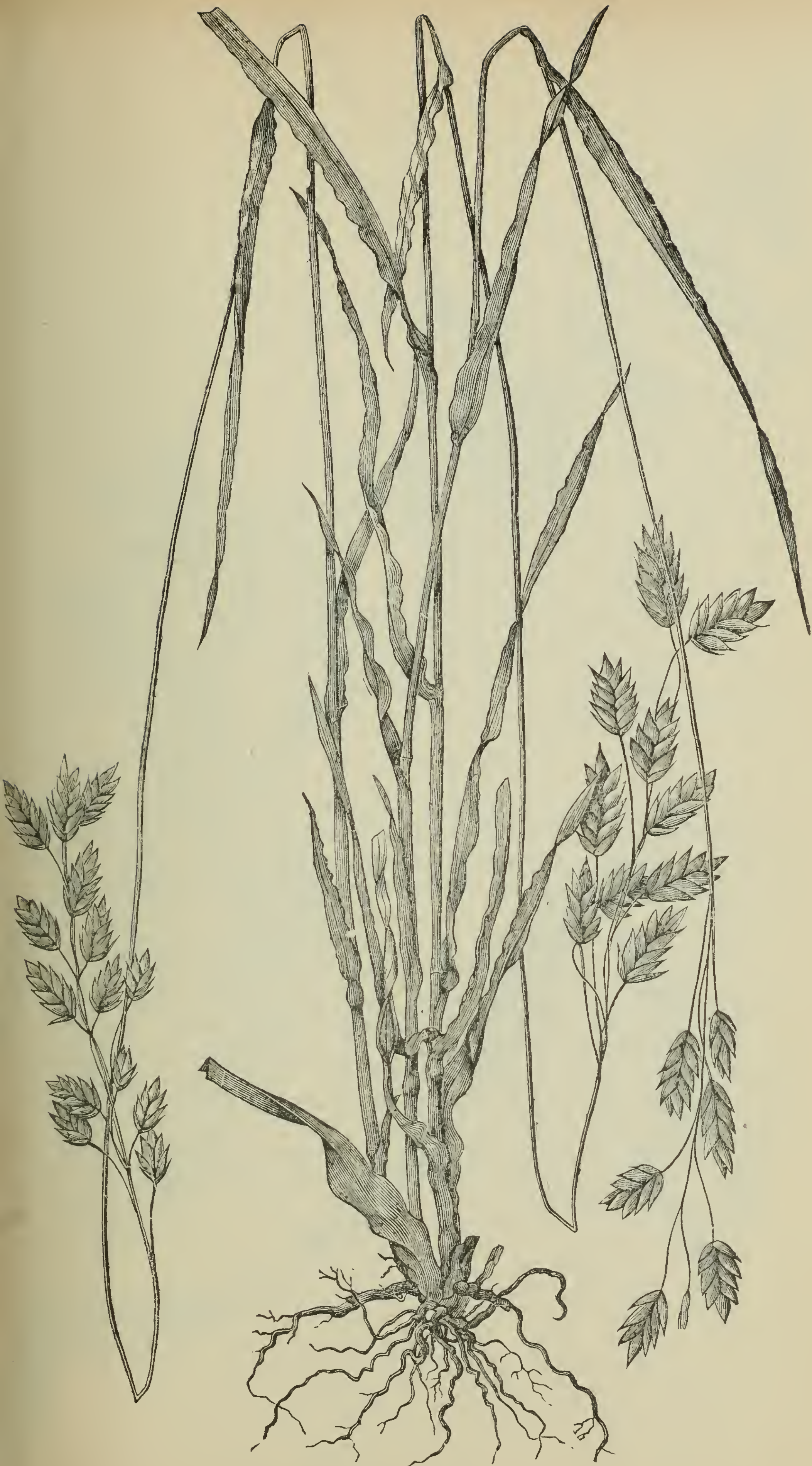


PLATE 24. *Bromus secalinus* (Chess.)

Avena fatua. L.—Wild Oat. (Plate 25.)

Roots.—Annual, fibrous, thickened at base.

Culms.—Erect, simple, smooth.

Leaves.—Leafy, linear, flat, and rough.

Inflorescence. Loose panicle, nodding, branched, and spreading.

Spikelets.—Pendulous and long.

Glumes.—*Empty*, large, long, and unequal;

Flowering, rounded on back, 5-11 nerved, bearing a bent awn and covered with long brown hairs.

Palea.—Shorter than its glume, ribbed, green along the margin, fringed at edge.

Flowers—in July.

Wild Oats are at home in any soil that will grow cereals, and they ripen their seeds among almost any cereal crop. The seeds possess wonderful vitality, some of them remaining buried in the soil for years and germinating as soon as they are brought under favorable conditions.

From what has been said, it follows that on a field infested with wild oats, cereal crops should be dropped out of the rotation as far as possible; and hoed crops, soiling crops, hay, and pasture should take their place. To get the land under grass, it should be fallowed during part of the season, the cultivation being frequent and shallow, to destroy all seeds that may have germinated in the upper layer of soil. The land can then be sown with winter wheat and seeded, or with an early variety of barley, which should be cut on the green side. The treatment mentioned, is suitable for pasture land, or land which has produced a hay or soiling crop during the fore part of the season.

Plate 25. *Avena fatua* (Wild Oat.)

Setaria glauca. Beauv.—Foxtail, Yellow Foxtail, Bottle grass, Puss grass, Pigeon grass. (Plate 26.)

Roots.—Perennial.

Culms.—Erect, about 2 ft. high, rough; sheath smooth, ligule, a fringe of hairs.

Leaves.—Flat, quite rough above, and smoother on under surface.

Inflorescence.—Dense, close spike, cylindrical, bristly, and tawny yellow in color.

Spikelets.—Ovoid, below the joint are solitary or clustered bristles, resembling awns, 6-12 in cluster.

Glumes.—*Empty*, 3, lower one small and the second shorter than the third;

Flowering, transversely wrinkled.

Palea.—Thin.

Flowers in August.

It has very little agricultural value. It is a common weed in stubble, fallow, or root fields.

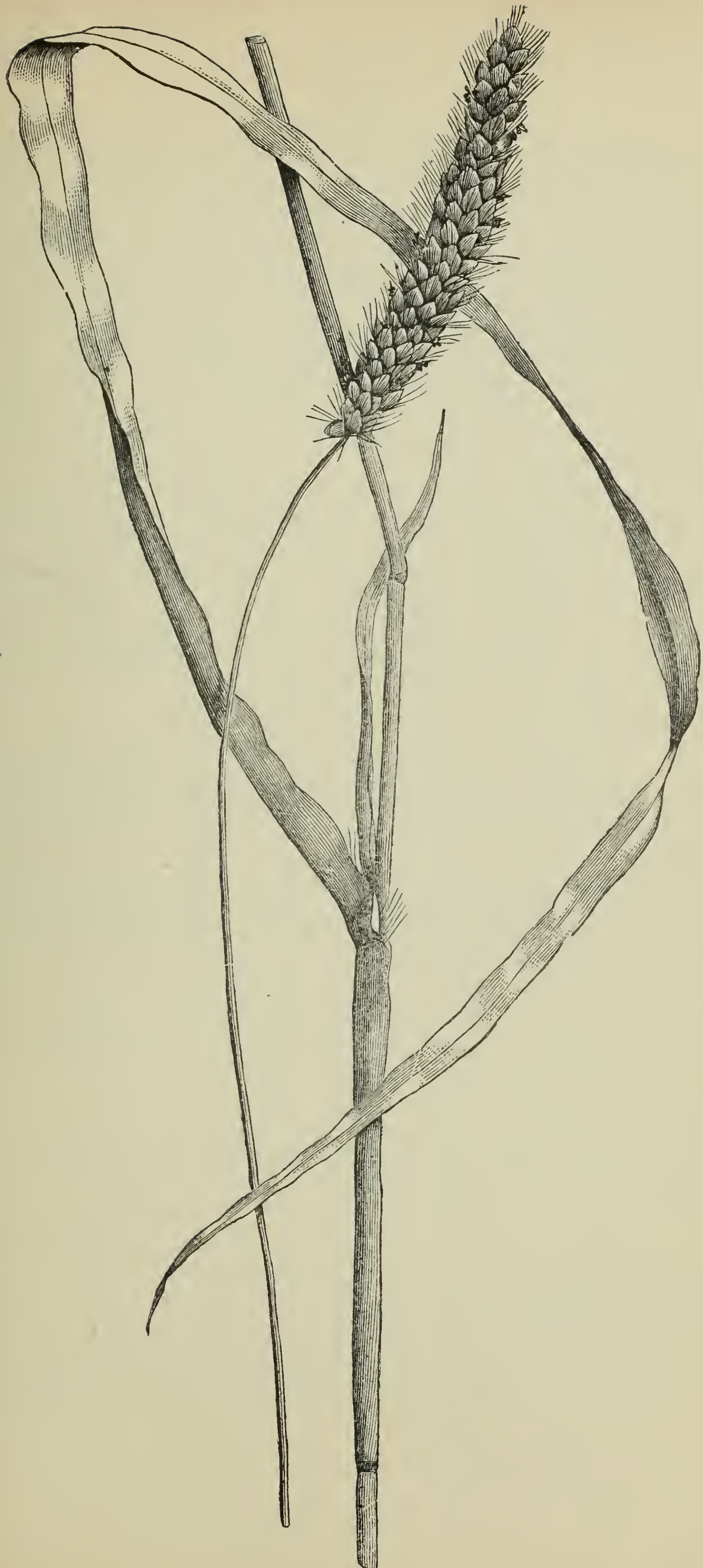


Plate 26. *Setaria glauca.* (Yellow Foxtail.)

General Observations in Conclusion.

In ordering grass seeds, it is always best to give the scientific as well as the common name of the varieties ordered. This is advisable in order to prevent mistakes, for frequently the same common name is applied to different varieties by different people.

Grass and clover seeds form a common medium for the distribution of weed seeds, and it therefore becomes necessary for the buyer to exercise great care in his selection. Only responsible dealers should be patronized.

In the preparation of the soil for grass seeds, fertility, cleanliness, and fineness of tilth are of prime importance. It is the height of folly to sow grass seed on poor, dirty, badly cultivated soil. The cleaning crop should precede the grass, and it is just as unreasonable to expect a good crop of hay from poor soil as it is to expect a heavy crop of grain under like conditions. Also, the finer the state of tilth to which the land is worked, the larger is the per centage of grass seeds which will germinate, and the better able are the young plants to withstand the summer droughts.

Care should also be taken not to cover grass seeds deeply. In light soils they admit of being covered more deeply than in clay, but in any soil light covering is in order. If a harrow is used after the seed is sown it should be a very light one; but rolling is usually sufficient.

The question of grass mixtures is a very complicated one, and it is impossible to state which would be the most suitable mixture for all conditions. It is highly probable that the old standard mixture of timothy and clover will continue to be used in many districts for years to come. As noted before, however, timothy has many deficiencies as a pasture grass, and does not compare with orchard grass, fescue, or tall oat grass, for this purpose. Its great powers of remaining green during droughts, and the strong vitality of its seeds, render orchard grass particularly valuable for pasture.

Though no attempt is made to dictate regarding seed mixtures, it is perhaps not out of place to give a few examples. A mixture that has been used on the College Farm is as follows:

Red clover	6 lbs.
Alsike	3 "
Timothy	4 "
Perennial Rye Grass	2 "
Total	15 lb. per acre.

This mixture is for meadows that are to be broken up at the end of the second year. The alsike clover not only gives variety, but, if there are any low places in the field, it thrives much better on the low land than the red clover. The value of perennial rye grass in the mixture is doubtful, and on many soils it may profitably be discarded ; or, perhaps better still (if the land is to be pastured during part of the time), its place may be taken by orchard grass.

For permanent pastures, or lands that are to be pastured for several years, the following mixture was suggested by Mr. Zavitz, our Experimentalist, in the College Report for 1893 :

Orchard grass	4 lbs.
Meadow Fescue	4 "
Tall Oat grass	3 "
Timothy	2 "
Meadow Foxtail	2 "
Alfalfa	5 "
Alsike clover	2 "
White clover	1 "
Yellow clover	1 "
Total seed per acre	24 lbs.

The foregoing mixture was not given by Mr. Zavitz as conclusive, nor is it offered here as such. On low, rather wet lands or on land with a stiff clay subsoil, it would be little use to sow Alfalfa, and grasses could be selected to takes its place. Thus a great many changes could be made in the mixture to suit the conditions under which it was to be sown, without materially altering its value.

For lawns, the following will be found a very satisfactory mixture :

Kentucky Blue Grass	5 lbs.
Red Top	5 "
White Clover	5 "
Total	15 lbs. per acre.

Rhode Island Bent (*Agrostis canina*) might be substituted for red top, or a less quantity of white clover might be used, according to the taste of the user.

As a rule, it is unsatisfactory to purchase any prepared seed mixtures. It is far better to deal with some reliable seedsman, order seeds by their scientific as well as their common names, and prepare a mixture to suit oneself. By following this plan a person knows what he is getting ; but ready-made mixtures frequently contain an abundance of trash, utterly worthless for the purpose intended.

Composition of Grasses described in this Bulletin—Compiled from Dominion and United States analyses.

	Species.		Stage of growth.	Fresh or Green material.						Water, free substance.				
	Technical.	Common.		Water.	Ash.	Album-inoids.	Fibre.	Car-bo-hy-drates.	Fat.	Ash.	Album-inoids.	Fibre.	Car-bo-hy-drates.	Fat.
1	Phleum pratense	Timothy	Speared	71.35	2.05	3.30	7.22	15.03	1.14	7 37	12.63	25.98	50.03	3.98
2	"	"	Seed formed	64.59	1.56	2.80	10.80	19.22	1.00	4.38	7.96	30.48	54.31	2.86
3	Lolium perenne	Perennial Rye	In flower	79.40	1.59	2.12	6 22	10.17	.50	7.72	10.50	30.83	48.44	2.51
4	Dactylis glomerata	Orchard grass	Hay	14.30	6.87	7.49	22.33	46.96	2.05	8.02	8.74	26.05	54.80	2.39
5	Festuca elatior	Meadow Fescue	In flower	74.38	1.72	2.93	9.88	10.55	.54	6.73	11.44	38 61	41.08	2.14
6	Festuca ovina	Sheep's Fescue	Just before flowering	67.00	1.85	3.26	7.85	19.21	.83	5.60	9.90	23.79	58.20	2.51
7	Arrhenatherum avenaceum	Tall oat grass	Before flowering	62.30	2.99	3.31	9.17	20.71	1.52	7.93	8.78	24.33	54.93	4.03
8	Poa pratensis	Kentucky Blue grass	In flower	66.05	2.12	4.63	7.85	18.08	1.25	6.26	13.62	23.13	53.27	3.70
9	Poa compressa	Canadian Blue grass	After flowering	66.42	2.01	3.77	7.55	19.26	.98	6.00	11.41	22.31	57.17	3.10
10	Agrostis vulgaris	Red Top	In flower	61.40	2.81	4.29	8.50	21.93	1.11	7.27	11.02	22.02	56.82	2.87
11	Alopecurus pratensis	Moadow Fox-tail	In flower	70.76	2.38	3.29	7.86	14.77	.93	8.39	11.49	28.72	48.27	3.11
12	Setaria Italica	Hungarian Millet	In flower	68.06	1.91	2.91	9.40	17.24	.48	6.00	9.13	29.44	53.93	1.51
13	Anthoxanthum odoratum	Vernal grass	In flower	78.80	1.50	2.01	4.37	12.61	.71	7.09	9.47	20 63	59.45	3.36
14	Muhlenbergia Mexicana	Satin grass	Seed formed	49.78	2.39	4.64	14.92	27.59	.68	4.77	9.25	29.72	54.91	1.35
15	Elymus virginicus	Wild Rye	In flower	68.38	1.26	2.62	11.34	16.01	.39	4.04	8.29	39.04	47.38	1.25
16	Calamagrostis Canadensis	Canadian Blue Joint.	Seed formed.	56.69	2.02	4.57	16.06	19.28	1.38	4.68	10.56	36.09	45.49	3.18
17	Glyceria Canadensis		Hay	14.30	6.26	6.97	21.94	48.64	1.89	7.30	8.13	25.60	56.77	2.20
18	Muhlenbergia glomerata.		In flower	62 72	2.86	5.40	11.19	17.37	.46	7.67	14.50	30.03	46.56	1.24
19	Phalaris arundinacea	Reed Canary grass		67.55	2.22	5.39	7.35	16.62	.87	6.84	16.62	22.67	51.19	2.68
20	Poa serotina	Fowl meadow grass	In flower	67.57	2.18	3.93	11.83	13.54	.95	6.74	12.12	36.48	41.73	2.93
21	Hierochloe borealis	Indian Hay	In seed	75.32	1.64	4.93	6.14	10.68	1.29	6.63	20.00	43.25	24.88	5.24
22	Panicum Crus-galli	Barnyard grass	Hay	14.30	5 98	6.66	24.78	46.44	1.84	6.98	7.17	28.91	54.19	2.15
23	Agropyrum repens	Couch grass	In flower	72.88	2.02	4.54	8.15	11.57	.84	7.45	16.75	30.03	42.66	3.11
24	Bromus secalinus	Chess	Ripe	14.30	6.10	6.61	20.39	49.11	3.49	7.12	7.71	23.79	57.30	4.08
25	Avena fatua	Wild oat	Ripe	14.30	4.25	7.50	22.42	48.10	3.43	4.96	8.75	26.16	56.13	4.00
26	Setaria glauca	Yellow Fox-tail	Seed	68.40	2 30	2.86	8.13	17.47	.84	7.94	8.52	21.94	58.54	3.06

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Ontario Agricultural College and Experimental Farm

EXPERIMENTS

WITH

WINTER WHEAT.

By C. A. Zavitz, B.S.A., Experimentalist.

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BULLETIN 100.

EXPERIMENTS WITH WINTER WHEAT.

By C. A. Zavitz, B.S.A., Experimentalist at Ontario Agricultural College and Experimental Farm, Guelph, Ont.

One hundred and ninety-seven plots were used for winter wheat experiments at the Ontario Agricultural College during the past season. About one-half of this number was used for testing varieties, and the remainder for testing different dates of seeding, methods of seeding, selections of grain for seed, quantities of seed per acre, the yield and quality of wheat cut at different stages of ripeness, and the value of seed from wheat cut at different stages of maturity. This bulletin gives a concise report of the principal results of these tests, and it also gives the average results of some of the experiments which have been conducted for a number of years past.

Field Conditions.

The plots used in 1895 for the winter wheat experiments were situated in the northern portion of the large experimental field which lies to the rear of the main College building. The land has a gentle slope to the south-west and its position is somewhat elevated. Hence it was considerably exposed to the cold winter winds, which were so prevalent last season. The soil, which is an average clay loam, was prepared on the bare fallow system, and received a coating of fifteen tons of farmyard manure per acre in 1894. The plots were all the same size, each containing exactly $\frac{1}{100}$ of an acre. The yields per acre have been determined by the actual yields of the plots.

Conditions of Season and Growth.

The grain for the various winter wheat experiments was sown early in September. The germination of the seed was good, and the growth upon the different plots during autumn was quite satisfactory. There were very frequent strong, cold winds during the winter, and the snow was so often blown from the plots that they were only very thinly covered during the greater part of the cold weather. As the slope in the land extends throughout the whole length of the plots, there was no chance for water to lie upon any part of them, but a considerable amount of sleet which came in the early spring, along with the influence of the cold weather, seriously injured many of the less hardy varieties. Between the 12th and 22nd of May, there was frost on six different nights, and on one occasion a minimum thermometer on the College grounds registered only 22 degrees above zero. This late spring frost checked the growth of the crop considerably, but did not seem to do much injury further than this.

The past year has furnished us an excellent opportunity for studying the comparative hardiness of the different varieties under test, and some valuable object lessons under this head were furnished the thousands of Ontario farmers who visited the College in the month of June and witnessed the work which is being carried on in the Experimental Department.

Varieties Tested.

One hundred and two varieties of winter wheat were under test. The plots, as already intimated, were situated side by side and were exactly uniform in size. They were separated from each other by paths three feet wide. All the varieties were sown by hand at the rate of two bushels per acre, on September 6th, 1894, and the germination was quite uniform throughout. The varieties ripened between the 16th and 24th of July, which was about a day later than in 1894. The amount of rust and smut was small this season.

The following table gives the number of varieties tested and reported on within the past six years and also the average yields for each of these years :

Year.	Number of varieties grown each year.	Average weight of grain per measured bushel.	Average yield of—	
			Straw per acre.	Grain per acre.
		lbs.	tons.	bus.
1890	15	60 0	2.4	30.9
1891	23	63.3	2.0	52.9
1892	44	60.5	3.2	42.6
1893	52	58.4	2.1	29.9
1894	80	60.8	4.0	46.7
1895	102	60.4	1.2	26.1

It will be observed that there are great variations in the average results for the different years as given in the above table. The highest record in quality and yield of grain was made in 1891. That year an excellent opportunity was given for a comparison of the different varieties when grown under climatic conditions very favorable for the best development of the plants. In the years 1892 and 1894, much valuable information was obtained in regard to the comparative strength of straw, as many of the varieties were badly lodged, while others, growing beside them, stood upright until ripe. In 1890, 1892 and 1893, there was a considerable amount of rust on our winter wheat; but, as many of the varieties were much more affected than others, we were enabled to make some valuable comparisons. Almost all the varieties came well through the winters from 1890 to 1894, but in 1895 many of them were very much winter-killed, while others, growing beside and between the injured ones, sustained little or no injury.

The varieties of winter wheat which are most desirable for cultivation in Ontario, are those which possess the greatest number of good and the least number of bad qualities. To compare the different varieties in this respect is the object of the present bulletin. From what is said in the preceding paragraph, the reader will readily understand that it is of great importance to have these experiments extend over a period of *several* years, in order to have the varieties subjected to various climatic conditions.

Characteristics and Yields of Varieties.

The following table contains the characteristics and the yields of one hundred and two varieties tested during the past season. The horizontal rows give information regarding the different varieties, and the perpendicular columns furnish a means of comparing the characteristics and yields of the varieties with one another. Starting at the left hand side of the table, columns 1 and 2 give the numbers and names of the varieties; 3 and 4 refer to their characteristics; 5, 6, 7 and 8 give results for 1895; and 9, 10, 11 and 12 give average results for four, three or two years, or for one year, as indicated in column No. 2. Of the first fifty-three varieties mentioned in the table, we have grown some for six years, others for five years, and the remainder for four years; but, to allow a better comparison of the varieties, the average results of only the last four years are here presented.

The reader's attention is especially directed to the last column on the right hand side of the table, as this gives the average yield of grain per acre of each variety for the number of years reported upon, and the varieties are arranged in the table according to these average yields, starting with the highest and finishing with the lowest.

There is, perhaps, not a winter wheat grower in Ontario but is quite familiar with some of the varieties herein reported upon, as many of the old varieties have been tested along with the newer kinds. The following table furnishes an excellent opportunity for each farmer to compare the respective merits of the varieties which he has not grown, with those of the varieties with which he is familiar.

Characteristics and Yields of 102 Varieties of Winter Wheat.

Varieties.	Heads bearded or bald.	Color of grain.	Results for 1895. Condition of crop in spring of 1895.	Results for 1895. Weight per measured bushel.	Results for 1895. Straw per acre.	Results for 1895. Grain per acre (bus. 60 lbs.)	Average results for number of years reported upon as shown in first column to left. Amount of straw lodged.	Average results. Weight per measured bushel.	Average results. Straw per acre.	Average results. Grain per acre (bus. 60 lbs.)
Grown for four years.				lbs.	tons	bus.	p. c.	lbs.	tons	bus.
1. Dawson's Golden Chaff	Ba.	W .	Very good	59.9	1.8	40.3	2	59.5	2.9	**48.7**
2. Early Red Clawson.	Ba.	R ..	Good.....	58.8	1.6	39.9	51	58.4	3.2	**45.5**
3. Egyptian..........	Be.	R ..	Good.....	60.7	1.9	40.6	31	60.6	2.9	**45.1**
4. Golden Drop	Ba.	R ..	Medium..	59.3	1.4	31.5	51	61.2	3.2	**43.7**
5. Surprise	Ba.	W .	Good.....	57.4	1.8	35.4	22	58.6	2.9	**43.0**
6. Reliable	Be.	R ..	Very good	61.1	1.8	35.9	15	61.5	2.8	**42.0**
7. American Bronze..	Ba.	R ..	Very good	60.6	1.9	38.9	2	59.1	3.0	**41.9**
8. Bulgarian	Be.	W .	Good.....	60.6	1.3	28.7	19	61.3	2.6	**41.3**
9. Jones' Winter Fife.	Ba.	R ..	Good.....	59.9	1.5	31.3	15	59.5	2.6	**41.2**
10. Golden Cross or Volunteer........	Be.	R ..	Medium..	60.9	1.8	36.4	27	60.3	3.2	**40.6**
11. Standard	Ba.	W .	Good.....	59.9	1.7	40.3	14	58.3	2.8	**40.5**
12. Manchester	Ba.	R ..	Good....	61.5	1.5	34.9	23	60.4	3.0	**40.4**
13. Red Velvet Chaff..	Ba.	R ..	Very good	59.0	2.2	39.5	38	57.8	3.5	**40.2**
14. Bonnell or Landreth	Ba.	W .	Good.....	59.9	1.8	38.7	29	58.7	3.1	**40.0**
15. Russian Amber....	Be.	R ..	Medium..	60.1	1.5	30.4	23	61.0	2.6	**39.9**
16. Walker's Reliable..	Be.	R ..	Medium..	60.5	1.1	28.0	26	60.8	2.7	**39.0**
17. Democrat	Be.	W .	Good.....	62.3	1.2	29.3	17	61.5	2.3	**38.8**
18. Winter Pearl......	Ba.	W .	Good.....	62.3	1.7	35.0	16	61.2	2.5	**38.6**
19. Seneca or Clawson.	Ba.	W .	Good.....	59.3	1.7	33.8	29	58.9	3.0	**38.6**
20. Red Lion.....	Be.	R ..	Good.....	59.5	1.7	33.7	68	60.7	3.3	**38.5**
21. Martin Amber	Ba.	W .	Good.....	61.9	1.5	32.7	37	60.3	2.9	**38.2**
22. Canadian Velvet Chaff	Ba.	W .	Good.....	57.6	1.5	29.1	16	57.2	2.6	**37.7**
23. Garfield	Ba.	W .	Good.....	60.8	1.5	30.6	24	59.7	2.4	**36.8**
24. Hybrid Mediterranean	Be.	R ..	Very good	62.3	.9	22.0	35	60.9	3.1	**36.8**
25. New Monarch	Ba.	R ..	Good.....	59.6	1.5	29.8	25	60.1	2.8	**36.7**
26. Mediterranean	Be.	R ..	Medium..	60.6	1.3	30.8	36	60.6	3.0	**36.3**
27. Manilla	Ba.	W .	Very good	60.1	1.5	34.3	15	58.0	2.6	**36.1**
28. Lancaster	Be.	R ..	Very good	61.0	1.1	24.6	67	60.9	3.0	**36.0**
29. Rutherford........	Be.	R .	Medium..	61.0	1.1	26.3	35	60.0	2.9	**35.9**
30. Rogers	Ba.	R ..	Very good	60.6	1.0	25.1	38	59.9	3.0	**35.9**
31. Fultz	Ba.	R ..	Good.....	62.2	1.1	25.0	5	62.4	2.1	**35.3**
32. Valley	Be.	R ..	Poor.....	60.1	.6	13.7	11	60.6	2.3	**34.8**
33. Monette	Ba.	R ..	Medium..	60.0	1.2	27.2	20	59.3	2.4	**34.6**

Characteristics and Yields of 102 Varieties of Winter Wheat.—*Continued.*

Varieties.	Heads bearded or bald.	Color of grain.	Results for 1895. Condition of crop in spring of 1895.	Results for 1895. Weight per measured bushel.	Results for 1895. Straw per acre.	Results for 1895. Grain per acre (bus. 60 lbs.)	Average results for number of years reported upon as shown in first column to left. Amount of straw lodged.	Average results. Weight per measured bushel.	Average results. Straw per acre.	Average results. Grain per acre (bus. 60 lbs.)
Grown for four years.—*Con.*				lbs.	tons	bus.	p. c.	lbs.	tons	bus.
34. Hybrid Diehl......	Ba.	W .	Medium..	60.6	1.1	24.9	24	59.4	2.2	**34.6**
35. Genesee	Be.	W .	Medium..	60.0	.9	21.5	20	60.1	2.4	**34.1**
36. Scott	Ba.	R ..	Very good	61.3	1.4	34.2	13	60.1	1.4	**33.6**
37. Velvet Chaff	Be.	R ..	Medium..	62.8	1.1	25.8	3	62.5	2.2	**33.2**
38. Longberry Red....	Be.	R ..	Medium..	60.3	.9	21.7	44	60.4	2.5	**32.8**
39. Deitz Longberry ..	Be.	R ..	Medium..	61.6	1.1	26.0	24	61.8	2.4	**32.5**
40. Rumsey	Be.	W .	Medium..	60.0	.5	10.5	21	60.5	2.5	**32.3**
41. Red Wonder	Be.	R ..	Medium..	61.8	.9	22.3	36	61.7	2.9	**32.0**
42. Fulcaster..........	Be.	R ..	Medium..	59.8	1.3	10.3	27	61.6	2.7	**28.4**
43. Red Russian	Ba.	R ..	Poor	61.4	....	21.8	5	60.2	2.3	**27.9**
44. Saumur	Ba.	R ..	Medium..	57.1	1.0	23.7	13	53.5	2.2	**27.1**
45. Red Inversible	Ba.	R ..	Medium..	59.9	.7	14.0	20	56.1	2.3	**26.4**
46. Spalding Red......	Ba.	R ..	Medium..	61.9	.7	19.1	22	58.8	2.3	**26.2**
47. Browick Red.....	Ba.	R ..	Medium..	60.9	.9	26.5	13	54.8	2.2	**25.2**
48. Square Head......	Be.	W .	Very good	60.0	.7	16.0	17	59.2	.7	**24.5**
49. Regent...	Ba.	R ..	Good.....	59.3	1.5	29.1	27	53.8	2.5	**23.2**
50. White Patanelle...	Ba.	W .	Very good	59.6	.5	6.2	11	53.4	2.4	**21.5**
51. Dividend	Ba.	R ..	Medium..	58.8	.8	17.7	33	51.7	2.4	**21.1**
52. Galizien Summer..	Ba.	R ..	Good.....	59.6	.8	16.6	23	55.1	1.7	**20.9**
53. Kessingland Red ..	Ba.	R ..	Medium..	58.7	.8	20.7	13	51.2	2.0	**20.4**
Grown for three years.										
54. Stewart's Champion	Ba.	R ..	Very good	60.4	2.2	43.5	5	58.6	2.9	**38.9**
55. Early White Leader	Ba.	W .	Medium..	59.8	1.2	27.5	5	57.4	2.2	**38.2**
56. Soule's......	Ba.	W .	Good.....	58.8	1.4	31.5	7	56.9	2.6	**36.8**
57. South Sea	Ba.	W .	Medium..	59.4	1.1	23.8	3	59.9	1.9	**35.0**
58. Eureka............	Ba.	W .	Good.....	59.0	1.4	28.1	6	57.7	2.3	**34.3**
59. White Star........	Be.	R ..	Medium..	61.3	1.2	32.5	7	60.1	2.1	**34.0**
60. British Columbia ..	Ba.	R ..	Medium..	60.9	1.1	24.4	....	57.6	2.0	**28.4**
61. Treadwell	Ba.	W .	Very poor	59.0	.5	11.3	7	59.1	1.8	**25.2**
Grown for two years.										
62. Early Genesee Giant	Ba.	W .	Medium..	61.3	1.4	36.4	8	61.1	2.7	**46.7**
63. Siberian...........	Ba.	R ..	Very good	61.8	1.8	36.6	18	62.4	3.0	**43.1**
64. Early Ripe........	Ba.	R ..	Medium..	61.9	1.3	27.7	21	61.7	2.8	**41.5**
65. Tasmania Red.....	Be.	R ..	Good. ...	61.9	1.5	35.3	45	61.9	3.0	**41.2**
66. Jones'Square Head.	Ba.	W..	Very good	57.6	1.6	30.9	....	59.0	2.4	**39.6**

CHARACTERISTICS AND YIELDS OF 102 VARIETIES OF WINTER WHEAT.—*Continued.*

Varieties.	Heads bearded or bald.	Color of grain.	Results for 1895. Condition of crop in spring of 1895.	Results for 1895. Weight per measured bushel.	Results for 1895. Straw per acre.	Results for 1895. Grain per acre (bus. 60 lbs.)	Average results for number of years reported upon as shown in first column to left. Amount of straw lodged.	Average. Weight per measured bushel.	Average. Straw per acre.	Average. Grain per acre (bus. 60 lbs.)
Grown for two years.—*Con.*				lbs.	tons	bus.	p. c.	lbs.	tons	bus.
67. Pride of Genesee...	Be.	R..	Medium..	62.1	1.3	27.7	20	61.3	2.6	**39.6**
68. Turkish Red	Be.	R..	Very good	62.3	1.5	31.7	23	62.3	2.6	**39.2**
69. Egyptian Amber ..	Be.	R..	Good.....	61.9	1.3	32.1	33	61.1	2.9	**38.1**
70. McPherson.... ...	Ba.	R..	Very good	61.1	1.5	28.3	15	61.7	2.7	**36.7**
71. Arnold's Hybrid..	Ba.	R..	Good.....	60.0	1.2	25.1	11	61.1	2.6	**36.7**
72. Imperial Amber...	Be.	R..	Medium..	59.9	1.5	29.2	45	59.0	3.2	**36.3**
73. Poole	Ba.	R..	Medium..	59.6	.8	21.1	21	60.6	2.4	**35.9**
74. Zimmerman	Ba.	R..	Medium..	60.8	1.2	26.7	1	61.9	2.1	**35 5**
75. Geneva	Be.	R..	Medium..	63.2	1.2	30.0	34	62.4	2.7	**35.1**
76. Red May........	Ba.	R..	Medium..	62.2	.8	20.4	10	62.4	2.4	**34.4**
77. Emporium.........	Ba.	R..	Good.....	59.1	1.2	27.4	23	58.6	2.6	**34.3**
78. New Columbia	Ba.	R..	Medium..	58.8	.6	16.3	8	58.5	2.3	**33.2**
79. Simcoe Red	Be.	R..	Very good	60.6	1.3	27.7	30	58.8	2.8	**33.0**
80. Tuscan Island	Be.	R..	Medium..	59.5	.9	20.3	33	59.7	2.4	**32.6**
81. Kentucky Giant...	Be.	R..	Medium..	59.3	.8	18.4	35	58.9	2.4	**31.8**
82. Rudy	Be.	R..	Poor	61.4	.5	13.9	39	60.5	2.2	**31.4**
83. Penquit's Velvet Chaff	Be.	R..	Medium..	61.9	.9	21.6	1	62.0	2.3	**31.0**
84. Bissell	Be.	R..	Medium..	61.2	.8	20.3	36	61.0	2.4	**30.2**
85. Andrew's No. 4....	Be.	R..	Medium..	60.6	.7	17.1	24	60.3	2.6	**29.7**
86. Golden Tankard...	Be.	R..	Very good	60.9	1.1	25.9	46	60.2	3.2	**28.7**
87. Currell............	Ba.	R..	Medium..	60.9	.8	20.2	20	61.2	2.5	**28.7**
88. Currell's Prolific...	Ba.	R .	Medium..	60.6	.8	19.6	25	61.1	2.6	**28.2**
89. Hindostan	Be.	R..	Medium..	60.4	.5	11.7	23	61.0	2.3	**28.2**
90. Bullard's Velvet Chaff	Ba.	R...	Very poor	58.6	.2	3.5	....	60.8	1.3	**17.6**
Grown for one year.										
91. Michigan Amber ..	Be.	R..	Very good	61.8	1.4	35.5	....	61.8	1.4	**35.5**
92. Giant Square Head.	Be.	W .	Good.....	60.1	1.4	33.4	....	60.1	1.4	**33.4**
93. White Bearded	Be.	W .	Good.....	58.9	1.3	31.8	....	58.9	1.3	**31.8**
94. Silver Star	Ba.	W .	Good.....	61.7	1.3	27.8	....	61.7	1.3	**27.8**
95. Amherst Isle......	Be.	R..	Medium..	59.9	1.1	25.0	3	59.9	1.1	**25.0**
96. German Emperor..	Ba.	R..	Good.....	59.8	1.2	24.2	....	59.8	1.2	**24.2**
97. Hunter's Wheat...	Be.	R..	Medium..	60.9	1.0	22.4	....	60 9	1.0	**22.4**
98. Pride of Illinois ...	Ba.	R..	Good.....	60.2	1.0	21.5	....	60.2	1.0	**21.5**
99. Long Amber	Ba.	W .	Medium..	59.0	.8	13.8	....	59.0	.8	**18.8**
100. Kalina	Be.	R..	Good.....	60.1	.8	17.6	....	60.1	.8	**17.6**
101. Mealy	Ba.	R..	Medium .	60.4	.6	12.1	....	60.4	.6	**12.1**
102. Nonpareil	Be.	W .	Very poor	59.2	.4	7.4	....	59.2	.4	**7.4**

The varieties given in the preceding table were obtained from Ontario, the United States, Germany, France and Russia. Thirty kinds were imported from Europe by the College in the spring of 1889, and have been carefully tested in our plots; but, owing to lack of hardiness, twenty of the number have been discarded. The remaining ten have been grown for the past six years in succession, but are among the poorest yielders reported upon in this bulletin. All our leading varieties of winter wheat, therefore, have been obtained from either Canada or the United States. Mr. A. N. Jones, of Newark, N. Y., has been instrumental in introducing some very excellent varieties, among which the Early Red Clawson, American Bronze, Jones' Winter Fife and Early Genesee Giant are prominent. It is, however, to Mr. Robert Dawson of Paris, Ont., that we must give credit for Dawson's Golden Chaff, a variety which has made the highest average record of all the varieties tested at this station during the past four years.

Bald and Bearded Varieties. Of the one hundred and two varieties grown in 1895, fifty-six possessed bald heads and forty-six bearded heads. During each of the six years past, the bearded varieties gave a heavier weight per measured bushel than the bald sorts, but in yield of grain per acre the bald wheats came first in four out of the six years. In making up this comparison, varieties possessing very short beards were classed as bald wheats.

The following table gives the comparative results of the bald and the bearded varieties for 1895, and for the average of six years.

Periods.	Average results of bald varieties.			Average results of bearded varieties.		
	Weight per measured bushel.	Yield per acre.		Weight per measured bushel.	Yield per acre.	
		Straw.	Grain.		Straw.	Grain.
	lbs.	tons.	bush.	lbs.	tons.	bus.
1895..............	60.0	1.2	27.1	60.8	1.1	25.1
Average of 6 years, 1890-1895.......	60.1	2.5	38.8	61.3	2.5	37.1

Color of Grain. Twenty-nine varieties of white wheat and seventy-three varieties of red wheat were tested during the past year. In five of the last six years, the red wheats gave a heavier weight of grain per measured bushel than the white varieties, but in 1890 the white wheats gave slightly the heaviest grain. The amber, bronze and golden wheats have all been classed as red.

The following table gives the comparative results of the white and the red wheats for 1895, and for the average of six years :

Periods.	Average results of white wheat.			Average results of red wheats.		
	Weight per measured bushel.	Yield per acre.		Weight per measured bushel.	Yield per acre.	
		Straw.	Grain.		Straw.	Grain.
	lbs.	tons.	bush.	lbs.	tons.	bush.
1895.............. ...	59.9	1.3	27.5	60.6	1.1	25.6
Average of 6 years 1890-1895	60.0	2.5	39.3	60.9	2.5	37.7

It will be seen from the above tables that the amount of straw in the average of six years' trials was the same from bald, bearded, white and red varieties of winter wheat. The bearded kinds produced the heaviest weighing grain and the white varieties gave the largest average yield of grain per acre.

Experiments in the Methods of Winter Wheat Growing.

The following concise reports are made upon different winter wheat experiments conducted in the same portion of the experimental grounds that was used for the variety tests. Some of these experiments extend over a period of two and some over a period of three years.

Different Dates of Seeding. During each of the past three years two or more varieties of winter wheat have been sown at three different times in the month of September. The following table gives the average yields for the three years occupied by this experiment :

Dates of seeding.	Weight per measured bushel.	Yield of straw per acre.	Yield of grain per acre.
	lbs.	tons.	bush.
September 2-3....	57.8	2.4	31.8
" 7-9..............	58:0	2.5	31.3
" 17-19..............	56.2	1.6	25.2

It will be seen that the seedings of the 7th and 9th of September produced results about equal to those from the seedings of the 2nd and 3rd. Such is not the case, however, when the results of the last dates are compared with those of either the first or the second, as they are considerably lower in every particular.

Methods of Seeding. An experiment in sowing winter wheat broadcast and with a grain drill has been conducted in duplicate during the past two years. The results show the yields of both straw and grain to be practically the same from sowing similar quantities of grain by the two methods ; but, in weight of grain per measured bushel, the product of the drilled grain has been heavier than that sown broadcast in each of the four tests, the average difference being two-fifths of a pound.

Different Quantities of Seed per Acre. In 1894 and in 1895, two varieties of winter wheat were sown broadcast on small plots, at the rates of one, one and one-half and two bushels per acre. The largest yields of both grain and straw were obtained from the thickest seeding and the smallest yields from the thinnest seeding during each of the two years. The weight of grain per measured bushel was nearly the same from all the plots. To determine the proper quantity of winter wheat to sow per acre, in order to obtain the best results upon different farms, the individual wheat growers can best experiment for themselves, as so much depends upon the fertility of the soil and other conditions.

The Yield and Quality of Winter Wheat as affected by cutting at different stages of maturity. Five plots each of the Dawson's Golden Chaff and the Early Genesee Giant varieties of winter wheat, were sown upon the same date in 1893 and again in 1894. These two varieties reached the stage of maturity at which wheat is usually cut in Ontario, on the 19th of July, in 1894, and on the 18th of July in 1895. The two wheats were cut at five different periods during the two years, as follows : July 4th, July 11th, July 18th and 19th, July 25th and August 2nd. During both years, the greatest yield of straw was obtained from cutting on July 4th, and the heaviest weight of grain per measured bushel from cutting on July 18th and 19th. The yield of grain per acre was largest from the last cutting in 1894 and from the second last cutting in 1895. The lowest results in yield of grain per acre and in weight of grain per measured bushel, were obtained from the cutting of each variety on July 4th of each year.

Value of Grain for Seed as affected by cutting at different stages of maturity. Dawson's Golden Chaff and the Early Genesee Giant varieties of winter wheat were both sown on the same day in 1893, and a plot of each was cut on July 4th, 11th, 19th and 25th, and August 2nd, 1894. The first cutting took place about two weeks before, and the last cutting about two weeks after, that stage of ripeness at which winter wheat is usually cut. A quantity of seed of each variety was taken from each of the five different cuttings, and these ten equal amounts of grain were sown upon a similar number of uniform plots on Sept. 7th, 1894. In 1895, the plots were all harvested at one time, and, in the case of each variety, it was found that the largest yield of grain per acre was produced by the seed of the last cutting of the previous year, and the plumpest sample was produced from the seed of the second and third cuttings.

Selection of Seed. Several experiments are being conducted in the selection of grain for seed ; but it will be some time before the most valuable results can be obtained from this line of experimental work.

Co-operative Experiments with Winter Wheat.

Fifteen varieties of winter wheat, which have been the most successful among all the varieties tested on our experimental grounds, have been distributed over Ontario within the past three years. These have been sent out in sets of five varieties each. Five thousand eight hundred packages of winter wheat alone have been distributed during the three years, and comparative tests have been made upon more than eleven hundred Ontario farms. This system of co-operative experimental work was established by the ex-students of the Agricultural College ; but, through repeated requests from other farmers, the invitation is extended to all interested persons to join in the work. The results have, on the whole, been very gratifying and the numerous experimenters have become much interested in the different experiments undertaken. For detailed reports of these co-operative experiments, the reader is referred to the Annual Report of the Agricultural Experimental Union which is printed along with the report of the Agricultural College. From among ten conclusions given in the report of last year regarding these co-operative experiments with winter wheat for 1894, the following two conclusions are quoted as being of interest in connection with the results given in this bulletin.

1. "Dawson's Golden Chaff gave the largest yield of grain per acre among the nine varieties tested over Ontario in 1894, as well as among the eleven varieties tested in 1893."

2. "Dawson's Golden Chaff was decidedly the most popular variety with the experimenters in both 1894 and 1893."

All the varieties of winter wheat distributed over Ontario each year are grown in duplicate in our Experimental Department on exactly the same sized plots that are used throughout the Province.

Conclusions.

1. The average results of winter-wheat growing on the experimental plots for six years in succession are as follows: Weight of grain per measured bushel, 60.6 lbs.; yield of straw per acre, 2.5 tons; and yield of grain per acre 38 2 bushels.

2. Dawson's Golden Chaff gave the largest average yield of grain per acre among fifty-three varieties of winter wheat grown at the Ontario Agricultural College for four years in succession; also among nine leading varieties tested over Ontario in 1894, and among eleven leading varieties tested over Ontario in 1893.

3 The varieties which possessed the stiffest straw among fifty-three kinds of winter wheat grown for four years in succession, were Dawson's Golden Chaff, American Bronze, Fultz, Velvet Chaff and Red Russian.

4 The varieties of winter wheat which proved the hardiest in 1895, among one hundred and two varieties tested, were Dawson's Golden Chaff, Stewart's Champion, Siberian, Jones' Square Head, Turkish Red and McPherson.

5. When winter wheat was sown later than September 9th, the crop was much poorer than when the seeding took place on or before that date.

6 In 1895, the varieties of winter wheat possessing bald heads and white grain gave an average of 4.3 bushels of grain per acre more than the varieties possessing bearded heads and red grain, but in average weight per measured bushel the latter surpassed the former by 1·3 pounds.

Distribution of Seed for Testing Purposes.

In the following table will be found two sets of winter wheat varieties, which will be sent free, by mail, in half-pound lots of each variety to farmers applying for them, who will carefully test the five kinds in the set which they choose, and will report the results after harvest next year. The seed will be sent out in the order in which the applications are received, as long as the supply lasts.

Two sets of winter wheat for Co-operative Tests.

Set 1.	Set 2.
Dawson's Golden Chaff.	Dawson's Golden Chaff.
Early Red Clawson.	Early Genesee Giant.
Jones' Winter Fife.	Pride of Genesee.
Surprise.	Bulgarian.
American Bronze.	Jones' Square Head.

Each person wishing one of these sets should write to the Experimentalist, Agricultural College, Guelph, *mentioning which set he desires*, and the grain, with instructions for testing and blank forms on which to report, will be forwarded free of cost to his address, until the supply of grain for distribution becomes exhausted.

Seed Wheat.

The Dawson's Golden Chaff and the Early Genesee Giant varieties of winter wheat were grown in the Farm Department in 1895. Limited quantities of these are offered for sale by the Farm Superintendent at $1.25 per bushel for the former and $1.50 per bushel for the latter. The price of cotton bags is 20 cents each and of jute bags 10 cents.

BULLETIN 101. APRIL, 1896.

Ontario Agricultural College and Experimental Farm

DAIRY BULLETIN

BY THE

DAIRY SCHOOL, GUELPH.

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THE ONTARIO AGRICULTURAL COLLEGE

AND

EXPERIMENTAL FARM, GUELPH, ONT.

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BULLETIN 101.

DAIRY BULLETIN—DAIRY SCHOOL, GUELPH.

The material for this bulletin was prepared by the instructors of the Guelph Dairy School in connection with the Ontario Agricultural College. Readers will find it a practical, up-to-date bulletin, giving the latest information on separators and separating milk; butter-making in separator and cream gathering creameries, as well as in the private dairy; cheese-making in spring, summer, and fall; and milk-testing, including notes on the Babcock tester, lactometer, and methods of dividing proceeds among patrons of cheese factories and creameries according to the latest knowledge on the subject.

The instructors of the Guelph Dairy School for 1896 were:

T. B. Millar and R. W. Stratton, in cheese-making.
Mark Sprague, in separators and separating milk.
T. C. Rogers and J. H. Findlay, in butter-making.
J. W. Mitchell, B.A., in milk testing.
Jas. Stonehouse, in home dairy.

SEPARATORS AND THE SEPARATION OF MILK.

By Mark Sprague, Instructor.

As cream separators are coming more into use every day in the creameries of the Province, we feel that a few hints as to their care and management would be welcomed by all who are interested in butter-making.

As there are six or seven kinds of separators on the market, differing very much in construction, it would need as many sets of directions to make this part of our bulletin complete; but space will not permit of so full a treatment of this special department.

The principle of separation in each machine being the same, we will divide our separators into two classes, viz., belt separators, and steam or turbine separators, the latter being driven by steam direct from the boiler.

1. *Belt Machines.* A stone foundation is not required for those makes of separators that are built with a rubber ring around the upper bearing, but the best results are got from having all separators

solidly placed or set. First, place the intermediate, or jack, in position. Level it and put it in line with the driving shaft. Then fasten it in position with bolts or lag-screws, bearing in mind that it may be placed immediately under, or several feet either way from the centre of the driving shaft, as best suits the requirements, and taking care that the pulley on the driving shaft be of sufficient width to carry the belt and allow of its being shifted from the tight to the loose pulley of the intermediate, and *vice versa,* and of the proper size to give the exact speed required.

Next, place the frame of the separator in position, far enough from the intermediate to give the proper tension to the endless belt. Level the machine both ways by placing your level on the top of the cast frame, which is turned true for this purpose. Line the separator with the intermediate by bringing the right hand outside surface of the spindle pulley in line with the centre of the face of the large intermediate pulley, having the vertical centre line of the spindle level with the under side of the intermediate pulley; then bolt the separator securely to the floor or foundation, unless it be one that has the spindle and bowl connected by a socket-joint. If the spindle is so connected, bolting down will be unnecessary.

Bear in mind that the separator bowl should revolve or turn to the right, or with the sun, and that the intermediate should run from the separator. Never put the idler or tightener on the draw-side of the belt. Where only one separator is used, put on all the belting and start the separator with the engine, taking from ten to fifteen minutes to reach the proper speed. Wipe all bearings to free them from dust or dirt, and see that all oil tubes are cleaned and free to allow the oil to flow to the bearings. Look carefully after this matter from day to day

2. *Steam or Turbine Separators.* In setting a steam or turbine machine you have only to decide on the place to set it. This separator also must be set solid so as to be free from the possibility of vibration, and must be levelled in the same way as the belt machines. Turbine separators are all fitted with three-quarter steam fittings, but if the separator be placed so that more than twenty feet of pipe is required to reach to the boiler, use a larger pipe to insure sufficient steam to drive it properly, adding one-quarter of an inch in size of pipe for every twenty feet in distance. Take care to remove all scales and cuttings from pipes before placing them in position.

The exhaust pipe is usually made of galvanized iron, four inches in diameter. It may be conducted through the side of the building, provided it is placed so as to drain well, or it may be put through the roof. The latter method is to be preferred, as the danger of frightening horses is thus done away with. It should be long enough to reach higher than any point of the roof, in order that the draft may not be interfered with. When it is put through the roof, a drain pipe must be connected with the elbow at the lowest point to carry away the condensed steam. This in most cases may be put through the floor or be allowed to run into a pail. Next put the bowl and spindle in place, being sure to have all bearings cleaned and oiled. Then fill the bowl with water, if it be a separator that has steam turned directly against the bowl. This will keep the bowl cool until sufficient speed has been reached to cause a current of air around the bowl, which will keep it cool thereafter. Apply steam gradually, having the regulating valve set so that it will keep the pressure at from forty-five to fifty pounds on the steam guage. If there is no safety valve, the pressure will have to be regulated by the globe valve.

After speed has been reached in either the turbine or the belt separator, the milk should be turned on full feed, until both the cream and the skim-milk flow freely; then it should be closed off till the cream is the desired thickness.

Milk separates best when fresh or new, and at a temperature of ninety degrees. But in creameries the usual practice is to bring the night's and morning's milk together to the factory. In such cases, if the temperature has fallen below eighty-five degrees, the milk should be heated to eighty-five or ninety degrees at least eight or ten minutes before going into the separator. This is done by means of a tempering vat, holding about 400 pounds, and attached to the receiving vat, so as to have a constant and regular flow to the separator.

Heating increases the difference in the specific gravity between the serum and the fat of milk and thus facilitates the separation of the latter. Frozen milk separates better when heated five to eight degrees higher than that which has not been frozen.

After all the milk has been separated, the cream left in bowl can be forced out by putting in some skim-milk or warm water; about two pailfuls will be needed for this purpose. Shut off the feed tap for a few seconds when about one pailful has gone through; then turn it on again.

Always allow the bowl to stop of its own accord after the power has been taken off—never apply any brake or friction to it. Wash in tepid water the bowl and all the parts that come in contact with the milk or cream, cleaning all foreign substances from the skim-milk tubes, etc. Then scald with steam or boiling water and allow to dry, after which the parts may be put together for operation next day.

Two thicknesses of quarter-inch rubber packing placed under the outside edge of the base, before bolting the separator down, improves the running of any separator. Four rubber rings, one under each corner, also have a beneficial effect in making the separator run smoothly and quietly.

In conclusion, we would say to any one who gets a separator: If you are not familiar with it, get some person who has had experience to assist you in setting it up. The very high rate of speed at which cream separators run, makes them somewhat dangerous in the hands of inexperienced operators.

CARE OF MILK FOR CREAMERIES.

BY J. H. FINDLAY, ASSISTANT INSTRUCTOR.

As it is necessary that the cheese and butter makers should be supplied with first-class material to work with, we should look more closely to the care of the milk. Only milk of a good quality and free from any taint or odor should be accepted at a creamery. The cows should be supplied with good wholesome food, and have access at all times to pure water. The cow's udder should be well brushed each time before commencing to milk, and the milking should be done with dry hands and as quickly as possible, care being taken to get the "strippings," as this is the richest part of the milk. As soon as the milk is drawn from the cow it should be taken to a convenient place and strained and aerated, care being taken to see that the surrounding atmosphere is pure, as milk is very susceptible to taints or odors. The aerating may be done by dipping or pouring the milk from one vessel to another; and milk that is properly aerated will require very little cooling. All pails, strainers, etc., should be of tin and should be washed with warm water and then scalded with boiling water immediately after being used. The butter maker should reject any milk that is tainted in any way and notify the patrons as to its defect. He should also give the remedy if possible. Cleanliness should be practised at all times both by the butter maker and by the patrons supplying the milk.

CARE AND CHURNING OF SEPARATOR CREAM.

By T. C. Rogers, Instructor.

The cream being at a high temperature as it comes from the separator, it is very necessary that ample provision be made for cooling it to a proper ripening temperature immediately after separation. High ripening and churning temperatures give the butter a soft, oily texture that diminishes its value. Plenty of ice should be securely stored at the proper time for use when needed, and a cream cooler should be made to hold ice and water, over which the cream may flow from the separator to the cream vat. This vat should be deep and narrow with a seven or eight inch space around it for water and ice, so that, for ripening, the cream may be cooled to sixty degrees within one hour after separation, and to a lower temperature in warm weather.

In creameries where the cream cannot be quickly cooled to sixty degrees, the butter-maker should persist in cooling until a temperature lower than sixty degrees is reached before night, especially in warm weather when the lactic acid is already developing in the milk before separating.

If the cream is to be held for two days before churning, it should be cooled to fifty-two degrees in winter and to fifty degrees in summer. At these low ripening temperatures, the texture of the butter is better. Cream should be stirred frequently for the first six hours after separation and occasionally afterwards while ripening, to improve the flavor and ripen it more uniformly.

We think that the best results can be attained by using a starter to develop lactic acid in the cream, sufficient to cause it to thicken, or coagulate, about six or eight hours before the time for churning. Our experience is that a good clean flavored starter used in this way improves the flavor and keeping quality of the butter and enables the butter-maker to ripen the cream more uniformly from day to day. The cream should always be carefully examined before retiring at night and the person in charge may arrange to have the temperature gradually lowering somewhat, especially in warm weather, so long as the ripening is not delayed too much.

A Starter.

Take one gallon of skim-milk or fresh whole milk (having a good flavor) for each ten gallons of cream to be ripened, and warm it to ninety degrees ; add to it about a gallon and a half of clean water for each ten gallons of milk used in making the starter and set in a clean warm place for twenty to twenty-four hours. Then break up fine by pouring or stirring, and strain into the cream the amount necessary to ripen it properly in the desired time. When a good flavor is got in this way, it is advisable to propagate it by Pasteurizing the milk used in making the starter from day to-day. Do this by setting the milk in boiling water and stirring constantly while it is heating to 160 degrees ; then remove and let stand for twenty or thirty minutes. Afterwards place in cold water and stir till it cools to seventy-five or eighty degrees ; then add about a quart of the old starter (having the good flavor) to each ten gallons of Pasteurized milk, with a gallon and a half of clean water at the same temperature. Mix and set in a clean warm place. Do not stir again until it is wanted ; then use from one to four quarts of the starter in each ten gallons of cream to be ripened, varying according to the condition of the cream, the season of the year, and the time allowed for the cream to ripen.

The starter should be put into the cream vat when the separating begins, to fix the flavor of the cream before any undesirable bacteria develop in it.

Churning.

Separator cream should contain about thirty per cent. of butter-fat and be cooled to fifty-two degrees to fifty-four degrees in winter and fifty degrees to fifty-two degrees in summer, about two hours (and longer if the cream is ripened at high temperatures) before the time for churning. Cream containing a high percentage of butter-fat gives less volume to cool and handle, and it can be churned at a lower temperature, which gives the butter a firmer texture. The churn should first be cleaned with hot water, and then cooled with cold water, before straining the cream into it. The churn should not be filled half full ; one-third full is better. Add butter color to the cream before starting, if required to give the butter the proper color to suit the market. It may be added at the rate of about half an ounce of coloring to 1,000 pounds of milk. A smaller quantity of coloring is required in the spring ; but, in the fall, the amount may be gradually increased to the above figure. Cream containing a high percentage of butter-fat will thicken in churning, and the desired concussion may then cease. At this stage, add to the cream about one gallon of water to each two gallons of cream being churned (at the same temperature), and continue churning until the butter is about half gathered ; then add sufficient water at a lower temperature to keep the butter in the granular form until the cream is properly churned—till the granules are even in size and not larger than grains of wheat. The churn should make from sixty to seventy revolutions per minute, and the time required to churn should be from forty-five to sixty minutes. The lower temperature at which cream can be churned in this length of time, the better will be the texture of the butter. If small specks of butter appear on the first buttermilk drawn off, then the churning should be continued a little longer, and more water should be added if there is danger of the butter gathering too much by the additional churning. Always run the churn at a high speed when finishing the churning and when washing.

Washing.

The quantity of water used for washing the butter should be equal to the quantity of cream churned, and should be at a temperature of from 54° to 58° in winter and 48° in summer, if the butter is to be salted on the worker; and at 45°, or lower, when it is to be salted in the churn. If the water which you have in summer is too warm, use about two quarts of salt in the water and let it stand for ten minutes before drawing off. Avoid using water at high and low temperatures on the same lot of butter, as it has a tendency to cause white specks and an uneven body in the butter. When the butter is to be packed for export, or held for some time, wash it twice, but only once when it is going into consumption within about a month. Unwashed butter, from cream churned at a low temperature, gives good satisfaction, if it is put up in pound prints and forwarded to market as soon as it is made. This method works well in fall and winter, and where water is scarce. When not intending to wash the butter, the maker will find it an advantage to add an extra quantity of very cold water to the contents of the churn when the granules are the proper size, and revolve the churn quickly for a few turns before drawing off the buttermilk. This will cause the buttermilk to run off the butter more freely and give less trouble when working the butter. It is also well to use a little water to wash the buttermilk from around the butter when near done working, but none on the butter.

Salting.

The butter should remain in the churn to dry for twenty or thirty minutes before salting. Salt for butter should have a fine, even grain, and be kept in a clean, cool place, free from bad odors. The salt should be fresh and clean. The proper time and place to salt butter is while in the churn. Use about one and one-eighth ounces of salt to each twenty-five pounds of milk separated, or to the number of pounds of milk required to make a pound of butter. Sift on about half of the salt; then tip the churn gradually to turn the salted portion under. Sift on some more, and turn the churn the opposite way till the remainder of the unsalted portion is exposed; then sift on the remainder of the salt. Use a long wooden fork or spade to mix the butter and salt evenly. If the work is done properly, it will not be necessary to revolve the churn. The butter should remain in the churn, if the room is cold enough ; if not, it should be removed to the cold storage room for from two to four hours before working. Salting in the churn is the most perfect method of salting butter, as by that method a more even color is obtained and the texture of the butter is preserved in consequence of less working being necessary. When salting butter on the worker, use about one ounce of salt to one pound of washed butter, and one and a quarter ounces per pound of unwashed butter, varying the quantity to suit the taste of the market. About one-half to three-quarters of an ounce per pound suits the English market when the butter is shipped fresh.

Working the Butter

Work carefully and evenly all parts of the butter alike, turning in and out and doubling alternately on the revolving worker. When the butter is salted on the revolving worker, the worker should be turned twenty-four times to finish the butter at one working. When the butter is to be worked twice, about eight turns the first time will be sufficient, and say ten turns, or just enough to make the color even, the second time. We prefer working butter twice when packing for export, as in this way we get less moisture, a closer body and a more even color. It is also preferable to the one-working method for the inexperienced butter-maker.

When the butter is salted in the churn, ten to fourteen revolutions of the worker will be sufficient, the aim being to remove the excess of moisture and get an even color. This should be done in every case. The butter, when working, should in no case be colder in winter or warmer in summer than fifty-five degrees.

Packages.

Ash or spruce tubs should be soaked for twenty-four hours with a strong, hot brine, or for two days with a cold brine ; then be washed clean and lined with parchment paper. Tubs or boxes lined with paraffin wax should also have parchment paper inside. Pack the butter in the tubs or boxes close around the sides and corners. Fill to within half an inch of the top of the tub and finish off level without giving the butter a greasy appearance. Cover the butter with parchment paper or butter-cloth and put on a paste made of salt and water. Then put into cold storage at fifty-six degrees, or as much lower as the temperature can be kept uniform. Changes in temperature have an injurious effect on the keeping of butter. Fresh brine should be added occasionally to keep the paste on the top of the tub in a moist condition.

Shipping.

The tubs or boxes should be clean and the lids fastened on properly; the weight of butter in all the tubs or boxes should be the same, and it should be marked plainly on the outside of each; about half to three-quarters of a pound extra should be added to each, when filling, to make the butter hold out in weight. When the butter is shipped in one-pound prints, it should be securely protected from the sun in warm weather by the use of ice in the shipping box. A piece of clean brown paper laid over the top of the butter will protect it from the sun and heat.

Cream-Gathering Creameries.

Only competent, honest, courteous men should be employed in or about creameries. It would be of very great advantage to the patrons, if the cream-gatherers had a good knowledge of cream-raising, so as to give instruction where needed. There is enough cream, or butter-fat, lost in the skim-milk through carelessness, neglect and ignorance, to pay the entire cost of manufacturing the butter in most of these creameries. The cream-gatherer should be accurate and just in measuring the cream, taking samples properly, and doing all in his power to promote harmony between the patrons and managers of the creamery.

The waggons should be covered to protect the tanks or cans from the sun, that the cream may be delivered at the creamery as cool as possible. After the cream is strained into the cream vat, the butter-maker should examine its condition regarding temperature and lactic acid. A safe rule in warm weather is to cool the cream immediately to fifty-six or fifty-eight degrees, hold at this temperature over night, and churn at about fifty-eight degrees in the morning. When the cream is delivered cold and sweet in the fall, the temperature should be raised to sixty degrees to ripen. Some fresh buttermilk may be used to hasten the ripening process. The cream may be churned at sixty degrees in the fall. For hints on the effects of temperature in churning and washing, also on salting, working, packing, etc., see "Separator Creameries." Perfect cleanliness and fresh air are extremely important factors in a creamery—so important that, without them, success is impossible.

CREAM-GATHERING CREAMERIES AND THE PRIVATE DAIRY.

By James Stonehouse, Instructor.

Whether the object is to make the cream into butter on the farm or to send it to a creamery to be churned and marketed, the first point to be aimed at should be to get pure, wholesome milk, free from any bad taint or odor.

During the summer months, when cows are on grass, this is not difficult to do; but during fall and winter months, when the cows are housed, the conditions are very much changed, and it is during these months that we find it most difficult to get milk free from undesirable taints and flavors, which come most frequently either from the filthy surroundings of the cow or from food which imparts to the milk an objectionable flavor.

Cleanliness must be enforced at every step of the process of butter-making, if we are to have an A1 product.

All pails and other utensils should be thoroughly washed; then scalded, after which they should be placed outside in a pure atmosphere to be well aired.

Always use a brush for washing milk utensils; and after scalding, allow the heat to dry them.

The milk-room should be kept cool, clean, and sweet. Strain and set the milk as soon as possible after milking; and, if deep cans are used, set in water at a temperature of forty-five degrees or below in summer, and thirty-eight to forty degrees or below in fall and winter.

Every farmer who handles milk should use a thermometer, so that he will know when his milk is cooled to the above temperatures, as the loss of cream or butter-fat is much greater when the milk is cooled to only fifty degrees.

To have profitable returns from the handling of milk, plenty of ice should be provided and stored in a convenient place near the milk room. Milk set in deep cans with plenty of ice to keep the temperature at forty-five degrees or below can be skimmed in twelve hours in the summer; but in the fall and winter, it should stand at least twenty-four hours. The longer milk can stand in covered cans and be kept perfectly sweet the thicker and richer the cream will be.

Thick, rich cream has many advantages over poor, thin cream, which will be treated of under the head of "Churning."

Where the skim-milk is not drawn from the bottom of the can, a skimmer six inches in diameter across the top, without any wire around the edge, and tapering to a point six inches deep, with a handle ten to twelve inches long, will be found very convenient for skimming the cream from the top of the can. If the milk is drawn from the bottom of the can, we would suggest having a bottom with four or five inches of a slant, to carry off any sediment that may be on the bottom; and by having the bottom run down to a point, the skim-milk can be drawn off much closer than can be done with a flat bottom.

The per cent. of butter-fat in the cream depends upon the amount of skim-milk in the cream, as cream is simply tiny globules of butter-fat mixed with skim-milk. The amount of cream depends upon the per cent. of fat in the milk, the temperature to which the milk has been cooled, and the length of time it has been standing. There will be more cream on milk containing four per cent. of fat than on milk containing only three per cent. of fat, and there will be more cream on milk cooled to forty-two degrees than on milk cooled to only fifty degrees, other things being equal. No expensive creamer is necessary to get all the cream out of the milk, so long as the proper temperature is maintained, as it is the temperature of the water around the milk which does the work. Any ordinary box or barrel which will hold water will do the work just as well as the most expensive creamer made, if there is plenty of room for ice around the cans.

If the water in the tank becomes foul from milk spilled into it or from any other cause, it should be changed immediately.

Where ice cannot be procured, nor spring water as low as the temperatures indicated, we would recommend a separator for a herd of fifteen to twenty cows. These separators usually leave about one-tenth of one per cent. of fat in the milk, while milk from deep setting without ice, and cooled to only fifty degrees, usually has about one per cent., or ten times as much loss as separator skim-milk, while if the same milk were cooled to forty-two degrees by the use of ice, the loss of fat would be but from one to three-tenths of one per cent. of fat.

If a separator cannot be had, we would prefer the shallow pan system over the deep setting without ice or cold spring water, as all our experiments go to show that the deep setting without ice, either in summer or winter, causes a large loss of butter-fat in the skim-milk. Many people have the idea that in cold weather ice is not needed, but it is a great mistake, as ice is just as important in winter as in summer.

Where the shallow-pan system is followed, the milk should be set in a clean, cool room at a temperature of sixty degrees or lower for thirty-six hours, but no longer, as the cream is all up by that time and of a better quality than if allowed to remain longer, as the cream, being exposed to the air in warm weather, becomes thick and tough and will not run through the strainer into the churn; and such cream should never be accepted in a creamery, for it is hardly possible to make butter free from white specks from such cream. It is also difficult to make good flavored butter in a creamery from a mixed lot of shallow-pan cream, because there are so few milk rooms that are fit to set milk in; and, if cream takes on a disagreeable flavor from its surroundings, it is impossible to make first-class butter from it. Buyers always look for flavor first, and if that is not good, no other quality in the butter will compensate for its loss, and the price is gauged accordingly.

No dairy farmer should be without a Babcock milk tester for testing the milk of each individual cow and also the skim-milk. Each cow should give at least 6,000 pounds of milk per year, which should make about 250 pounds of butter. Each cow's milk should be weighed and the milk tested to ascertain how much butter-fat the cow is giving. The cow which is giving the largest amount of milk and is perhaps considered the most profitable cow in the herd, may be giving much less butter-fat than another cow which gives a much smaller quantity of milk.

The skim-milk should be tested, that the farmer may know whether he is getting all of the butter-fat out of the milk. We have frequently tested skim-milk from farmers, which showed from one to one and a half per cent. of butter fat, which means a loss of about twenty-five per cent. of all the butter-fat in the milk, or, in other words, the butter from every fourth cow was thrown away in the skim-milk.

Care of Cream.

After the milk has been carefully skimmed, the cream should be kept in a covered can with the temperature somewhat below fifty degrees, and stirred well each time fresh cream is added.

If the temperature of the milk room or cellar is not down to fifty degrees, the cream should be set in ice water, if it is separator or shallow-pan cream; but, if it is from deep setting cans raised with ice, there should be no difficulty in keeping it perfectly sweet in an ordinary cellar, because the temperature is low when the cream is taken from the milk. If the cream is cared for in this way, there will be no complaints about sour cream before it is wanted; and, if the farmer is a patron of a creamery, he will have done his duty in supplying the butter-maker with the raw material in prime condition for making gilt-edge butter. Cream should never be set in open crocks or pails in cellars, pantries, or any other place where the air is not pure, nor where the temperature is above sixty degrees, as it is sure to sour and will often be in churning condition before it is wanted. When the cream can is emptied, it should be thoroughly washed and scalded and placed where it will get plenty of fresh, pure air before it is again needed.

Churning in the Farm Dairy.

The preparation of the cream is the first thing to be thought of, and that should commence at least eighteen hours before churning, if the cream has been kept sweet up to this time.

The first thing to be done is to raise the temperature up to a point at which the acid will begin to develop; and, where no starter is used this will usually be about sixty-five degrees. This is easily done by placing the cream can in a tub of warm water at ninety or a hundred degrees and stirring constantly until sixty-five degrees is reached. Care should be taken in warm weather that it does not go much above this temperature. If it does, the cream is liable to become too sour or overripe before churning time.

If the cream has a slightly acid taste before bringing it from the cellar, it should not be raised above sixty degrees, and that not more than twelve or fourteen hours before churning time.

In cold weather, it is advisable to use a starter, so that the cream may sour more rapidly and at a lower temperature, as cream ripened at a high temperature and kept there till near churning time makes soft butter of a poor texture. A good plan to secure a starter is to take a quart or so of the ripened cream, if it is of a good flavor, and put it into the cream can which is to hold the cream for the next churning, care being taken to keep the temperature low enough (fifty degrees) to prevent the acid germs from developing until the cream is warmed up for ripening, when the acid will develop rapidly. In this case the temperature need not be over sixty degrees to secure sufficient acid or ripeness in eighteen hours. Repeat the starter as before.

The temperature at which cream can be churned varies from fifty to seventy degrees. Where a separator is used and the cream-screw is gauged to give cream with twenty-five to thirty per cent. of fat in it, it can be churned at a temperature of forty-eight to fifty-two degrees, and the butter from such cream comes much firmer, while the loss in the butter-milk is less than from thin cream. The ordinary dairy cream usually has about sixteen to eighteen per cent. of fat in it, and must be churned at fifty-eight to sixty-two degrees in summer and from sixty-two to sixty-four degrees in winter. The cream should always be strained into the churn to break up any pieces of curd. The time of churning will vary with the temperature of the cream, the breed of cows, and the time they have been giving milk.

Cream with sixteen to twenty per cent. of fat in it and at the right temperature will churn and gather into granules without the addition of any water; but cream with twenty-five to thirty per cent. of fat will thicken up in the churn, so that concussion will cease. At this stage, about ten per cent. of water at the temperature of the cream should be added; and, when it breaks, the same quantity, two or three degrees lower, should be added, so as to prevent the granules from massing together, and to give the butter sufficient liquid to float in, so as to get a good separation from the butter milk. When the granules are about the size of wheat kernels, draw off the butter-milk; then wash with sufficient water to keep the granules apart and at a temperature a little lower than the churning temperature of the cream; and, if the butter is to be packed or held for a market, repeat the washing until the water comes off clear.

Salting in the churn is coming largely into vogue, and we recommend it very strongly as the best method of salting butter, for the reason that we can have our butter free from specks and streaks with the least possible amount of working.

If this method is to be followed, a churn without dashers should be used, and the water for the last washing should be cold enough to harden the butter granules, so that they will not easily mass together while the churn is being revolved after the salt has been added. This is the main point in salting in the churn, and must be carefully guarded to insure good results.

After the washing is done, let the butter drain for fifteen minutes; then salt with one and one-eighth to one and one-quarter ounces to the pound, as considerable of the salt is carried off with the water left in the butter; tip the churn backward and forward as the salt is being added; then revolve the churn very slowly a few times and let it stand for fifteen minutes, after which revolve till the butter masses into a lump. (It should be hard enough to stand revolving four or five minutes before massing.) Now let it stand in the churn or put it away in the butter tray for about three hours, when it will be ready to make up for market with a very slight amount of working, as the salt has been thoroughly mixed with the butter in the granular state, and most of it is already dissolved.

CHEESE MAKING.

By T. B. Millar, Instructor.

Spring Cheese.

In cheese-making, as in all lines of dairying, in order to gain the best results, cleanliness must be observed in every particular by patron and maker alike, the cheese-maker being careful to reject all tainted or sour milk, as first-class goods can be made only from first-class material.

For early cheese, heat the milk to eighty-four degrees or eighty-six degrees Fahr. Stir the milk gently while heating, for quick or rough stirring at this stage causes a loss of butter-fat. The rennet test should then be made as soon as possible, to ascertain the degree of ripeness. To make the test, to eight ounces of milk at a temperature of eighty-six degrees, add one dram of rennet (of known strength), and stir rapidly for ten seconds. If coagulation takes place in from eighteen to twenty seconds, the milk is sufficiently matured, and the rennet should be added at once. If a piece of match one-half inch long be dropped in the milk as the milk is started in motion around the glass, the instant that coagulation takes place can be readily noted by the sudden stopping of the piece of stick. It may be necessary to vary the test a few seconds to suit the conditions of different localities, but with judgment a few trials will enable the maker to tell just when the milk is matured sufficiently for setting

Ripen the milk so that sufficient acid for dipping will develop in two and a half hours after setting. When dipped, the curd should not show more than one-eighth inch acid by the hot iron test. Great care and watchfulness should be exercised at this stage, as the acid develops very rapidly.

Use sufficient rennet (from three to five ounces per 1,000 pounds of milk) to coagulate the milk fit for cutting in from fifteen to twenty minutes. The curd is then cut by using, first, the horizontal knife and then the perpendicular one, cutting continuously until completed. Commence cutting early, taking plenty of time to do it properly.

Stir the curd gently with the hands for ten minutes before any steam is turned on, and be sure that the curd is free from the sides of the vat before applying the steam. Rough handling at this stage means a loss, both in quantity and quality, as a greater percentage of butter-fat will be lost in the whey.

Heat the curd slowly to ninety-eight degrees, taking from about thirty to thirty-five minutes to do so. After the heat is up to the desired point, continue stirring for fifteen or twenty minutes to insure uniform cooking. Draw off a portion of the whey early, stirring occasionally ; then dip the curd with a small acid, from one-sixteenth to one eighth inch, as shown by the hot iron test. Stir well in the sink to let the whey escape before allowing to mat. When the curd is matted firm enough to stand handling without breaking, cut into narrow strips (about six inches wide) and turn every ten or fifteen minutes, or often enough to prevent the whey from gathering in pools on the curd. After they are turned once or twice, these strips may be piled two deep. Keep the temperature at from ninety to ninety-four degrees until the curd is ready for milling. Mill early—as soon as the curd becomes flaky and shows three quarters of an inch acid by the hot iron test.

Air well by stirring, and salt the curd when it becomes mellow, feels like velvet, and smells like newly-made butter. Use some brand of pure dairy salt, salting at the rate of one and a half to two pounds of salt per 1,000 pounds of milk. At the time of salting, the temperature of the curd should be from eighty-three to eighty-six degrees ; and when the salt is thoroughly dissolved, put to press, having the temperature about eighty degrees.

Apply the pressure gently at first, until the whey begins to run clear, then gradually increase the pressure. After the cheese have been in the press forty-five minutes, or rather longer, take them out, pare off all shoulders, and bandage properly by pulling up the bandage neatly. leaving no wrinkles on the side, and trimming the ends so as to leave about three-quarters of an inch of bandage on each end. Turn them in the hoops in the morning, allow them to remain in the press at least twenty hours, and see that each cheese is finished perfectly before allowing it to be taken to the curing-room. The curing-room should be kept at an even temperature of from sixty-five to seventy degrees, and should be well ventilated.

Note.—When quick curing cheese is not desired, use less rennet and more salt.

Summer Cheese.

Heat the milk gradually to eighty-six degrees Fahr., and make a rennet test. In very hot weather, it is advisable to make the test before the temperature quite reaches the eighty-six degrees, as it will show how quickly acid is likely to develop. Endeavor to have the milk ripened, so that the curd will be ready to dip with one quarter of an inch acid in from two and one-half to three hours from the time the rennet is added.

Use enough rennet to have perfect coagulation, fit for cutting, in from thirty to thirty-five minutes.

Commence cutting early. See directions for cutting, stirring, and cooking the curd under the heading of "Spring Cheese."

Draw off a portion of the whey early, so as to be prepared for the quick development of acid. Dip the curd when it shows from one-eighth to one-quarter inch acid, and continue to stir by hand until the curd is sufficiently dry before allowing to mat. When matted, cut into convenient strips and turn every ten or fifteen minutes, piling a little deeper each time it is turned, and leaving a space between each column to allow the whey to escape.

Mill early, or when the curd becomes flaky and shows from one to one and one-quarter inch acid by the hot iron test; then air well by stirring immediately after milling.

Mature well before salting. In salting, use at the rate of two and one-half to two and three-quarter pounds of salt per 1,000 pounds of milk; the amount of salt used is regulated by the amount of moisture in the curd.

In warm weather, endeavor to lower the temperaturs of the curd as much as possible before putting to press.

Fall Cheese.

In making fall cheese, the system is similar to that used in making summer cheese, excepting the following points of difference:

If the milk is working slowly, use some clean flavored starter.

Use enough rennet to have coagulation take place in from forty to forty-five minutes.

Set the milk so that it will be ready to dip, with one-quarter inch acid, in from two and three-quarters to three hours time after setting.

Keep the curd warm, about ninety degrees, until ready for milling. Mill when the curd becomes flaky, showing one and one-quarter to one and one-half inch acid.

Salt at the rate of two and three quarters to three pounds salt per 1,000 pounds of milk, and put to press at a temperature of from eighty to eighty-five degrees.

Leave the cheese in the press one hour before bandaging.

In the case of gassy milk, note the following points:

The milk should be matured more than usual before setting (some two or three seconds more.)

When cuttiug the curd, be careful to leave the cubes larger, so as to retain more moisture; then stir for fifteen minutes before turning on the steam.

When cooking, heat slowly to ninety-six degrees, raising it to ninety-eight degrees just before dipping.

Dip the curd with one-quarter inch acid, and do not stir much in the sink after dipping.

Turn frequently, at the same time piling the curd three or four deep in the sink; then mill when the curd becomes flaky, showing one and one quarter inch acid. Air and mature well before salting.

In handling overripe milk, set the milk as soon as possible at a lower temperature than usual, at from eighty to eighty-four degrees; then, as always, make a rennet test. In a case of this kind more rennet should be used, from one-half to one ounce extra per 1,000 pounds of milk.

Commence to cut the curd early, cutting finer than usual, thus enabling you to cook the curd more quickly.

A portion of the whey should be drawn off as soon as possible; and when it can be managed, the curd should be dipped with less acid than usual and then well stirred before allowing it to mat in the sink.

Mill early, or when the curd shows three-quarters of an inch of acid, and try to have the curd in a flaky condition at this stage.

Do not be in a hurry to salt a curd of this description; for if it has been milled at the proper time and well stirred, there is no danger of its getting too much acid in the sink.

With tainted milk, heat to eighty-eight degrees and air frequently by dipping or pouring, until the milk is ready for setting. If you have a sharp, clean flavored starter, it will be an advantage to use a little extra with milk of this kind.

When the curd is heated to ninety-eight degrees, draw off a portion of the whey, and just before the curd is ready for dipping raise the temperature two degrees and stir well.

Dip the curd with a small amount of acid, about one-eighth inch, endeavoring to have it in such a condition that it will not require much stirring in the sink, and keep up the temperature to ninety-two or ninety-four degrees until the curd is ready for milling. Mill when the curd is in a flaky condition and shows one inch acid. Air by frequent stirring and mature well before salting.

When making colored cheese, pour the coloring into a large dipper of milk taken from the vat, then draw the dipper quickly along under the surface of the milk from one end of the vat to the other, and make sure that it is thoroughly mixed before the rennet is added.

The rennet should be diluted with one gallon of pure water to each vat, and the milk should be well stirred for from three to five minutes according to the condition of the milk, after the rennet has been added. In the case of overripe milk, two minutes will be ample time to stir after adding the rennet.

Everything in and about the factory should be kept scrupulously clean.

A STARTER.

By R. W. Stratton, Assistant Instructor.

A starter is some milk in which the lactic acid has been allowed to develop, and is used to hasten the ripening of milk.

A suitable can for keeping it in should first be provided; one similar to the ordinary cream gathering can will do, having double walls with a hollow space between. It should have two lids, one fitting closely inside of the can with a flange to keep it from going below the shoulder, and the other covering over all and fitting close to the outside.

In preparing the starter, use only milk of the best quality, which has been well aired, and is free from any foreign flavor. It is better to use the same patron's milk each day, endeavoring to arrange with some one whom you know to be scrupulously clean, and who has some fresh milkers in his herd, as the acid in milk from fresh cows will develop much faster than in milk from those that are farther advanced in the period of lactation.

Save about twenty pounds for each vat and raise it to a temperature of from eighty to eighty-five degrees; then add one pound of the previous day's starter for every twenty-five or thirty pounds of the fresh milk saved; mix all thoroughly and allow to stand for about one hour. Then add about one-third as much water as there is milk, (in warm weather the water may be added at the time of adding the old starter), stir well, cover up closely, and set in a clean, warm room where an even temperature can be maintained, and do not disturb it until required for use.

Before using, it will be better to remove from one-half to two inches from the surface of the can, as the flavor on the surface will not be found so good as that which is below. Then break up the remainder by stirring it in the can, take out what is required, and pour from one pail to another a few times, when it will have a creamy consistency and be ready for use.

It is better, whenever practicable, to Pasteurize the milk used in making the starter, as it insures a better and more uniform flavor. Especially when making it in small quantities, we would recommend Pasteurizing by following the rule given in the creamery work.

When and How to Use a Starter.

Just when and how much to use cannot be definitely stated. It must be determined by the exercise of good judgment. Suffice it to say, that it is better to err on the safe side, by using too little rather than too much. First apply the rennet test, to be sure of the acidity of the milk, before adding the starter. A starter may be used with advantage at all times with gassy milk, and in cold weather when milk is being delivered at the factory very sweet. If it is known for a certainty that all the milk being delivered in the vat is perfectly sweet, a little may be added on the start; but the bulk should always be kept until the condition of the milk has been ascertained by the rennet test. Do not ripen the milk so low by two or three seconds when using a starter.

Let it always be remembered that while a good, clean-flavored starter can be used to advantage, a poor flavored one should never be used under any circumstances, as it would spoil the flavor of the whole vat.

MILK TESTING.

By J. W. Mitchell, B.A., Instructor.

Milk-testing is the determination of the quality of milk as regards the per cent. of fat and other constituents in it.

The two instruments commonly made use of in the testing of milk are the Babcock tester, used to determine the per cent. of fat in milk, and the lactometer, to determine the specific gravity of milk.

These two instruments at hand, we are enabled not only to determine the relative values of different milks delivered to a factory, but also to detect the various adulterations of milk.

Babcock Test.

The following is a brief explanation and outline of the Babcock test:

The scale on the neck of the ordinary test bottle is graduated to give a reading of the per cent. of fat only when eighteen grams are used in the test, *i.e.*, the fat extending over one of the larger divisions of the scale weighs *one per cent.*, or the one-hundredth part of eighteen grams. This fact, borne carefully in mind, will explain the various rules for determining the per cent. of fat when eighteen grams cannot be used in a test—as in the case of cream or cheese, in which the per cent. of fat is high.

Note.—The capacity of that part of the neck over which the scale extends is two cubic centimetres (c. c.), and of one of the larger divisions of the scale is .2 (2-10) c. c. Hence, the specific gravity of fat being .9 (9-10), the weight of the fat extending over one of the larger divisions of the scale is $.9 \times .2 = .18$ of a gram.

To Test Milk.

1. By means of a 17.6 c. c. pipette take eighteen grams of milk. Have the milk at a temperature of sixty to seventy degrees.

2. To this, add 17.5 c. c. of commercial sulphuric acid, having a specific gravity of 1.82 to 1.83, and thoroughly mix the acid and milk by giving the bottles a gentle rotary motion.

3. Place the bottles in the machine and turn for about five minutes at a speed varying from 700 to 1,200 revolutions per minute, according to the diameter of the machine (700 revolutions per minute with a machine twenty inches in diameter and faster for a smaller machine.)

4. Add water at from 130 to 150 degrees to bring the fat up into the neck of the bottle.

5. Turn the machine again for about two minutes, and take the reading before the fat cools.

Notes.

1. Be sure that the scale on the bottle is properly graduated. The most convenient way of doing this is to test the same milk in the different test-bottles and compare the readings. A bottle that differs by more than .2 (2-10) in its reading from the rest should be discarded. As the capacity of that part of the neck over which the scale extends should be two c. c., the accuracy of the scale may be tested by filling the bottle to the bottom of the scale with water at the temperature of the room, and then adding two c. c. of water at the same temperature by means of a two c. c. pipette.

2. Mix the milk well to obtain a representative sample. Mix by pouring from one vessel to another, as violent shaking is liable to churn it.

3. Be very careful to measure the exact amount of milk for a test, and to blow the pipette out well.

4. The amount of acid used must be varied to suit its strength. The right amount has been used when the fat presents a bright, golden appearance. Acid that is much too strong or too weak should be discarded, as satisfactory results cannot be obtained from its use.

5. Hold the test-bottle at a slant when pouring in the acid, to prevent the acid from falling directly upon and charring the milk.

6. If the temperature of the room be low, it is very necessary to pour hot water into the testing machine to keep up the temperature.

7. The water added to the test-bottles should be soft or distilled. If hard water be used, add a little sulphuric acid (four or five c. c. to a gallon of water) to soften it; this will prevent the appearance of foam above the fat.

8. Correct readings can never be taken when the fat has cooled. In such cases, set the bottles in hot water before taking a reading. *Always* do this when you have several readings to take. Adopt some *constant* temperature, not below 120 degrees and not above 150 degrees, for the water used for this purpose.

9. A pair of dividers, or compasses, is excellent for taking the length of the column of fat in reading. Read from the highest to the lowest point on the column.

10. The following are the causes of cloudy or burnt readings:

(1) The use of too much or too strong acid.

(2) Allowing the acid to fall directly upon and burn the milk.

(3) Shaking the bottle violently or with an up and down motion, when uniting the acid and milk.

(4) Having the milk at too high a temperature when adding the acid—the higher the temperature, the less acid is required.

(5) Allowing the bottles to stand too long, after adding the acid, before shaking them, will cause dark spots in the fat.

11. Light colored readings and floating particles of curd are due to—

(1) The use of too little or too weak acid.

(2) Having the milk or the acid at too low a temperature—the lower the temperature of either the more acid is required.

NOTE.—Better always to bring the milk to the right temperature (sixty to seventy degrees).

(3) Insufficient shaking of the bottles to unite the milk and acid.

12. See that your test bottles and pipettes are clean before using.

13. After using bottles, rinse them at least twice with hot water. Rinsing with sulphuric acid before rinsing with water, or else using a little sal soda in the first water, is often found necessary.

14. Care and attention to details are the great requisites for accurate milk-testing.

Skim-Milk, Buttermilk, and Whey.

1. Skim-milk, buttermilk, and whey may be tested in the ordinary bottle, just as whole milk is tested, taking 17.6 c. c. (or eighteen grams) in the test.

Note.—Whey requires only about two-thirds the usual amount of acid.

2. As the per cent. of fat is so small in skim-milk, buttermilk, and whey, a better method of testing these is by the use of the "skim-milk bottle," which has a double-sized bowl. To make the test, using this bottle, take a double measure (2 × 17.6 c.c.) of the milk or whey, and a corresponding amount of acid, and proceed with the test as in the case of whole milk. In taking the reading, we must call one of the small divisions on the scale .1 (1-10th) instead of .2 (2-10ths) of one per cent., since we have taken a double quantity in our sample, and the scale on the neck of the bottle is just the same as on the ordinary bottle.

To Test Cream, using the Ordinary Test Bottle.

1. By the use of a 6.04 c.c. pipette, take six grams of cream, and to this add twelve c.c. of water to make a mass of eighteen grams in all. Add the usual amount of acid (17.5 c.c.) and proceed as in testing milk. The reading must be multiplied by three to obtain the per cent. of fat in the cream.

2. Another way is by using the ordinary pipette. Take 17.6 c.c. of cream and to this add twice 17.6 c.c., or two pipettes, of water, and mix thoroughly. Then take 17.6 c.c. of the diluted cream and put into the test bottle, add the usual amount of acid and proceed as in testing milk. Multiply the reading by three to obtain the per cent. of fat in the cream.

Weighing instead of measuring the cream is an excellent plan when there are gram scales at hand.

To Test Cheese.

Obtain a representative sample of cheese by taking a plug extending from the outside well to the centre of the cheese; cut this into small strips extending from end to end of the plug, and by the use of gram scales weigh out say five grams of cheese—the amount generally taken. To this add twelve to fifteen c.c. of water at about 130 degrees, and shake the bottle to dissolve the cheese. Add 17.5 c.c., or the usual amount, of acid, and proceed as in testing milk.

To obtain the per cent. of fat in the cheese multiply the reading by eighteen, and divide by the number of grams used in the test. If other than six grams of *cream* be taken in a test, this rule may be applied to find the per cent. of fat.

The Lactometer and the Detection of Adulterations in Milk.

The lactometer is a specific gravity measurer of milk. There are several kinds of lactometers, but the Quevenne lactometer being the most suitable for milk testing, is the one that we shall here describe.

By means of the Quevenne lactometer we compare the density of milk at sixty degrees F. with that of pure water at sixty degrees. It has a scale graduated from fifteen to forty, and indicates a specific gravity of from 1.015 to 1.040. As it is not always convenient to have milk at sixty degrees when taking a lactometer reading, corrections for temperature are made as follows: To obtain the *corrected* lactometer reading, or reading at sixty degrees, add .1 (1-10th) to the lactometer reading for each degree in temperature above sixty degrees, and subtract .1 (1-10th) from the reading for each degree in temperature that the milk is below sixty degrees. Thus, if the lactometer reading at a temperature of sixty-five degrees be thirty-one, the corrected lactometer reading is $31 + .5 = 31.5$; if the lactometer reading be 32.5 and the temperature fifty-seven, the corrected lactometer reading is $32.5 - .3 = 32.2$. This rule is practically correct, if the temperature be kept within a range of from fifty to seventy degrees.

The lactometer reading of pure milk usually ranges from thirty to thirty-two, although it may fall as low as twenty-seven or go as high as thirty-four. The lactometer reading of skim-milk varies from thirty-three to thirty-six.

The composition of milk is about as follows:

Water	86 to 88 per cent.
Fat	3 per cent. and upwards.
Solids not fat	8.5 to 9.5 per cent.

To Find the Per Cent. of Solids not Fat (S.N.F.) in Milk.

Both the per cent. of fat and the lactometer reading at sixty degrees are required in finding this. Every per cent. of fat in milk lowers the lactometer reading by *one* from what it would be if the fat were not present. Hence, to obtain what the lactometer reading would be, if the fat were not present to interfere, we must add the lactometer reading and the per cent. of fat together. This obtained, then every reading of four on the lactometer is due to the presence of one per cent. of solids not fat in the milk. Hence the rule: To find the per cent. of solids not fat (S.N.F.) in milk, add the lactometer reading at sixty degrees (L.) and the per cent. of fat (F.) together and divide by four. Expressed briefly thus:

$$\frac{L. + F.}{4} = S.N.F. \text{ (per cent. solids not fat).}$$

L. = corrected lactometer reading, or reading at sixty degrees.

F. = per cent. of fat.

Example.—Let the lactometer reading of a sample of milk a sixty-four degrees be thirty-one, and the per cent. of fat three. Find the per cent. of solids not fat.

Corrected lactometer reading, $31 + .4 = 31.4$

$$\frac{31.4 + 3}{4} = \frac{34.4}{4} = 8.6 \text{ per cent. S.N.F.}$$

WATERED MILK.

To find the per cent. of pure milk in a watered sample of milk, multiply the per cent. S.N.F. in the watered sample by 100, and divide by the per cent. of solids not fat in the pure milk. This subtracted from 100 will give the per cent. of extra or extraneous water in the milk. To take an example:

L. reading of watered sample 26.5, temp. 55, per cent. of fat 2.8;
L. reading of pure milk 32, temp. 65, and per cent of fat 3.5.
Corrected L. reading of watered sample, $26.5 - .5 = 26$.
Corrected L. reading of pure milk, $32 + .5 = 32.5$.

$$\frac{26 + 2.8}{4} = \frac{28.8}{4} = 7.2 \text{ per cent. S.N.F. in watered sample.}$$

$$\frac{32.5 + 3.5}{4} = \frac{36}{4} = 9 \text{ per cent. S.N.F. in pure milk.}$$

Therefore, according to the rule given above,

$$\frac{7.2 \times 100}{9} = \frac{720}{9} = 80 \text{ per cent. of pure milk in the watered sample.}$$

$100 - 80 = 20$ per cent. of extra water in the watered sample.

Note.—When a sample of the pure milk cannot be obtained, use 8.5 in he early part of the season and 9 in the latter part for the per cent. S.N.F. in pure milk.

Points to be Observed.

1. Have the temperature of the milk uniform throughout and as near to sixty degrees as possible when taking the lactometer reading.

2. Always mix the milk well before taking the lactometer reading.

3. A lactometer reading should not be taken when milk is froth ing or foaming.

4. Milk fresh from the cows is saturated with air and should be allowed to stand an hour or more to reach its maximum density, before the lactometer reading is taken.

5. Have the lactometer free from the walls of the vessel and perfectly still when taking a reading.

6. A high lactometer reading accompanied by a low per cent. of fat is indicative of skimming.

7. A low lactometer reading accompanied by a low per cent. of fat is indicative of watering.

8. A normal lactometer reading with a *very* low per cent. of fat indicates both watering and skimming.

Composite Test.

In many butter and cheese factories at the present time, payment is made not according to the old "pooling" system of paying according to the weight of the milk, but by taking the quality as well as the quantity of the milk into consideration—the patron is paid according to the number of pounds of fat, or fat and casein, which he furnishes to the factory. A test of the milk cannot be made daily; so to overcome the difficulty, a small sample, say an ounce, of milk is taken from the milk furnished by each patron and put into a separate bottle or sealer in which is a small amount, five to ten grains (or what will lie on a ten-cent piece) of bichromate of potash. This amount of bichromate will preserve it in a liquid condition for from one to two weeks, at the end of which time a test of the sample is made in the usual way with the Babcock tester to obtain the average per cent. of fat in the milk furnished by the patron during the time. Knowing the per cent. of fat in the milk, one can calculate the number of pounds of fat furnished by the patron.

Points to be Observed in Composite Testing.

1. Be sure to obtain a representative sample from the weigh can.

2. Keep the bottles in a cool place and well corked.

3. The amount of bichromate to be used depends largely upon the weather and the time over which the test extends.

4. Too much bichromate will give rise to unsatisfactory tests, with cloudy readings.

5. Give the bottle a gentle rotary motion every day, after taking a sample, to keep down the cream and to mix the new sample with that containing the bichromate.

6. When the time for testing comes, set the bottles in warm water (one hundred to one hundred and twenty degrees) to melt the cream adhering to the walls of the bottle, and also to melt any other portion of the cream that would not otherwise mix readily with the rest of the milk.

7. Mix the milk well, before taking a test, by pouring from one vessel into another.

8. Proceed with the Babcock test of a composite sample, just as in the testing of ordinary milk.

9. Add the water to the test bottles at two different times, rather than all at once, filling the bottles about to the neck the first time. A clearer reading is thus obtained. Turn the machine about a minute or a minute and a half after each addition of water.

10. Set bottles in hot water before taking the readings.

Payment According to Quality.

While in creameries payment according to quality is always made in proportion to the amount of fat furnished by each patron, in cheese factories two different methods of payment exist:

(1) According to the per cent. of fat in the milk, as in creameries.

(2) By taking into consideration the casein, as well as the fat, of milk. As the per cent. of casein in milk is fairly constant, some constant number, as 2, is added to the per cent. of fat to allow for the casein in the milk.

To illustrate the difference between the two methods: If A and B send *equal quantities* of milk to a factory, testing 3 per cent. and 4 per cent. fat respectively, then, according to the first method, their dividends would be in the ratio of 3 to 4; while, according to the second method, taking 2 to represent the per cent. of casein in milk, they would be paid in the ratio of 3 + 2, *or 5*, to 4 + 2, *or 6*.

To make a division of money according to the second, or fat-casein method, taking 2 to represent the per cent. of casein in milk:

During a certain month milk is furnished to a cheese factory by three patrons, as follows:

A....	3,462	pounds	milk,	testing	3.1	per	cent.	fat.
B....	5,220	"	"	"	3.6	"	"	
C....	8,371	"	"	"	4.0	"	"	

From the above milk are made 1,650 pounds cheese. The cheese sells for $9\frac{3}{4}$c. a pound and it costs $1\frac{1}{4}$c. to manufacture it; net value of a pound of cheese ($9\frac{3}{4}$c. − $1\frac{1}{4}$c.)=$8\frac{1}{2}$c.; 1,650 pounds cheese at $8\frac{1}{2}$c. are worth (1,650 × $8\frac{1}{2}$c.)=$140.25. As seen below, there are 971 pounds of fat and casein.

971 pounds fat and casein are worth $140.25

1 pound " " is " .... $\frac{140.25}{971}$=14.443c.

Name.	Pounds milk.	Per cent. fat.	Per cent. fat and casein.	Total pounds fat and casein.	Value at 14.443c. per pound.
A	3,462	3.1	5.1	176.5	$25.49
B	5,220	3.6	5.6	292.3	42.21
C	8,371	4.0	6.0	502.2	72.53
Total	....	....	....	971.0	$140.23

Oil Test.

This is a churning process for the purpose of ascertaining the richness of cream in butter-fat, and is used mostly in cream-gathering creameries. To make the test: About half fill the glass tubes or bottles with cream, cork them tightly and place in the tin case to receive them.

Next place the bottles in water at from eighty-five to ninety degrees to heat the cream to this temperature. Then place in the oil test churn and begin the churning process. Should the cream at any time cool and thicken, place the bottles in warm water again to reheat it to the churning temperature. Continue churning until there is evidence of a clear separation of the fat; then place the bottles in hot water at from 160 to 170 degrees for from fifteen to twenty minutes.

If the separation is complete, the fat will be clear and yellow, and there will be three distinct columns with sharp lines of division between them, viz., a column of oily fat on top and one of whey next, with the casein at the bottom. If there be not a clear separation, cool down to about ninety degrees, churn again, and proceed as before.

To Take a Reading. There is a chart prepared for the purpose. Placing the bottle in an upright position on the "base line" of the chart, move it along until, looking by the right side of the bottle, the top of the column of fat comes even with the top slanting line on the chart. Next, still looking by the right side of the bottle, observe the line to which the bottom of the fat comes; the number on this line gives the reading.

Meaning of the Reading. Cream that gives a reading of 100 in the oil test will make one pound of butter for every inch of such cream in a cream pail twelve inches in diameter; an inch of cream testing 120 will make 1.20 pounds of butter, etc.

Notes. 1. Be sure that the cream for this purpose is well ripened, placing some in a warm place over night, if necessary, to ripen it.

2. It is advisable to pull the corks and let the gas out of the bottles a few minutes after beginning to churn.

3. Sometimes the fat, though clear, is somewhat open. In such cases, allow the fat to become cold, and then place in water at about 120 degrees before taking a reading About 120 degrees is perhaps the best temperature at which to take all oil test readings.

4. An inch of cream testing 100 (or its equivalent of cream of another grade) in a pail twelve inches in diameter is what is known as a *creamery inch.*

BULLETIN 102 MAY, 1896.

Ontario Agricultural College and Experimental Farm

EXPERIMENTS IN CHEESEMAKING:

By H. H. Dean, B.S.A., Professor of Dairy Husbandry.

PART I. Relation of Fat in Milk to Quantity and Quality of Cheese Produced in the Months of November and December, 1895

PART II. Summary of Two Years' Work on the Relation of Fat in Milk to Cheese Produced.

PART III. Effects of Salt, Temperature, Rennet, and Acid in Cheese-Making.

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BULLETIN 102.

EXPERIMENTS IN CHEESE-MAKING.

PART I.

Relation of Fat in Milk to Quantity and Quality of Cheese in the Months of November and December, 1895.

The cheese made from milk with different percentages of fat during the months of November and December, 1895, were not ripened sufficiently to be scored at the time for preparing our Annual College report : so the results for these two months, together with a summary of two years' work on the question of the relation of fat in milk to the quantity and quality of cheese produced, is submitted for the information of dairymen.

Conditions of Manufacture in November and December.

The quantity of milk in each vat was 300 lbs. The percentage of fat in the milk of the different vats during the two months varied from 3. to 5.50 per cent. The average temperature at which the milk was set was 86°F. The rennet test for ripeness was about eighteen seconds. The rate of rennet per 1,000 pounds of milk was three and one-third ounces. The cooking temperature for rich milk curd was 100°, and for the poorer curds 98°. In one experiment, on Dec. 30th, in which the milk tested 5.0 per cent. fat, it was set at 81°; and after cutting, it was gradually cooked to 100°, two hours having been spent in the process. The loss of fat in the whey was .5 per cent. The curd in this experiment was salted at the rate of three and a half pounds of salt per 100 pounds of curd. This method of handling did not prevent the cheese from being "sticky," "greasy," or "slippery."

The curds when dipped showed about one-quarter of an inch of string on the hot iron. The average time from setting to dipping was about three hours, and the the time from dipping to salting was about three and a half hours. The curd from rich milk was nearly always ready to salt first. The amount of salt used was from two and three-quarters to three and a quarter pounds per 100 pounds curd. The larger quantity was used on the curds from richer milk. The length of time for pressing the cheese was about twenty-one hours, in a gang press. The temperature of the curing room was from 65° to 70°. The moisture in the curing room was "normal," as indicated by the Hygrometer.

The tables show the percentage of fat in the milk on the different dates, the pounds of fat, the pounds of cheese produced, the ratio of cheese to milk and fat, and the loss of fat in the whey, as determined by the Babcock tester.

November.

Relation of fat in milk to quantity and quality of cheese :

Date.	Per cent. fat in milk.	Lbs. fat in milk.	Lbs. cheese.		Lbs. milk to 1 lb. cheese.		Lbs. cheese to 1 lb. fat in milk.		Per cent. fat in whey.
			Green	Cured	Green	Cured	Green	Cured	
1895.									
November 5....	3.90	11.70	33.25	31.75	......	.....	......	......	.30
	3.60	10.80	30.50	29.25	.....	......	.....	.. ..	.20
" 6....	4.00	12.00	33.50	32.00	......	....	.....	......	.35
	3 30	9.90	29.50	28.00	.....	.....	......	.....	.20
" 14 ...	3.85	11.55	33.75	32.25	......	.....	...	......	.20
	3 55	10.65	31.75	30.50	......	......	......	......	.20
" 15....	3.90	11.70	33.25	31.75	.. ..	......	......	.....	.20
	3.30	9.90	30.25	28.75	......	......	......	.... ..	.20
" 21....	4.00	12.00	33.50	32.00	.....	.. ...	....	......	.20
	3.50	10.50	31.50	29.75	......	.....	......	....	.15
" 22....	4.00	12.00	35.00	33.25	......	......	.....	......	.20
	3.57	10.65	31.25	29.50	......	......	... ..	.....	.20
" 28 ...	4.10	12.30	35.50	34.25	......	.....	......	......	.20
	3.80	11.40	32.50	31.25	.....	.....	... .	......	.20
" 29....	4.00	12.00	35.00	33.50	......	.. ...	.....	......	.20
	3.50	10.50	30 00	28.75	......	......	......	......	.20
Average for rich milk	3.97	95.25	272.75	260.75	8.79	9.20	2.86	2.73	.23
Average for poor milk	3.51	84.30	247.25	235.75	9.70	10.17	2.83	2.76	.19

The experiments for these two months agree with the results already published. The yield of cheese per 100 lbs. of milk was greater from the milk rich in butter-fat, but it was not in proportion to the butter-fat. Three hundred pounds of milk, testing 5.0 per cent. of butter-fat, produced 34.5 lbs. cheese, while on the same day 300 lbs. of 3.0 per cent. milk produced but 26 5 lbs. of cured cheese, a difference of 8 lbs. of cheese in 300 lbs. of milk. But the ratio of cheese to fat in the milk was 2.30 for the 5.0 per cent. milk, and 2.94 for the three per cent. milk. The ratio of cheese to fat in the milk testing 5.5 per cent. was 2.27. In a vat of milk testing 4 75 per cent. fat, the ratio was 2.38.

December.

Relation of fat in milk to quantity and quality of cheese :

Date.	Per cent. fat in milk.	Lbs. fat in milk.	Lbs. cheese.		Lbs. milk to 1 lb. cheese.		Lbs. cheese to 1 lb. fat in milk.		Per cent. fat in whey.
			Green	Cured	Green	Cured	Green	Cured	
1895.									
December 5....	4.00	12.00	34.75	33.25	......	......	....	....	.20
	3.40	10.20	30.25	29.00	......	......	......	......	.20
" 6....	4.10	12.30	35.25	34.00	......	......	......	......	.22
	3.40	10.20	30.50	29.00	......	......	......	......	.20
" 12....	3.90	11.70	35.25	33.50	......	......	......	......	.18
	3.30	9.90	31.00	29.50	......	......	......	......	.18
" 13....	4.00	12.00	34.50	33.00	......	......	......	.....	.20
	3.15	9.45	29.50	28.00	....	......	......	......	.20
" 20....	4.75	14.25	35.25	34.00	......	......	.....	......	.30
	3.25	9.75	28.25	26.75	......	......	......	......	.15
" 21....	5.50	16.50	39.25	37.50	......	......	......	......	.45
	3.20	9.60	28.50	26.50	......	......	......	......	.20
" 23....	4.40	13.20	35.50	33.75	......	......	......	......	.25
	3.10	9.30	28.50	26.75	......	......	.. .	......	.15
" 28....	5.10	15.30	37.25	35.50	......	......	......	......	.40
	3.00	9.00	28.50	26.75	......	......	......	......	.20
" 30....	5.00	15.00	35.75	34.50	......	......	......	......	.50
	3.00	9.00	28.50	26.50	......	. ...	......	......	.40
Average for rich milk	4.53	122.25	322.75	309.00	8.36	8.73	2.64	2.52	.30
Average for poor milk	3.20	86.40	263.50	249.25	10.24	10.82	3.05	2.85	.21

It will be noticed that the per cent. of fat in the whey was slightly higher from the rich milk, as compared with the poorer. This agrees with the results of our previous experiments.

The percentage of loss in weight at the end of one month was 4.4 for the rich milk cheese in November, and 4 6 for the poorer milk cheese. In December, the loss was respectively 4.2 and 5 3 per cent. As stated in the Report for 1895, this difference in loss of weight while the cheese are curing, is likely due to the fact that more surface is exposed per 100 lbs. of cheese in the case of the poorer milk cheese.

Scoring of the November and December Cheese.

The cheese made from milk containing different percentages of fat in the months of November and December, were scored at four different times (with a few exceptions) by the following gentlemen on the dates given :

The November cheese were judged by Messrs. Geo. Brill and T. B. Millar, on January 4th, 1896. These cheese, together with the December cheese, were again scored by Mr. R. M. Ballantyne, on Feb. 21st, 1896, by Mr. A. F. MacLaren on March 6th, and by the two latter gentlemen together, on April 7th.

Table showing the score of cheese made from milk containing different percentages of fat :

Date when cheese were made	Per cent. of fat in milk.	Scoring of judges. Maximum—100.					
		A.T. Bell.	T. B. Millar and Geo. Brill.	R. M. Ballantyne.	A. F. McLaren.	McLaren and Ballantyne.	Average
Dec. 28...	3.00	90	....	91	81	90	88
30...	3.00	89	....	92	89.5	88	89.6
23...	3.10	92	....	94	92	90	92
13...	3.15	84	....	95	88	91	89 5
21...	3.20	91	....	93	89	91	91
20...	3.25	92	....	97	94.5	94	94.3
Nov. 15...	3.30	.. ...	91	95	86	92	91
Dec. 12...	3.30	91	....	97	90	88	91.5
Nov. 6...	3.40	.....	90	89	90 5	....	89.8
Dec. 5...	3.40	89	....	92	91.5	92	91.1
6...	3.40	93	....	93	95	92.5	93.3
Nov. 21...	3.50	......	95	94	93.5	87	92.3
29...	3 50	.....	94	....	....	....	94
14...	3.55	.....	91	....	....	....	91
22...	3.55	......	91	95	90	93	92.2
5...	3.60	.. ..	85	80	80	82	81.7
28...	3.80	......	93	93	92.5	91	92.3
14...	3.85	......	95	....	.. ..	....	95
5...	3.90	. ....	90	87	88.5	....	88.5
15...	3.90	.....	93	94	93	89	92.2
Dec. 12..	3.90	91	....	94	92	90	91.7
Nov. 6...	4.00	......	92	84	89	85	87.5
21...	4.00	......	96	96	93	96	95.2
22...	4.00	......	94	97	91.5	93	93.8
29...	4.00	......	95	....	....	....	95
Dec. 5...	4.00	91	....	92	91	90	91
13...	4 00	93	....	97	92	92	93.5
Nov. 28...	4.10	.. ..	92	94	90	90	91.5
Dec. 6...	4.10	91	....	96	93	92	93
23...	4.40	89	....	92	95	86	90.5
20...	4.75	92	....	95	94	94	93.7
30...	5.00	91	....	96	93.5	93	93.3
23...	5.10	93	....	95	91	90	92.2
21...	5.50	90	....	95	89	....	91.3

The December cheese were first scored by Mr. A. T. Bell on February 17th, 1896; and then by Messrs. Ballantyne and MacLaren on the dates given for the November.

The table shows the score given for each cheese (arranged in the order of the percentages of fat in the milk) by each judge, or judges, and the average of all scores. They used the following scale of points: Flavor, 35; closeness, 20; even color, 15; texture, 20; finish, 10 (all cheese scored 10 points for finish); total, 100.

The table shows that the cheese scoring the highest average, 95.2 points, was made on November 21st, out of milk testing 4.0 per cent. of butter fat. The second highest scoring cheese was made on December 20th, out of milk testing 3.35 per cent. fat. This cheese scored an average of 94.3 points out of 100. The highest number of points given to a cheese by one judge at one scoring, was ninety-seven. The cheese scoring ninety-seven points were made out of 3.25, 3.30, and 4.0 per cent. milk on December 20th, November 15th, November 22nd, and December 13th, four cheese in all. These scores were all given by Mr. R. M. Ballantyne, on February 21st. Cheese scoring ninety-six points were made from milk testing 4.0, 4.1, and 5.0 per cent. milk. Cheese scoring ninety-five points, were made from 3 15, 3.30, 3.40, 3.50, 3.55, 3,84, 4.0, 4.40, 4.75, 5.10, and 5.50 per cent. milk.

The two cheese made in one day which scored the highest average (four scorings), were made on December 20th out of 3.25 and 4.75 per cent. milk. It will be noticed that these two cheese were scored uniformly high by all the judges. The next highest scoring pair were made on November 21st out of 3.50 and 4.0 per cent. milk. Both cheese scored uniformly high in all the tests, except in the case of the cheese made out of 3.5 per cent. milk, which was scored down to eighty-seven points by Messrs. Ballantyne and MacLaren on April 7th. It scored low in flavor and texture. The table of scorings by these gentlemen has a number of interesting points, besides the lesson of values as indicated by the scoring. It shows among other things, the difference in the opinions of different judges as to the value of a cheese. To illustrate: the cheese made December 13th, out of 3.15 per cent. milk, was scored eighty-four points by Mr. Bell on February 17th. On February 21st (four days later), Mr. Ballantyne scored this cheese ninety-five points. On March 6th (fourteen days later), Mr. MacLaren scored this same cheese eighty-eight points; and on April 7th, Messrs. MacLaren and Ballantyne scoring together, gave this cheese ninety-one points. A cheese made out of 3.3 per cent. milk on Nov. 15th, was scored ninety-five points by Mr. Ballantyne, eighty-six points by Mr. MacLaren, and ninety-two points by these two gentlemen a month later. While a cheese will no doubt, in two weeks or a month, undergo changes which will affect its scoring, we can scarcely conceive of a cheese changing from a ninety-five point to an eighty-six point cheese in two weeks, and then back to a ninety-two point cheese in four weeks' time, Evidently the different tastes, or judgments, of the persons scoring a cheese, are an important factor in determining its quality. It will be noticed, however, that, on the whole, the scorings were fairly uniform as to points given.

In the following table, the cheese made from milk ranging from 3.0 to 3.5 per cent. of fat have been grouped together, and the average scores in qualities (flavor, closeness, even color, and texture) are given. Most of the cheese were scored four times, and the average in each quality represents the average of all the scores of each cheese in a group, together with the average total score of all the cheese for the group. The cheese made from 3.55 to 4.0 per cent. milk are grouped together; also those from 4.05 to 4.50; those from 4.55 to 5.0; and those from 5.05 to 5.50, making five groups in the November and December cheese. In making these average score of qualities, a few of the cheese whose scores are recorded in the previous table, are left out, as they developed such a very bad flavor before the final scoring, that it would be unfair to group them with the others in making an average. Sometimes a very bad flavor will develop in a cheese, which it is difficult to account for. The number of cheese made out of milk testing over 4.0 per cent. of fat is too small to draw definite conclusions from them.

Table showing the average score of qualities in cheese made from milk containing different percentages of fat:

No. of cheese in group.	Average per cent. fat in milk	Average score.				
		Flavor—max. 35.	Closeness—max. 26.	Even color—max. 15.	Texture—max. 20.	Total—max. 90.
12............	3.26	30.91	18.43	14.15	18.03	81.52
11....	3.87	31.26	18.80	14.40	18.46	82.92
3............	4.20	30.60	18.70	13.86	18.03	81.19
2.......	4.87	32.15	19.00	14.15	18.05	83 35
2............	5.30	31.75	18.90	13.80	17.25	81.70
Averages ..	3.82	31.33	18.76	14.07	17.96	82.13

Of the cheese scored four times, the one which scored the highest average in flavor, was made December 30th, out of 5.0 per cent. milk. The average score was 32.6 out of thirty-five. It was scored 32 twice, 32 5 once, and 34 once The average score of this cheese in other qualities, was 18.8 for closeness, 14 for even color, and 17.8 for texture. The lowest average score (one cheese) in flavor, was one made out of milk testing 3.8 per cent. fat, on November 28th.

The score was 29.9 out of a possible 35. The remainder of the score was 18.8 for closeness, 14.3 for even color, and 18.6 for texture, which is higher in these qualities than the cheese which scored highest in flavor. Good flavor is not always found in a close, even-colored cheese, of good texture, nor are these qualities always found in a cheese with good flavor.

The highest average score for "closeness" was 19.2 points out of a possible 20. The cheese averaging this score were made out of 3.25, 3.50, and 4.75 per cent. milk, on December 20th and November 21st. The lowest average score for "closeness" was a cheese made out of milk testing 3.15 per cent. fat. The score was 16.5. The highest average score for "even color" was 14.7 out of a possible 15. This cheese was made out of 4.0 per cent. milk, on November 21st. Several cheese scored 14.5 points in color. The lowest score in "even color" was 13 points. The cheese was made out of 3 00 per cent. milk. A cheese made December 23rd, out of 4.4 per cent. milk, scored an average of 13.1 points. The highest average score in "texture" was 19.2 out of 20. This cheese was made November 21st, out of 4.0 per cent. milk. A cheese made December 6th, out of 3.4 per cent. milk, scored 19.1 points in texture; and several averaged 19 points.

The cheese scoring lowest in "texture" was one made on December 23rd, out of 4 4 per cent. milk. The score was 16.7. This cheese was also lowest in "color." The next lowest in "texture" was a cheese made from 5.5 per cent. milk, on December 21st. The "texture" was described by the experts as "greasy" and "slippery." The average score was seventeen. Once it was scored sixteen points.

Table showing the amounts of money that would be credited to H. and L. milk for the months of November and December, when reckoned according to the different methods, and according to the weight of cheese.

Month.	Lbs. milk.	Average per cent. fat in whole milk.	Lbs. cured cheese made.	Reckoning cheese at 8c. per lb., each lot would be credited with the following amounts of money when paid according to:			
				Weight of milk.	per cent. of fat.	per cent. of fat + two.	Weight of cheese.
				$ c.	$ c.	$ c.	$ c.
November	2,400 H	3.97	260.75	19 86	21 07	20 65	20 86
	2,400 L	3.51	235.75	19 86	18 65	19 06	18 86
December	2,700 H	4.53	309.00	22 33	26 17	24 86	24 72
	2,700 L	3.20	249.25	22 33	18 49	19 80	19 94

PART II.

Summary of Cheese Experiments relating to Medium, Rich, and Poor Milk, for the Years 1894 and 1895.

During these two years we have manufactured into cheese 287 vats of milk, averaging 300 pounds each, or 86,100 pounds altogether, in studying the problems connected with the question of the relation fat in milk to the quantity and quality of cheese made. A summary of these results is now given. In addition to the experiments herein summarized, there were over 100 experiments made during 1895, to determine the effects of different cooking temperatures and different quantities of salt on curds from medium, rich, and poor milk. These were fully outlined in the College Report for 1895. The experiments relating to these two points may be summarized by saying that curds from poor milk (below 3.25 per cent. fat) should be salted more lightly than average curds, to overcome the tendency to harshness, while curds from rich milk (4.0 per cent. fat and over) may be cooked one or two degrees higher than usual and be salted somewhat more heavily than average curds, in order to overcome the tendency to "pastiness" in cheese made from rich milk.

The experiments relate chiefly to the following points:

1. The relation of weight or volume of milk to the *quantity* of cheese produced.

2. The relation of the fat in milk containing different percentages of fat, to the amount of cheese produced.

3. The relation of the fat and casein in milk containing different percentages of fat, to the cheese produced.

4. The relation of the loss of fat in the whey to the percentage of fat contained in the milk.

5. The *quality* of the cheese produced from milk containing different percentages of fat.

6. The application of the results to different methods of dividing proceeds among patrons of cheese factories.

1. *Relation of weight of milk to the quantity of cheese produced from milk containing different percentages of fat.*

In making out reports of cheese factories, it is customary to give patrons a statement of the relation of the weight of milk delivered in a given time to the amount of cheese produced, in the form of the number of pounds of milk required to make a pound of cheese, together with the total pounds of cheese credited to each. The following table shows this relation in our experiments and also the pounds of cheese produced per 100 pounds of milk containing the different percentages of fat.

Group.	Percentage of fat.		Milk required to make 1 lb. of cheese.	Cheese produced per 100 lbs. of milk.	Cheese produced from 1 lb. of fat.	Per cent of fat in whey.
	Range.	Average.				
			lbs.	lbs.	lbs.	
I.	Below 3	2.85	11.644	8.587	2.01	0.182
II.	3.00 to 3.50	3.23	11.127	8.987	2.78	0.187
III.	3.55 to 4.00	3.85	10.027	9.972	2.59	0.200
IV.	4.05 to 4.50	4.198	9.435	10.597	2.52	0 222
V.	4.55 to 5.00	4.87	8.759	11.416	2.34	0.400
VI.	5.05 to 5.50	5.30	8.219	12.166	2.29	0.425
Av'rage.	....	....	10.399	9.615	2.66	

If we take the average decrease in the pounds of milk to make a pound of cheese for each increase of one-half of one per cent. of fat in the milk, we find it is about one-half a pound, except in the case of group 3 (3.50 to 4.20 per cent. fat), in which case the decrease in the pounds of milk required to make a pound of cheese, as compared with the previous group (3.0 to 3.5 per cent. fat) is about one pound of milk. To state it in another way—for every increase of one half of one per cent. of fat in the milk, the yield of cheese is increased about half a pound per 100 pounds of milk, though in group three the increase is nearly one pound over the previous group.

This extra yield of cheese in group three (3.55 to 4.0 per cent. fat) as compared with the previous group, is rather remarkable. The explanation is probably found in the fact that this group appears to have the greatest increase in the percentage of casein (when compared with the previous group) that is found in any of the groups. (See College Report for 1895, p. 22)

The decrease in the yield of cheese per pound of fat in the milk by groups, was about one-quarter of a pound in group II, as compared with group I; about two-tenths of a pound in group III, as compared with group II; 0.7 of a pound in group IV, as compared with group III; .18 of a pound in group V, and .05 in group VI, compared with group V. The extreme difference in the yield of cheese per pound of fat in the milk was .71 pounds of cheese less in group VI (5.30 per cent. fat) as compared with the yield of cheese per pound of fat in the milk in group I (2.85 per cent. fat.) The decrease in the yield of cheese per pound of fat in the milk continues from poor to rich milk.

The average pounds of cheese produced from one pound of fat in the milk from all the experiments was 2.66.

3. *Relation of fat and casein to the cheese produced from milk with varying percentages of fat.*

In this case we are met at the outset with a somewhat difficult problem for cheesemakers, viz., how to determine the casein of milk. No short method, such as the Babcock test for determining fat, has yet been discovered for determining the casein of milk. Our chemist has analysed a great many of the samples here reported upon, and the results of casein determinations in milk containing varying percentages of fat, are given in the College report for 1895. To simplify matters, we have assumed that two represents the percentage of casein which is retained in the cheese. The amount above two per cent. of casein in milk, is nearly all, if not quite all, represented by the loss of fat and casein in the whey and in the pressing and curing of the cheese. If the percentage of casein increases to some extent with the fat, so does the loss of fat in the process of manufacture by all methods known at present.

The table also shows the relation of fat and casein to cheese by groups when using a sliding scale for the casein, and the relation when using the addend 2.3.

Table showing pounds of cheese per pound of fat and casein in milk with varying percentages of fat :

Addend representing casein.	Group I., per cent. fat—av. 2.85.	Group II., per cent. fat—av. 3.23.	Group III., per cent. fat—av. 3.85.	Group IV., per cent. fat—av. 4.198.	Group V., per cent. fat—av. 4.87.	Group VI., per cent. fat—av. 5.30.	Average of all
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	
2	1.770	1.718	1.704	1.709	1.661	1.666	1.713
Sliding scale from 2.3 to 2.7	1.700	1.625	1.595	1.582	1.528	1.520	1.608
2.3.............	1.667	1.625	1.621	1.631	1.592	1.600	1.626

4. *Loss of fat in the whey from manufacturing into Cheddar cheese milk containing varying percentages of fat.*

These fat determinations in the whey were made by the Babcock method, and include, in most cases, the "white whey," after milling and pressing, which was mixed with the first whey dipped, and a sample of the whole was taken. We may conclude that the percentages in the table fairly represent the loss of fat in the manufacture of cheese by careful makers, except the "grease" which is sometimes found about the press or on the outside of the cheese. There was always the largest quantity of this "grease" from cheese made out of rich milk.

It will be noticed that the average percentage of fat in the whey increases with an increase of fat in the milk. If we subtract the pounds of cheese from the pounds of milk used to make the cheese in each group, we shall have, near enough for all practical purposes, the pounds of whey in each group. By multiplying the pounds of whey by the average percentage of fat in the whey, we have the loss of fat in each group. The total losses of fat in each group and the loss of fat in the whey per 100 pounds of cured cheese, are as follows:

Total pounds milk used.	Average per cent. fat in milk.	Total loss of fat in the whey.	Loss of fat in the whey per 100 lbs. cured cheese.
		lbs.	lbs.
5,700	2.85	9.48	1.93
33,000	3.23	56.16	1.89
34,200	3.85	61.57	1.80
12,000	4.198	23 81	1 87
600	4.87	2.12	3.10
600	5 30	2.23	3.06

5. *The relation of the fat in the milk to the quality of cheese made.*

All the cheese made in our experiments were scored at the College dairy by men who are recognized as expert judges. Most of the men who judged the cheese are investing their money in cheese nearly every day and ought to be able to judge of its money value.

We are indebted to the following gentlemen who have kindly assisted us in the judging: Messrs. A. F. MacLaren, Stratford, president of the Western Dairymen's Association of Ontario and judge of cheese at the World's Fair; R. M. Ballantyne, Stratford, son of the Hon. Thos. Ballantyne; A. T. Bell, Tavistock; T. B. Millar, Kincardine, inspector and instructor for the Western Dairymen's Association; G. J. Brill, Guelph.

The cheese were scored at about one month old. The November and December cheese of 1895 were scored several times, as reported under the results for those months. The average score for flavor, closeness, even color, and texture in the different groups is shown in the table. The score for finish is not given, as all were scored alike under this head.

Percentage fat in milk.	Flavor. (Max. 35.)	Closeness. (Max. 20.)	Even color. (Max. 15)	Texture. (Max. 20.)	Average total score. (Max. 90.)
Under 3 %	30.28	18.11	14.71	17.00	80.10
3 to 3.50 %	30.49	17.78	14.00	17.15	79.42
3.55 to 4.0 %	30.86	17.92	14.05	17.36	80.19
4.05 to 4.50 %	30.90	18.10	13.87	17.19	83.06
*4.55 to 5.0 %	32.00	19.50	13.00	17.00	81.50
*5.05 to 5 50 %	32.00	19.50	13.50	16.50	81.50

* Only two cheese.

Two cheese made June 4th, 1894, were kept until June 25th, 1895, and were scored by Messrs. Brill and Bell. The cheese made out of 3.2 per cent. milk, scored seventy points out of 100, and the one made from 4.5 per cent. milk scored sixty-five points. The cheese were kept in a box in the basement of the dairy after they had been cured, and both were badly off in flavor, as the score shows. Three cheese made (one each month) in the months of September, October, and November, 1894, out of poor or medium milk, and three in the same months made out of rich milk, were kept in the basement of the dairy after curing, and were scored June 25th, 1895, by Messrs. Brill and Bell. The average score of the three cheese made from rich milk was 88.3. The average score of the others was 87.6. These cheese were examined again by Mr. Walker, of Guelph, on April 8th, 1895. He did not score them but he gave his judgment as follows: The cheese made from the rich milk in September was the better of the two. In the two October's he could not see much difference. The cheese made in November from poor or medium milk he pronounced the best cheese of the lot.

6. *Practical Application of the Two Years' Experiments to Methods of Dividing Proceeds Among Patrons of Cheese Factories.*

The experiments on the relation of fat in milk to the quanity and quality of cheese produced, have several scientific and practical bearings, but their most practical bearing at the present time is upon the question of the best method of dividing the proceeds among patrons of cheese factories. It might be well to mention the three systems of apportioning dividends now in use among our cheese factories.

(1) The oldest is that of dividing according to the weight of milk delivered by each patron. This system is based on the principle that all samples of milk delivered by patrons are of equal value (per 100 pounds) for cheesemaking purposes. If a difference is admitted, it is considered so small that it is not worth considering. Our experiments go to show that there is a difference of two pounds of cheese per 100 pounds of milk between milk testing 4.2 per cent. fat and milk testing 2.85 per cent. fat. The difference in cheese-producing power of 100 pounds of 3.85 per cent. milk when compared with 100 pounds of 3.25 per cent. milk, is nearly one pound of cheese in favor of the richer milk. In other words, in those factories in which pooling according to the weight of milk is practised, there is taken from the patrons who send in milk averaging, say, 4.2 per cent. of fat, about one pound of their cheese, which is given to the patrons who send in 2 85 per cent milk, for each 100 pounds of milk delivered by both parties. In the case of 3.25 and 3 75 per cent. milk, about half a pound of cheese per 100 pounds of milk is taken from the richer milk and added to the poorer. If cheese nets eight cents a pound, the patrons with four per cent milk lose about eight cents per 100 pounds of milk by pooling with patrons delivering milk under three per cent., as they are credited with but *half* the increased cheese which their milk makes.

Having shown that this system is grossly unjust where the percentage of fat varies in the milk, it will be next in order to show what variation is to be found in milk delivered at our cheese factories. Messrs. A T. Bell, Tavistock, L. Patton, Oxford Mills, William Eager, Morrisburg, and the Secretary of the Elma factory, near Atwood in the Listowel district, have kindly furnished us with the highest, lowest, and average percentage of fat in milk delivered at their factories by months during the past year. Two of these factories are in Western Ontario and two in Eastern Ontario. The variation in the western factories is also given for 1894.

The widest difference in the percentage of fat in the milk delivered at the Oxford Mills factory was one per cent., which occurred in the months of June and October. The average difference for the six months between the highest and the lowest testing milk at this factory was .85 per cent.

Table showing variation in milk delivered by patrons of four factories in Ontario :

Name of factory.	Year.	Month.	Percentage of fat in milk delivered.			
			Highest.	Lowest.	Average of all.	Difference.
			per cent.	per cent.	per cent.	per cent.
Oxford Mills	1895	May . .	3.80	3.00	3.41	0.80
No. 13, Eager Combination	1895	" ...	3.54	3 28	3.39	0.26
Tavistock .... {	1895	" ...	3.80	2.80	3.26	1.00
	1894	" . .	3.80	2.80	3.41	1.00
Elma.................. {	1895	" ...	4.00	3.20	3.35	0.80
	1894	" ..	3.75	2 94	3.35	0.81
Oxford Mills	1895	June ...	4.00	3.00	3 52	1.00
No. 13, Eager Combination	1895	" ...	3.60	3 34	3.49	0.26
Tavistock............... {	1895	" ..	3.50	2.90	3.27	0.60
	1894	" ...	3 80	3.00	3.43	0.80
Elma............... ... {	1895	" ..	3 60	3.05	3.34	0.55
	1894	" ..	4.00	3.13	3.44	0.87
Oxford Mills	1895	July ..	3 90	3.20	3.57	0.70
No. 13, Eager Combination	1895	" ...	3.50	3.30	3.41	0.20
Tavistock............... {	1895	" ...	3.80	2 80	3.13	1.00
	1894	" ...	3.80	3.00	3.35	0.80
Elma.................. {	1895	" ...	3 70	3.00	3.33	0.70
	1894	" ..	3.77	3.06	3.48	0.71
Oxford Mills.......... ..	1895	August.	4.00	3.10	3.63	0.90
No. 13, Eager Combination	1895	" .	3 75	3.30	3.63	0.45
Tavistock. .... {	1895	" .	3.80	3.00	3.31	0.80
	1894	" .	4 00	3.00	3.45	1.00
Elma.................. {	1895	" .	3.65	2.60	3 43	1.05
	1894	" .	3.88	3.17	3.53	0.71
Oxford Mills	1895	Sept ...	4.10	3.40	3.78	0.70
No. 13, Eager Combination	1895	" ...	3.90	3.50	3.68	0.40
Tavistock............... {	1895	" ...	4.00	2.90	3.46	1.10
	1894	" ...	4.50	3.00	3.70	1.50
Elma.................. {	1895	" ...	4.00	3.20	3.42	0.80
	1894	" ...	4.10	3 23	3.69	0.87
Oxford Mills	1895	Oct	4.40	3.40	8.86	1.00
No. 13, Eager Combination	1895	"	4.00	3.55	3.90	0.45
Tavistock. .... {	1895	"	4.90	2.80	3.84	2.10
	1894	"	4.80	3.30	3.89	1.50
Elma.................. {	1895	"	4.25	3.50	....	0.75
	1894	"	4.40	3 35	3.87	1.05
No. 13, Eager Combination	1895	Nov ..	4.60	3.70	4 14	0.90
Tavistock	1894	"	5.20	2.60	3.85	2.60
Elma.......... .... {	1895	"	4.60	3.00	....	1.10
	1894	"	4.65	3.60	4.03	1.05

No. 13 of the Eager Combination did not vary so much as the other three. The widest difference was .9 per cent. in the month of November. During the remainder of the season, the milk delivered by different patrons was very similar in the percentage of fat. The average difference for the year between the highest and the lowest testing milk was .41 per cent. for the seven months. Mr. Eager mentions as one of the advantages of testing, that it tends to produce a more even quality of milk delivered by each patron.

The variation in the per cent. of fat in the milk at the Tavistock factory was the widest of the four. The greatest difference occurred in the month of October, 1895, and in November, 1894. The difference between the highest and lowest percentage of fat in milk delivered by patrons was 2.1 and 2.6, respectively, for these two months. The average difference for the season of 1895 was 1.1, and for 1894 1.3 per cent.

At the Elma factory, where the monthly variation was from .55 to 1.5 per cent. of fat, the average difference for 1895 was .92, and for 1894 the average difference in the fat of milk delivered for the season was .82 per cent. between the highest and the lowest.

Assuming that the difference in the quality of the milk delivered at these four factories represents the average difference for the Province, we can see how unjust it is to pool or divide money according to the weight of milk delivered. The average of the highest testing milk for the four factories is 4.02 ; and the average of all the low testing milk is 3.13, or an average difference of .89 per cent. of fat. A difference of .89 per cent. of fat in the milk is equal to a difference of about one and a half pounds of cheese per 100 pounds of milk. When cheese nets eight cents per pound it makes the four per cent. milk worth twelve cents more per 100 pounds than the three per cent. milk. If these two men pool their milk together, the man with the richer milk loses six cents per 100 pounds on all milk pooled, as he is credited with but half the increased value of his milk. A loss of six cents per 100 pounds of milk is a loss of $3 on 5,000 pounds, or $30 on ten cows' milk for the season. A patron who sends in four per cent. milk to a factory, feeds, milks, and cares for about one cow out of the ten for the benefit of his three per cent. neighbor when pooling according to the weight of milk.

(2) The second system proposed, and adopted by a member of our cheese factories, is what is known as the "Butter Fat System," or "Relative Value Plan," or the "Test System." This system apportions dividends among patrons according to the weight of fat delivered, as determined by the Babcock test. The principle upon which it is based, is that milk is valuable for cheese-making in proportion to the butter-fat which it contains. For a time this system was quite popular, but owing to various causes, the chief of which are the expense and the lack of confidence in its justice, this system has been discarded by a number of factories. Omitting the questions of

expense, risk of improper testing, extra labor for maker and secretary, all of which are important factors in the minds of patrons, some felt that cheese is not made out of butter-fat alone, and that something else in the milk ought to be considered when deciding so important a matter as the reward for skill and labor in dairy farming. Practical cheese factory experience went to prove that the yield of cheese was not in exact proportion to the butter-fat contained in the milk. It was considered by many of the patrons that the *many* were being deprived of their rights for the benefit of the few who delivered very rich milk. The new system differed in principle from the old, chiefly in this, that it placed a premium on butter-fat, instead of on water and skim-milk. This was an improvement as to the point on which the premium should be placed; but the question still remained unsettled, as to whether it was just to place so great a premium on butter-fat for cheese-making. To illustrate: The average percentage of fat in the milk of Group IV. (4.05 to 4.55 per cent. fat) was practically 4.2. The pounds of cheese made in this Group was 10.6 per 100 pounds milk. Group II. (3 to 3.50 per cent. fat) averaged practically 3.25 per cent of fat, and produced nine pounds of cheese per 100 pounds of milk. 10.6 pounds at eight cents equals 84.8 cents. Nine pounds at eight cents equals seventy-two cents—a difference of 12.8 cents per 100 pounds of milk in favor of the richer milk. Now if we divide on the fat basis the account stands: 4.2 pounds fat at 21.048 cents per pound equals 88.4 cents; 3.25 pounds fat at 21.048 cents per pound equals 68.4 cents, or a difference of twenty cents in favor of the richer milk. The actual cheese value of 100 pounds of milk testing 3.25 per cent. of fat is seventy-two cents, as previously shown; but the butter-fat system proposes to take 3.6 cents (seventy-two cents minus 68.4 cents equals 3.6) per 100 from such milk and add it to the richer milk. Why is this done? Some argue that the richer milk mixed with the poorer milk makes a better quality of cheese, and therefore the patron furnishing such milk ought to receive more for it than its actual value, as determined by the quantity of cheese made. It is a question how far this is true with normal milk. A man who sends in 3.25 per cent. milk to a cheese factory and pools it with 4.2 per cent milk on the fat basis, loses, as previously shown, 3.6 cents per 100 pounds, or $1.80 per 5,000 pounds milk, and $18 in a season on ten cows (5,000 pounds per cow per season). He feeds, milks, and cares for about three-fifths of a cow for the benefit of his neighbors with rich milk.

(3) The third system proposed, and adopted by some of our factories is what may be called the "fat and casein system." Various methods of valuing the casein have been proposed. For reasons stated in a previous part of this Bulletin, the writer has adopted the addend *two* in connection with the fat to represent the casein. While it is not claimed that this system will give the *exact* amount of cheese

produced by all samples of milk, it comes near enough for all practical purposes, and is probably as near as any system of calculation will come. No formula or addend will give *exactly* the pounds of cheese which a given quantity and quality of milk will produce, for the reason that it is almost impossible to make cheese day after day with the same losses of fat, casein, etc., and of exactly the same composition. During the last two years we had thirty-one vats (300 pounds each), which tested 4.0 per cent. of butter fat. The pounds of cured cheese from each vat of 300 pounds of milk varied from 27.75 pounds to 33 5 pounds—a difference of 5.75 pounds of cheese from 300 pounds milk. We had also twenty-one vats testing 3.0 fat; and the pounds of cheese produced from 300 pounds of milk testing three per cent. fat ranged from 25.25 pounds to 28.25 pounds—a difference of three pounds of cheese from 300 pounds of milk. As wide variations as these will be found in all classes of milk, and these two are given in illustration of the difficulty met with in applying formulas to milk and fat in the calculation of the yield of cheese.

If we take the same groups (II. and IV.) as we did for fat alone, to illustrate the fat and casein method, and use the addend two for the casein, we shall find the account to stand as follows per 100 lbs. of milk: 4 2°/o fat + 2=6 2 pounds fat and casein at 13 694 cents per pound=84 9 cents. The value of the cheese is 10.6 pounds at eight cents = 84 8 cents; 3 25°/o fat + 2 = 5.25 pounds fat casein per 100 pounds; 5.25 pounds fat and casein at 13.694 cents = 71.89 cents. The value of the cheese was nine pounds at eight cents, or 72 cents. This is very close to the exact value of the cheese made from both lots; but it gives a slight advantage to the richer milk and a corresponding disadvantage to the poorer milk. The same thing is noticed in the table that follows, in which it may be assumed that the average quality of milk in the six groups was furnished by six patrons, whose milk varied from 2.85 per cent. to 5.30 per cent of fat. The table shows the amount of money that would be credited to each patron by the three systems of dividing, and also the money value of the cheese made, at eight cents per pound This table covers two years' work, embracing 280 vats of milk (300 pounds each), or 86,100 pounds in all. From this milk were made 8,279 pounds of cured cheese. There were nineteen vats averaging 2.85 per cent. fat, 110 vats averaging 3.23 per cent. fat, 114 vats averaging 3.85 per cent. fat, forty vats averaging 4.198 per cent. fat, two vats averaging 4.87 per cent. fat, and two vats averaging 5.30 per cent. fat. We may consider that the table covers fairly well all variations in fat that are likely to be met with in factories and the conclusions may be considered fairly reliable, except in the case of the very rich milk—over 4.5 per cent. fat. The experiments in reference to this class of milk are not sufficient in number to warrant us in stating anything very definite concerning them. This milk, however, is not often met with in factory work.

It will be seen by the table that adding two per cent. to the fat readings places a slight discount on the milk averaging 2.85 and 3.23 per cent. of fat, and gives a small premium to the persons sending in average and richer milk. This premium is sufficient to induce patrons to send in good milk to the factory; it discourages tampering with the milk, and has all the advantages of the butter-fat system, without the disadvantage of placing too large a premium upon rich milk, to the disadvantage of medium and poorer milk. Milk with a low percentage of fat (under 3.25 per cent.) contributes a small amount of cheese for the benefit of the richer milk. The contribution is sufficient to induce the owners of such milk to furnish as high testing milk as possible; at the same time it does not unduly lower the rewards for present efforts.

We can recommend the fat and casein system (the casein being represented by the addend two) to patrons and managers of cheese factories, believing that it comes as near to justice as it is possible in factory work; and it is a simple method.

Table showing amount of money credited to different lots of milk with varying percentages of fat, according to three systems of distribution and according to the actual weight of cheese:

Lbs. Milk.	Average p. c. fat.	Lbs. cheese made.	Amounts of money (cheese 8c.) credited by three systems and according to weight of cheese.				
			Wt. milk.	P.c. fat.	P. c. fat+2	Wt. cheese	Diff'r'nce
			$ c.	$ c.	$ c.	$ c.	$ c.
5,700	2.85	489.50	43 83	34 60	37 89	39 16	−1 27
33,000	3.23	2,965.75	353 77	227 01	236 57	237 26	−0 69
34,200	3 85	3,410.50	263 00	280 42	274 24	272 84	+1 40
12,000	4.198	1,271.75	92 28	107 29	101 95	101 74	+0 21
600	4.87	68.50	4 61	6 22	5 65	5 48	+0 17
600	5.30	73.00	4 64	6 77	6 00	5 84	+0 16

In the two years' experiments, there were 38,700 pounds of milk testing less than 3.25 per cent. of fat. There were 47,400 pounds testing over 3.50 per cent. of fat. The milk under 3.25 per cent. of fat on the basis of the percentage of butter-fat plus two, contributes $1.96 to the richer milk.

Conclusions.

Our two years' experiments on the question of the relation of the fat in milk to the quantity and quality of cheese produced, seem to warrant the following conclusions:

1. That whole milk is not valuable for cheese making in proportion to its weight or volume, as 100 pounds of three per cent.

milk will make about one and a half pounds less cheese than 100 pounds of four per cent. milk.

2. That whole milk does not produce cheese exactly in proportion to the butter-fat contained in it, as one pound of fat in milk testing an average of 3.23 per cent., produced 2 78 pounds of cured cheese, while one pound of fat in milk testing an average of 4.2 per cent., produced an average of 2.52 pounds of cured cheese.

3. That the yield of cheese is fairly uniform in proportion to the fat and casein contained in the milk, when the latter is represented by adding two to the percentage of fat. This method gives results slightly lower than the actual yield of cheese, for milk testing under 3.25 per cent. of fat, and slightly above the actual yield, for milks testing over this percentage of fat

4. The percentage of fat in the whey was greater from rich milk than from poor milk, but the loss of fat per 100 pounds of cheese made, did not differ materially until milk with over 4.50 per cent. of fat was used.

5. That the relation of the fat of the milk to the quality of the cheese produced is the most difficult point of all to settle, as there is so much difference of opinion as to what constitutes "quality" in a cheese. It is difficult to get two judges to agree as to the number of points which cheese should be scored; and there does not seem to be a very definite relation between points scored and the market or money value. A cheese that would bring top price in one market might not do so in another. At present there is not enough discrimination made in cheese sold on the markets. All our cheese made at the College were sold for the same price each month.

6. That the cheese made from poor milk had a tendency to become harsh in texture, which may be partially remedied by using less salt and leaving more moisture in the cheese. Rich milk has a tendency to produce cheese somewhat "pasty" and "slippery" in character, which may be partially remedied by the use of extra salt and by cooking one or two degrees higher than usual. The flavor, closeness, even color, and texture of a cheese are somewhat dependent upon the fat present in the milk and retained in the cheese; but with normal milk there are a number of factors equally important in the manufacture and sale of Cheddar cheese. Among these are (1) what may be called good physical qualities in the milk, such as smell and taste; (2) skilful making; (3) differences in the tastes of judges and consumers.

7. That the percentage of fat in milk plus two is a fair basis upon which to distribute proceeds among patrons of cheese factories.

PART III.

Effects of Salt, Temperatures for Setting Milk, Acid at Milling Stage, and Temperature at Time of Putting Curd to Press.

Salt on Curds from Average Milk.

In addition to the experiments on the effect of salt on curds from average milk which were reported on page 50 of the College Report for 1895, three other experiments were made in November and December. The quantity ranged from two to four pounds of salt per 100 pounds of curd. The difference in the quality of the cheese made was not very marked, except in the case of the curd salted at the rate of four pounds of salt per 100 pounds of curd (December 18th—3.5 per cent. of fat in milk), which was pronounced a very "harsh" cheese by Mr. Bell on February 17th, 1896, and also by Mr. Ballantyne on February 21st. The flavor, closeness, and color were good, but the texture was scored down to thirteen by Mr. Bell and fifteen by Mr. Ballantyne out of a possible twenty. This cheese was again scored on April 7th, and still pronounced "harsh and short in texture" by Messrs. MacLaren and Ballantyne. It scored but twelve points out of twenty. We thought that the texture would likely improve if the cheese were kept, as it was good in every other quality. The large quantity of salt seems to have effectually stopped the "breaking down" process.

Table showing effect of salt on curd from milk containing an average per cent. of fat :

Date.	Lbs. milk.	Per cent. fat in milk.	Lbs. salt per 100 lbs. curd.	Lbs. cheese. Green.	Lbs. cheese. Cured.	Score, max. 100
Nov. 20th	600	3.70	2	33.00	31.50	93
			$2\frac{3}{4}$	32.75	31.25	92
Dec. 4th...	600	3.45	$2\frac{3}{4}$	33.00	31.50	90
			$3\frac{1}{2}$	32.50	31.25	90
Dec. 18th	600	3.50	$2\frac{3}{4}$	30.25	28.75	93
			4	30.50	28.75	90

Different Temperatures for adding Rennet to Milk.

With a normal working milk, most of our makers have settled on a temperature of eighty-six degrees for the milk when the rennet is added. To see the effect of other temperatures than those commonly used, seven experiments were made in November and December. The setting temperature varied from seventy to ninety-five degrees. The lower the temperature of the milk at setting, the longer the time required for curdling or coagulating. At a temperature of seventy degrees on November 12th, the time for curdling was one hour and sixteen minutes, while a vat of similar milk at eighty-six degrees coagulated in thirty-one minutes. At seventy-four degrees, the time was fifty-one minutes, as compared with twenty-eight minutes at eighty-seven degrees. Above eighty-six degrees, the time for coagulating was also shortened. At ninety degrees, coagulation was complete in thirty-one minutes, as compared with thirty-five minutes at eighty-six degrees. At ninety-five degrees, the time was twenty-two minutes, as compared with thirty-one minutes at eighty-six degrees.

These experiments indicate that above eighty-six degrees, up to ninety-five degrees, each increase of one degree in temperature in the milk will decrease the time required for coagulation by one minute. Below eighty-six degrees, down to seventy degrees, each degree of fall in temperature increases the time required for coagulation by about two minutes, other things being equal. The effect of setting-temperature on the time from setting to dipping seems to be that a temperature below eighty-six degrees requires a longer time before the curd is in a condition to "dip," as tested by the hot iron. Above eighty-six degrees, in the two experiments made, there was little difference in the time. The time from dipping to salting was practically the same at all the temperatures tried.

Perhaps the most important point of all was the extra loss of fat in the whey from setting at low temperatures. The loss was one half of one per cent. when set below eighty degrees. There was a corresponding decrease in the yield of cheese from these temperatures. The effect on the quality of cheese did not seem to be very marked. The two cheese made on December 16th, were kept until April 7th, when they were scored again by Messrs. MacLaren and Ballantyne. The cheese made from milk set at eighty-six degrees scored ninety-five points, and the one set at ninety-five degrees scored ninety-six points out of a possible one hundred. The cheese made from milk set at ninety-five degrees scored thirty-three for flavor, nineteen for closeness, fifteen for even color, and nineteen for texture. It lost two points in flavor and one point in both closeness and texture. This approaches close to perfection for a cheese made in December which was scored when nearly four months old. Its mate set at eighty-six degrees was but one point behind. In the "remarks," when these cheese were made, it is noted, "The curds were of a tough, harsh nature." The cheese appear to have turned out all right.

Effect of Setting at Different Temperatures.

Date.	Lbs. milk.	Per cent. fat in milk.	Temperature for setting.	Minutes curdling.	Hours from setting to dipping.	Hours from dipping to salting.	Per cent. fat in whey.	Lbs. cheese.	Score.
			°		h. m.	h. m.			
November 4....	300	3.5	87	28	2 53	3 16	.2	30.25	90
	300	3.5	74	51	3 24	3 27	.5	28.25	91
" 12....	300	3.65	86	31	2 54	3 05	.2	30.25	87
	300	3.65	70	76	3 08	3 27	.5	28.25	89
" 19....	300	4.00	87	24	2 02	3 18	.25	31.75	89
	300	4.00	78	41	2 16	3 10	.4	31.00	88
" 26....	300	3.9	86	32	4 02	2 43	.25	30.75	90
	300	3.9	80	45	3 58	2 38	.30	30.75	89
December 2....	300	3.6	86	35	3 28	4 08	.20	30.25	88
	300	3.6	90	31	3 39	4 13	.20	30.50	90
" 9....	300	3.6	86	27	2 47	4 02	.20	30.75	89
	300	3.6	82	35	2 50	4 03	.20	30.75	92
" 16....	300	3.55	86	31	2 55	4 18	.25	30.00	94
	300	3.55	95	22	3 00	4 13	.25	30.50	93

Effect of Different Quantities of Rennet in Cheesemaking.

In addition to the experiments made in the spring on the effect of rennet in cheesemaking, three more were made in November and December. There is nothing special to report in these experiments, except that the extra rennet added, coagulated the milk in much less time than the ordinary amount did; but the time required for coagulation with a given quantity of rennet in these months was larger than in the spring, though the milk was of similar ripeness, as indicated by the rennet test. For instance, on April 6th and 9th, when the rennet test was twenty and eighteen seconds, the time required for coagulation was twenty-three minutes. On November 13th, with a rennet test of twenty-one seconds, the time required for coagulation was thirty minutes. Four ounces of rennet per 1,000 pounds of milk were used in all cases. On April 13th, with a rennet test of twenty seconds, the time required for coagulation was fifteen minutes ; and on December 11th, with a rennet test of nineteen seconds, the time for coagulation was twenty minutes, eight ounces of rennet per 1,000 pounds of milk being used in both cases.

The experiments are not numerous enough to establish a law for the time required in coagulation with different quantities of runnet ; but taking the results so far, and averaging the time for spring and fall in cases where it is possible to do so, we obtain the following table :

Rate of Rennet, per 1,000 lbs. of milk.	Time of year.	Minutes coagulating.
1 oz. (one expt.)	Spring.	65 minutes.
2 ozs. " "	"	42 "
2½ " " "	"	40 "
3 " (av. 3 expts.)	"	33 "
3⅓ " " "	Fall	32.6 "
3½ " (av. 2 expts)	Spring	27 "
4 " (av. 4 expts)	Spring and Fall	26 "
4½ " (av. 2 expts.)	Spring	25.5 "
5 " (1 expt.)	"	20 "
6 " (av. 2 expts.)	Spring and Fall	18 "
7 " (1 expt.)	Spring	16 "
8 " (av. 2 expts.)	Spring and Fall	17.5 "
9 " (1 expt.)	Spring	13 "

The rennet test at setting in all these experiments, varied from eighteen to twenty-one seconds. Only one vat was set at eightteen seconds and one at twenty-one seconds. The remainder were set at nineteen and twenty seconds.

In all our experiments, an extra quantity of rennet added to the milk, caused the cheese to cure or ripen more quickly. To quote the words of one of the expert judges who scored a cheese made by adding a large quantity of rennet, and compared it with another cheese made on the same date under similar conditions, except in the quantity of rennet used : " There is a cheese (made with large amount of rennet) that will be rotten by the time this one (usual amount of rennet) is ripe." He did not know how the cheese were made at the time of judging them. The percentage of moisture was determined in these cheese, and there was little difference in them in this respect.

Table showing the effect of different quantities of rennet used in milk :

Date.	Rate of runnet per 1,000 lbs. milk.	Runnet test. Seconds.	Minutes Coagulating.	Time from setting to dipping.	Time from dipping to salting.	Lbs. cured cheese from 300 lbs. milk.	Per cent. fat in Whole milk.	Per cent. fat in Whey.	Score.
	oz.			h. m.	h. m.				
Nov. 13th . . .	3⅓	21	34	3 35	3 48	30.25	34	.20	91
	4		30	3 28	3 55	30.25		.20	91
" 27th	3⅓	20	31	2 54	3 34	31.25	36	.20	93.5
	6		22	2 48	3 27	31.50		.20	93
Dec. 11th	3⅓	19	33	3 17	3 38	32 25	37	.20	92
	8		20	3 12	3 38	32.00		.20	92

Milling the Curd.

Between July 25th and Nov. 25th, 1895, twelve experiments were made to determine if possible the best stage at which to "mill" or "grind" curds. Six hundred pounds of milk were put into a vat, and the curd was kept together until it was time to mill one portion. The curd was then divided equally, and that part which was to be milled at an early stage was put through a Harris mill. The other half was delayed for some time, and afterwards milled with the same mill.

The test used for milling was the "hot iron test." It is usual to express this test in terms of so many inches or fractions of an inch of acid, though it is a question whether this test indicates acidity at all in the true sense of the term. In all probability it indicates a *condition* of the curd which may or may not be accompanied by corresponding degrees of acidity. We shall, however, continue to use the common terms for lack of something better. In these experiments, the "acid" at milling varied from "no acid" to two inches (A peculiar condition of the curd at times indicates "no acid" or "strings" at all, when tested with the hot iron test.) The table shows the results.

Effect of Milling at Different Stages of Acid.

Date.	Lbs. milk.	Per cent. fat.	Hours from dipping to milling.	Acid on hot iron at milling.	Hours from dipping to salting.	Per cent. fat in whey.	Lbs. cured cheese.	Score.
			h. m.	Length of strings.	h. m.			
July 25 ...	600	3.4	1 50	1⅛ inches	3 15	.20	27.75	87
			1 15	⅝ "	3 18	.20	27.75	88
Aug. 9 ...	600	3.5	1 43	1 "	3 15	.20	28	84
			1 15	¾ "	3 17	.20	27½	86
" 23 ...	600	3.4	1 30	⅜ "	3 30	.20	28.75	89
			1 45	½ "	3 32	.20	28.75	89
Sept. 6 ...	600	3.3	1 40	1 "	3 50	.15	28	88.5
			2 00	1¼ "	3 52	.15	28	90.5
" 20 ...	600	3.4	1 45	⅞ "	4 00	.20	28.25	88.5
			2 15	1¼ "	4 02	.20	28.50	89
Oct. 4 ...	600	3.5	1 45	¾ "	3 30	.15	30.75	88.5
			2 30	1 "	3 32	.15	30.75	85
" 18 ...	600	3.4	1 37	1¼ "	3 25	.20	29	91.5
			2 45	1½ "	3 30	.20	29.75	90
Nov. 1 ...	600	3.6	1 40	1⅛ "	3 20	.20	30.75	91
			3 00	1¼ "	3 22	.20	31.25	90
" 8 ...	600	3.5	1 30	¾ "	3 23	.40	28.25	87
			3 05	1¼ "	3 25	.40	28.25	85
" 11 ...	600	3.8	2 00	No acid.	4 13	.25	31.75	91
			4 00	"	4 15	.25	33.25	90
" 18 ...	600	3.8	2 00	1¼ inches	4 00	.20	31.75	92
			3 55	2 "	4 02	.20	30.75	90
" 25 ...	600	3.75	1 05	1¼ "	3 20	.20	31.00	91
			1 55	1⅝ "	3 22	.20	31.00	90

It will be noticed that the length of time from dipping to salting, did not appear to be materially affected by the time or condition of milling within the range given. In other words, these curds were ready to salt in about the same length of time after dipping, whether milled early or late. The yield of cured cheese was very similar in all cases, except on Nov. 11th and 18th, in which cases on the 11th both curds showed "no acid" and on the 18th one curd showed two inches of acid at milling, and there was one pound less cheese from this curd.

The quality of the cheese made on the same day was quite uniform throughout. The cheese made on Nov. 18th, 1895, were scored by Messrs. Brill and Millar, January 4th, 1896, and scored respectively ninety-two and ninety points, being two points in favor of early milling. The cheese made from the curd milled at two inches of acid, was pronounced "pasty." A few days afterwards these two cheese were scored at Woodstock (Dairy Convention), by Mr. A. F. MacLaren, and the score was ninety-five and ninety-six points, being one point in favor of the cheese milled at two inches of acid. Both cheese were scored alike in texture. These cheese were again scored on April 7th, and the score was 91.5 and 88.5, being three points in favor of early milling. The cheese milled at one and one-quarter inches of acid scored thirty two points in flavor, the same as it did at Woodstock. The cheese milled later scored thirty points, having lost three points since the last scoring. It had also become badly mottled in color, but whether this was due to the milling or not we are unable to say.

Effect of Different Temperatures of Curd when put to Press.

A temperature of eigthy degrees to eighty-five degrees at the time of putting the curd to press is usually considered to be about right. Above eighty-five degrees at this stage, it is considered that cheese are more liable to "huff;" and below eighty degrees, that there is more difficulty in getting a "close" cheese. As the table shows, in all the experiments quoted there was little or no complaint as to "open" cheese in a range of temperatures from sixty-six degrees to ninety-four degrees. Further experiments are needed to settle the point of the best temperature for putting curds to press. It would seem from these experiments that the temperature of the curd at the time it is put to press has not much to do with making the cheese "open."

Table Showing Effect of Temperature of Curd when put to Press.

Date.	Lbs. milk.	Per cent. fat in milk.	Lbs. cheese. Green.	Lbs. cheese. Cured.	Temperature when put to press.	Scoring of cheese. Flavor.	Closeness.	Even color.	Texture.	Finish.	Total
					Deg.						
Nov. 2	600	3.50	34.00	32.50	80	32	19	15	19	10	95
			34.25	32.75	66	32	20	15	19	10	96
" 30	600	3.50	31.00	29.50	82	31	19	14	19	10	93
			31.25	29.50	70	30	19	14	18	10	91
Dec. 3	600	3.80	33.00	31.75	80	32	19	13	15	10	89
			34.00	32.50	8	32	19	13	15	10	89
" 7	600	3.60	32.75	31.50	80	31	19	14	17	10	91
			33.50	32.23	70	31	19	14	17	10	91
" 10	600	3.60	33.75	32.25	82	32	19	14	17	10	92
			35.00	33.25	70	32	19	14	17	10	92
" 14	600	3.60	32.25	31.00	83	32	20	14	16	10	92
			31.50	30.25	94	32	19	14	16	10	91
" 17	600	3.55	32.00	30 50	81	30	18	13	15	10	86
			31.50	30.00	90	32	19	13	15	10	89

The cheese made Nov. 2nd and those made Dec. 17th, 1895, were kept until April 7th, during which time the November cheese were scored four times and the Decembers three times. The table of scoring shows the difference in these cheese from time to time. The two cheese made Dec. 17th were of a peculiar yellow and white color on April 7th, the cause of which we are unable to state. Of the two cheese made Nov. 2nd, put to press at eighty degrees and sixty-six degrees respectively, it will be noticed that the cheese put to press at eighty degrees remained a uniform quality until April 7th, while that put to press at sixty-six degrees deteriorated.

Date cheese were made.	Temperature put to press.	Names of Judges.	Date of scoring.	Scoring of the cheese. Flavor.	Closeness.	Even color.	Texture.	Finish.	Total score.
Nov. 2 ...	80° F.	T. B. Millar and G. J. Brill.	Jan. 4, '96	32	19	15	19	10	95
		A. F. MacLaren......	" 9, '96	32	18	14	18	10	92
		R. M. Ballantyne..........	Feb. 21, '96	30	19	15	19	10	93
		R. M. B and A. F. M	Apr. 7, '96	33	19	14	19	10	95
" 2....	66° F.	T. B. M. and G. J. B......	Jan. 4, '96	32	20	15	19	10	96
		A. F. M	" 9, '96	32	19	14	19	10	94
		R. M. B	Feb. 21, '96	28	19	15	19	10	91
		A. M. B. and A. F. M.....	Apr. 7, '96	27	19	14	19	10	89
Dec. 17....	81° F.	A. T. Bell.................	Feb. 17, '96	30	18	13	15	10	86
		R. M. B	" 21, '96	30	19	14	18	10	91
		R. M. B. and A. F. M.....	Apr. 7, '96	27	18	8	16	10	79
" 17....	90° F.	A. T. Bell.................	Feb. 17, '96	32	19	13	15	10	89
		R. M. B	" 21, '96	32	19	14	18	10	93
		R. M. B. and A. F. M.. ..	Apr. 7, '96	30	19	10	15	10	84

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ntario Agricultural College and Experimental Farm

EXPERIMENTS

WITH

WINTER WHEAT

BY C. A. ZAVITZ, B.S.A., EXPERIMENTALIST.

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BULLETIN 103.

EXPERIMENTS WITH WINTER WHEAT.

By C. A. Zavitz, B.S.A., Experimentalist.

One hundred and thirty-three varieties of winter wheat have been tested at the Ontario Agricultural College within the last seven years. Of this number, fifty-three varieties have been grown for five years, and the remainder have been tested from one to four years. Besides testing the varieties, there have been experiments conducted in different dates of seeding, methods of seeding, selection of grain for seed, quantities of seed per acre, application of fertilizers, sowing of spring grain to act as a mulch for winter wheat, the yield and quality of wheat cut at different stages of maturity, and the value of seed from wheat cut at different stages of maturity. These different experiments have occupied eight hundred and eighty-five plots. This bulletin gives a summary report of the principal experiments conducted under these heads in 1896, and the average results of some of the experiments conducted for several years in succession.

Conditions of Soil.

The field in which the grain was sown in 1896 is a good average clay loam, quite uniform in character, and has a very gentle slope towards the south-west. No manure nor commercial fertilizers had been applied to the land since the spring of 1893, when twenty tons per acre of farm-yard manure were used. The land produced a crop of corn in 1893, a crop of grain in 1894, and a crop for green manuring in 1895, which was plowed under in July of that year. No other plowing was done, but the land was well cultivated up to the first of September. The plots were made of uniform size for the different experiments, each containing one one-hundredth of an acre.

Conditions of Season and Growth.

The seeding for all the experiments took place in the month of September. The germination was quite satisfactory throughout, and the growth of the wheats in the autumn was good. On examination of the crop in the following April, it was found that many of the varieties showed but little signs of winter killing, while others had been considerably frozen out, thus affording ample data for a comparison of the different plots in respect to hardiness.

Several thousand farmers visited our winter wheat plots in the month of June, and appeared to be much interested in the comparative growth shown by the different experiments.

Varieties Tested.

Eighty-one varieties of winter wheat have been under test this season. The plots were situated side by side, the soil being quite uniform throughout. They were separated from each other by paths three feet wide. All the plots were sown by hand, at the rate of two bushels per acre, on September 4th, with the exception of eight varieties, which were sown on small sized plots, about ten days later, and which are not included in the tabulated results. The varieties ripened between the 10th and the 18th of July, which was about six days earlier than in 1895. The trouble from smut this season was very slight. The yields per acre have been calculated from the actual yields of the plots.

The following table gives the number of varieties tested and reported on within the past seven years, and also the average yields for each of these years:

Year.	Number of varieties grown each year.	Average weight of grain per measured bushel.	Average yield of—	
			Straw per acre.	Grain per acre.
		lbs.	tons.	bus.
1890	15	60.0	2.4	30.9
1891	23	63.3	2.0	52.9
1892	44	60.5	3.2	42.6
1893	52	58.4	2.1	29.9
1894	80	60.8	4.0	46.7
1895	102	60.4	1.2	26.1
1896	81	60.3	2.6	42.1

From this table it will be observed that the eighty-one varieties tested in 1896, gave an average of 2.6 tons of straw, and 42.1 bushels of grain per acre, and an average weight of grain per measured bushel of 60.3 pounds. The yield of grain, therefore, is about four and a half bushels per acre more than the average yield of the past seven years. The average weight per measured bushel, however, is one-fifth of a pound less than the average of these years. The largest yield of grain per acre was obtained in 1891, and the smallest in 1895. It will be observed that there is a great difference in the quality of grain produced in the several years. The average weight per measured bushel in 1891 was 63.3 pounds, and in 1893 58.4 pounds. For some of the reasons of these variations, reference can be made to the six bulletins on winter wheat, previously issued. From a careful study of the above table and the previous winter wheat bulletins, the reader will readily understand that it is of great importance to have these experiments extend over a period of several years, in order to have the varieties subjected to various climatic conditions. We wish to emphasize the fact that the average results of three, four or five years' experimental work should be of much greater value than the results obtained from experiments of only one year.

DAWSON'S GOLDEN CHAFF—WINTER WHEAT.

EARLY GENESEE GIANT—WINTER WHEAT.

Characteristics and Yields of Varieties.

The following table contains the characteristics and the yields of seventy-four varieties tested during the past season. The horizontal rows give information regarding the different varieties, and the perpendicular columns furnish a means of comparing the characteristics and the yields of the varieties with one another. Starting at the left hand side of the table, columns 1 and 2 give the numbers and names of the varieties, and indicate the numbers of years reported upon; 3 and 4 refer to their characteristics; 5, 6 and 7 give results for 1896; and 8, 9, 10, 11, 12, 13 and 14 give average results for five, four, three or two years, or for one year, as indicated in columns Nos. 1 and 2.

The first twenty-five varieties mentioned in the table include those which have given the most satisfactory results in the trials of six and seven years, as well as the results of the varieties which were grown for the first time in 1892. In order to make a better comparison of these varieties, the average results of only the last five years are here presented.

The reader's attention is especially directed to the last column on the right hand side of the table, as this gives the average yield of grain per acre of each variety for the number of years reported upon, and the varieties are arranged in the table according to their average yields, starting with the highest, and finishing with the lowest.

One of the principal advantages of giving the results of so many varieties as are here recorded, is to enable any farmer to compare the varieties which are new to him with those he has been familar with for several years.

New Varieties not Included in Table. Seven new varieties were sown ten days later than the others, and on plots exactly one-half the size. As the conditions of the experiment were not the same as for the rest of the varieties, these are not included in the present table. The following list gives the names of these varieties, and the yield of each in bushels of grain per acre: Johnson, 36.8; Bearded White Fife, 32.2; Eastman, 37.2; Gold Coin, 31.1; Roberts, 27.8; French Hero, 25.7, and White Golden Cross, 19.3.

Varieties Discarded after Four, Five, or Six Years' Tests. In our bulletin of 1895, it was mentioned that fifty-three varieties had been tested for four, five, or six years in succession. Of this number twenty-five of the best varieties have again been grown in 1896, and twenty-eight of the less satisfactory kinds have been dropped from our experiments. The following list gives the names of the varieties which we have discarded: Kessingland Red, Galizien Summer, Dividend, White Patanelle, Regent, Square Head, Browick Red, Spalding Red, Red Inversible, Saumur, Red Russian, Fulcaster, Red Wonder, Rumsey, Rogers, Rutherford, Lancaster, New Monarch, Hybrid Mediterranean, Garfield, Canadian Velvet Chaff, Martin Amber, Red Lion, Seneca or Clawson, White Pearl, Democrat, Walker's Reliable and Manchester.

Characteristics and Yields of 74 Varieties of Winter Wheat.

Varieties. Arranged according to the last column of this table, which gives the average yield of grain per acre for the number of years grown.	Heads, Bearded or Bald.	Color of Grain.	Results for 1896. Per cent. of rust.	Results for 1896. Weight of grain per measured bushel.	Results for 1896. Yield of grain per acre (bush. 60 lbs.)	Average results for number of years reported upon. Date of maturity.	Height of crop.	Per cent. of straw lodged.	Weight of 1,000 kernels.	Weight per measured bus	Yield per acre— Straw.	Yield per acre— Grain (bu. 60 lb.)
			0=free.	lbs.	bush.	July.	ins.	0=all stand'ng	drams.	lbs.	tons	bush.
Grown for five years.												
1. Dawson's Golden Chaff...	Ba	W	40	61.0	54 6	18	43.8	2	21	59.8	2.9	**49.9**
2. Egyptian	Be	R	25	61.0	53.6	20	46.7	29	18	60.7	3.0	**46.8**
3. Golden Drop.....	Ba	R	30	62.6	57.6	19	44.1	47	21	61.5	3.2	**46.5**
4. Early Red Clawson..	Ba	R	50	59.9	48.9	19	44.3	45	23	58.7	3.1	**46.2**
5. Reliable	Be	R	15	62.4	58.4	19	45.7	14	19	61.7	2.9	**45.3**
6. Russian Amber }...........	Be	R	20	63.6	60.4	20	44.5	19	19	61.5	2.8	**44.0**
7. American Bronze	Ba	R	70	59.9	46.3	21	46.8	2	20	59.3	3.0	**42.8**
8. Bulgarian	Be	W	40	60.3	45.5	21	47.4	18	20	61.1	2.6	**42.1**
9. Red Velvet Chaff	Ba	R	45	60.8	46.8	20	47.6	35	17	58.4	3.3	**41.5**
10. Golden Cross or Volunteer.	Be	R	50	59.2	39.4	22	46.9	22	21	60.1	3.0	**40.4**
11. Standard	Ba	W	45	59.4	35.1	21	44.5	16	16	58.5	2.7	**39.4**
12. Surprise.	Ba	W	45	57.2	24.6	20	45.3	25	18	58.3	2.7	**39.3**
13. Bonnell or Landreth	Ba	W	40	59.4	36.5	21	47.5	26	20	58.8	2.9	**39.3**
14. Jones' Winter Fife.... ...	Ba	R	40	57.8	27.1	20	45.3	22	18	59.2	2.4	**38.4**
15. Longberry Red...........	Be	R	20	63.4	55.7	20	43.9	42	24	61.0	2.7	**37.4**
16. Scott	Ba	R	23	61.4	51.9	21	44.6	15	20	60.4	1.8	**37.3**
17. Valley....................	Be	R	50	62 4	46.3	19	43.9	10	18	61.0	2.4	**37.1**
18. Mediterranean.......	Be	R	55	59.8	39.3	20	44.0	31	22	60.4	2.9	**36.9**
19. Monette	Ba	R	25	60 9	44.0	20	43.9	17	20	59.6	2.4	**36.5**
20. Genesee	Be	W	33	61.4	43.0	20	45.6	19	21	60.4	2.4	**35.9**
21. Velvet Chaff...	Be	R	35	63.8	41.7	18	41.3	5	21	62.8	2.2	**34.9**
22. Fultz	Ba	R	45	62.4	33.2	18	40.9	5	18	62.4	2.1	**34.9**
23. Deitz Longberry	Be	R	45	61.3	42.9	20	45.1	24	23	61.7	2.3	**34.6**
24. Manilla	Ba	W	60	55.5	23.2	21	44.4	14	20	57.5	2.4	**33.5**
25. Hybrid Delhi	Ba	W	55	59.4	22.2	21	44.2	20	20	59.4	2.1	**32.1**
Grown for four years.												
26. Stewart's Champion	Ba	R	45	58.6	32.0	19	48.4	6	18	58.6	2.8	**37.2**
27. Early White Leader . ..	Ba	W	70	53.9	20.4	20	45.1	5	19	56.5	2.0	**33.8**
28. Soules	Ba	W	60	58.9	24.3	17	45.6	7	17	57.4	2.3	**33.7**
29. White Star	Be	R	70	58 9	29.2	18	45.8	6	23	59.8	2.0	**32.8**
30. Treadwell	Be	W	35	60.8	41.2	19	46.9	6	21	59.5	2.0	**29.2**
Grown for three years.												
31. Early Genesee Giant	Be	W	70	60.6	49.9	18	46.3	5	22	60.9	2.9	**47.8**
32. Imperial Amber	Be	R	15	61.1	66.4	17	45.5	37	20	59.7	3.6	**46.3**
33. Tasmania Red............	Be	R	35	61.6	54.8	16	41.7	47	20	61.8	3.1	**45.7**
34. Early Ripe................	Ba	R	45	61.6	52.1	17	44.5	18	20	61.7	3.0	**45.0**
35. Egyptian Amber..........	Be	R	15	62.9	55.5	16	44.2	27	18	61.7	3.1	**43.9**
36. Poole	Ba	R	35	61.8	59.7	17	42.3	15	21	61.0	2.7	**43.8**
37. New Columbia............	Ba	R	45	60.6	58.7	16	43.9	5	20	59 2	2.7	**41.7**
38. Siberian	Ba	R	35	61.9	38.7	19	43.9	19	19	62.3	2.8	**41.6**

CHARACTERISTICS AND YIELDS OF 74 VARIETIES OF WINTER WHEAT.—*Concluded.*

VARIETIES.—*Concluded.* Arranged according to the last column of this table, which gives the average yield of grain per acre for the number of years grown.	Heads, Bearded or Bald.	Color of Grain.	Results for 1896. Per cent. of rust.	Results for 1896. Weight of grain per measured bushel.	Results for 1896. Yield of grain per acre (bush. 60 lbs.)	Average results for number of years reported upon. Date of maturity.	Height of crop.	Per cent. of straw lodged.	Weight of 1,000 kernels.	Weight per measured bu.	Yield per acre— Straw.	Yield per acre— Grain (bu. 60 lbs.)
			0=free.	lbs.	bush.	July.	ins.	0=all stand'ng	drams.	lbs.	tons	bush.
Grown for three years.—*Concluded.*												
39. Pride of Genesee	Be	R	30	62 3	43.8	16	44.8	22	22	61.6	2.6	**41.0**
40. Red May	Ba	R	25	61.9	52.4	15	44.4	13	19	62.3	2.7	**40.4**
41. Geneva	Be	R	25	62.6	50.7	15	42.3	33	19	62.5	3.0	**40.3**
42. Arnold's Hybrid	Ba	R	35	62.8	46.0	15	43.5	12	18	61.7	2.7	**39.8**
43. Bissell	Be	R	20	62.4	57.5	15	41.5	34	21	61.5	2.7	**39.3**
44. Emporium	Ba	R	10	60.7	48.9	19	46.9	20	18	59.3	2.9	**39.2**
45. Rudy	Be	R	50	61.1	54.2	14	43.2	34	23	60.7	2.4	**39.0**
46. Tuscan Island	Be	R	65	61.1	50.1	16	44 6	30	22	60.2	2.6	**38.4**
47. Zimmerman	Ba	R	25	61.1	42.4	16	41.7	6	17	61 6	2.3	**37.8**
48. McPherson	Ba	R	30	61.4	38.4	15	42.5	25	20	61.6	2.7	**37.3**
49. Golden Tankard	Be	R	55	60.9	52.3	15	45.4	33	21	60.5	3.4	**36.6**
50. Andrew's No. 4	Be	R	60	59.5	48.6	20	46 6	17	21	60 0	2.9	**36.0**
51. Simcoe Red	Be	R	35	60.1	41.5	15	45.8	25	16	59.2	2.8	**35.8**
52. Turkish Red	Be	R	15	61.5	26.0	15	38 4	42	18	62 0	2.2	**34.8**
53. Kentucky Giant	Be	R	35	60.1	40 1	18	44.3	32	23	59 3	2 5	**34.6**
54. Jones' Square Head	Ba	W	50	57.4	22.3	17	43.9	4	20	58.5	2 1	**33.8**
55. Penquit's Velvet Chaff	Be	R	70	60.3	35.9	16	42.3	12	19	61.4	2.3	**32.6**
56. Currell	Ba	R	50	60.6	37.9	16	43.3	18	19	61.0	2.6	**31.8**
57. Hindostan	Be	R	85	60.1	38.1	19	44.1	29	23	60.7	2.4	**31.5**
58. Bullard's Velvet Chaff	Ba	R	70	60.0	39.8	20	43.9	2	19	60.5	1.8	**25.0**
Grown for two years.												
59. Giant Square Head	Be	W	75	60.6	59.0	18	43.5	1	22	60.4	2.6	**46.2**
60. Michigan Amber	Be	R	40	61.2	57.0	16	41.5	8	19	61.5	2.7	**46.2**
61. Hunter's Wheat	Be	R	25	62.7	57.8	17	38.5	8	19	61.8	2.2	**40.1**
62. Pride of Illinois	Ba	R	50	63.0	52.4	14	38.3	15	21	61.6	2.1	**37.0**
63. White Bearded	Be	W	45	60.1	38.8	17	37.5	2	20	59.5	1.8	**35.3**
64. German Emperor	Ba	R	30	62.1	42.1	17	39 0	30	21	61.0	2.5	**33.1**
65. Silver Star	Ba	W	65	60.8	33.2	19	40 8	5	22	61.2	1.7	**30.5**
66. Kalina	Be	R	60	60.2	38.1	18	40.3	5	24	60.2	1.7	**27.9**
67. Amherst Isle	Be	R	10	59.8	29.3	17	30 5	43	19	59.9	1.3	**27.2**
68. Nonpareil	Be	W	40	61.5	46.4	18	40.3	1	22	60.4	1.5	**26.9**
69. Mealy	Ba	R	60	61.7	40.2	16	37.8	4	20	61.1	1.4	**26.2**
70. Long Amber	Ba	W	70	53.7	19.3	21	37.0	13	20	56.4	1.1	**19.1**
Grown for one year.												
71. Queen Meg	Be	W	55	61.1	56.7	14	50 3	0	22	61.1	3.4	**56.7**
72. Bailey	Ba	W	55	58.4	40.6	12	42.5	5	19	58.4	2.4	**40.6**
73. Beattie's Victor	Be	W	60	59.6	34.8	14	47.3	1	19	59.6	2.2	**34 8**
74. Murray's Hybrid	Be	W	35	59.4	33.9	12	45.3	15	21	59 4	2.4	**33 9**

Observations on the Variety Tests.

1. The numbers of bearded and of bald varieties of winter wheat which have been grown in our trial grounds are about equal.

2. In each of the seven years past, the bearded varieties have given a heavier weight per measured bushel than the bald varieties, the average being 1.2 pounds in favor of the bearded.

3. In yield of grain per acre for the past seven years, the bald varieties have given an average of 38.8 bushels, and the bearded varieties 38.2 bushels. In 1896, however, the bearded varieties gave about five bushels per acre more than the bald; and in 1891 the bald varieties surpassed the bearded by nearly ten bushels per acre.

4. Of all the winter wheats tested in 1896, fifty-four were red grained and twenty-seven were white grained varieties.

5. In six of the past seven years, the red wheats have given a heavier average weight per measured bushel than the white wheats by about one pound.

6. In 1896 the red wheats gave an average of exactly ten bushels per acre more than the white wheats; but in 1891 and 1894, the white wheats gave considerably larger yields than the red varieties, the average for the seven years being about equal.

7. In 1896, the varieties with bald heads and white grain gave only two-thirds as much in average yield of grain per acre, as the varieties with bearded heads and red grain.

8. The varieties which produced the least amount of rust in 1896 are, Reliable, Turkish Red, Egyptian Amber, Imperial Amber, Emporium, and Amherst Isle; and the variety most subject to rust was Hindostan.

9. The varieties which gave the heaviest weight per measured bushel in 1896 are, Velvet Chaff, Russian Amber, Longberry Red, Pride of Illinois and Egyptian Amber.

10. The varieties which gave the largest yield of grain per acre in 1896 are, Imperial Amber, Russian Amber, Poole, Giant Square Head, Hunter's Wheat and New Columbia.

11. The varieties which were first in reaching maturity in 1896 are Fultz, Turkish Red, Egyptian Amber, McPherson, Arnold's Hybrid, Imperial Amber, Geneva, Red May and Tuscan Island.

12. The varieties which produced the longest straw in 1896 are, Andrew's No. 4, Giant Square Head, Emporium, Golden Tankard, Simcoe Red and Imperial Amber.

13. The varieties which produced the longest average heads in 1896 are Long Amber, Manilla, Pride of Genesee, Stewart's Champion and Silver Star; and those which produced the shortest average heads are Queen Meg, Giant Square Head and Early Genesee Giant.

14. On examination of the yields per acre of eighty-one varieties of winter wheat tested in 1896, it is found that the ten varieties possessing the shortest heads produced an average of eleven bushels per acre more than the ten varieties possessing the longest heads.

15. The varieties which produced the largest grains, or kernels, in 1896 are Rudy, Longberry Red, Deitz Longberry, Early Red Clawson, Kentucky Giant and Tuscan Island.

16. Dawson's Golden Chaff, Egyptian Amber, Imperial Amber, Poole and Giant Square Head varieties all came through the winter exceptionally well, and made a fine appearance in the spring of 1896.

Experiments in the Methods of Winter Wheat Growing.

The following concise reports are made upon the different wheat experiments conducted in the same portion of the experimental grounds that was used for the variety test. Some of these experiments extend over a period of three, and some over a period of four years.

Different Dates of Seeding. Two or more varieties of winter wheat have been sown at three different dates, in the month of September, in each of the past four years, and at four different dates in 1896.

The following table gives the average results for each date of seeding in 1896, and also for four years in which these experiments have been conducted :

Dates of seeding.	General appearance of plot in 1896.	Height of crop in 1896.	Straw per acre.		Weight per measured bushel.		Yield of grain per acre.	
			1896.	Average 4 years.	1896.	Average 4 years.	1896.	Average 4 years.
		ins.	tons.	tons.	lbs.	lbs.	bus.	bus.
Sept. 2-3	Good	51	3.4	2.8	61.2	58.7	61.9	39 3
Sept. 7-9	Good......	50	3.3	2.8	60.9	58.7	58.4	38.1
Sept. 17-20	Medium...	45	2.5	1.9	59.0	56.9	44.9	30.1
Sept. 26..........	Poor	41	1.7	....	57.1	....	27.3	....

It will be observed from the foregoing table that, in 1896, the best yield of both grain and straw per acre, and the heaviest weight of grain per measured bushel, were produced from the first seeding, which took place on the 3rd of September. The seeding of September 26th produced less than that of September 3rd by 34.6 bushels of grain and 1.7 tons of straw per acre, and by 4.1 pounds of grain per measured bushel. In the average results for four years, it will be seen that there is an average result of over 9 bushels of grain per acre, and a weight of nearly 2 pounds per measured bushel in favor of the seedings on September 2nd and 3rd, as compared with those of September 17th and 20th.

Methods of Seeding. An experiment in sowing winter wheat broadcast, and with a grain drill, has been conducted in duplicate in each of the past three years. The average results from sowing the same qualities of grain by the two methods are very similar, there being a very slight advantage in favor of the drilled crop in both yield of grain and straw per acre, and in weight per measured bushel.

Different Quantities of Seed per Acre. In 1894, 1895 and 1896, two varieties of winter wheat were sown broadcast on small plots, at the rates of 1, 1½ and 2 bushels per acre. The best yields of both grain and straw were obtained from the thickest seeding, and the smallest yields from the thinnest seeding, in each of the three years. It must be remembered that this experiment was conducted on small plots.

For wheat growers to determine the proper quantity of winter wheat to sow per acre in order to get the best results upon their respective farms, it will be advisable for them to observe and experiment for themselves, as so much depends upon the fertility of the soil and other conditions.

The Yield and Quantity of Winter Wheat as Affected by Cutting at Different Stages of Maturity. Five plots each, of the Dawson's Golden Chaff and the Early Genesee Giant winter wheats were sown on the same date in 1893, 1894, and again in 1895. These two varieties reached the stage of maturity at which winter wheat is usually cut in Ontario, on the 19th of July, 1894, the 18th of July, 1895, and the 11th of July, 1896. The two wheats were cut at five different periods during the three years, commencing on July 4th in 1894 and in 1895, and on June 30th in 1896. The periods between the cuttings were one week in length. In each of the three years the greatest yield of straw was obtained from the first cutting, and the heaviest weight of grain per measured bushel from the second and third cuttings The yield of grain per acre was best from the last cutting in 1894 and in 1896, and from the second last cutting in 1895. The lowest results in yield of grain per acre and in weight of grain per measured bushel were obtained from the first cutting of each variety in each year. The quality of the straw in 1896 was decidedly the best from the first two cuttings, and was decidedly the poorest from the last two cuttings.

Value of Grain for Seed as affected by cutting at different stages of maturity. Dawson's Golden Chaff and the Early Genesee Giant varieties of winter wheat, were both sown on the same date in 1893 and again in 1894; and the plots were cut on July 4th, 11th, 18th, 19th and 25th, and August 2nd in 1894 and in 1895. The first cutting took place about two weeks before and the last cutting about two weeks after that stage of ripeness at which winter wheat is usually cut. A quantity of seed of each variety was taken both years from each of the five different cuttings, and these equal amounts of grain were sown upon a smaller number of uniform plots in the autumn of 1894 and 1895. The plots of the one year were all harvested at one time in July, 1895, and of the other year in July, 1896. It was found in the results of each year that the largest yield of grain per acre was produced by the seed of the last cutting of the previous year.

Co-operative Experiments with Winter Wheat.

Seventeen varieties of winter wheat which have been the most successful among all the varieties tested in the Experimental Department of the College, have been distributed over Ontario within the past four years. These have been sent out in sets of five varieties each. Eight thousand one hundred and fifty-five packets of winter wheat have been distributed during the past four years, and comparative tests have been made upon seventeen hundred Ontario farms. This system of co-operative experimental work was established by the ex-students of the Agricultural College; but, through repeated requests from other farmers, an invitation is extended to all interested persons to join in the work. The results have, on the whole, been very gratifying; and the numerous experimenters have become much interested in the different experiments undertaken. For detailed reports of these co-operative experiments, the reader is referred to the

Annual Report of the Ontario Agricultural and Experimental Union which is printed along with the report of the Ontario Agricultural College. From among fourteen conclusions given in the report of last year regarding these co-operative experiments with winter wheat for 1895, the following five conclusions are quoted as being of interest in connection with the results given in this bulletin :

1. "In average yield of winter wheat per acre, Dawson's Golden Chaff stood highest among eleven varieties tested over Ontario in 1893, nine varieties in 1894 and nine varieties in 1895.

2. "In the co-operative experiments for 1895 Dawson's Golden Chaff, Jones' Winter Fife and the Early Genesee Giant give the best yields on heavy soils ; and Dawson's Golden Chaff, the Early Genesee Giant and the American Bronze on light soils.

3. "Early Genesee Giant and Dawson's Golden Chaff made the best general appearance in the spring of 1895.

4. "American Bronze, Early Genesee Giant and Dawson's Golden Chaff possessed the stiffest straw in 1895.

5. "The Dawson's Golden Chaff was the most popular with the experimenters in each of the past three years ; and during the present season it was chosen by over sixty per cent. of the farmers who sent in full reports as being the best among the varieties tested."

Conclusions.

1 The average results of winter wheat growing on the experimental plots for seven years in succession are as follows : Weight of grain per measured bushel, 60.5 pounds; yield of straw per acre, 2.5 tons ; and yield of grain per acre, 38.7 bushels.

2. Dawson's Golden Chaff has given the largest average yield of grain per acre among fifty-three varieties of winter wheat grown at the Ontario Agricultural College for five years; also among eleven leading varieties tested over Ontario in 1893, nine varieties in 1894, and nine varieties in 1895.

3. The Early Genesee Giant has given the largest average yield of grain per acre among twenty-eight new varieties which were tested for the first time in 1894, and have now been tested for three years in succession. This variety also stood second in average yield per acre among nine leading varieties of winter wheat tested over Ontario in 1894, and nine leading varieties tested over Ontario in 1895.

4. The Early Genesee Giant, Giant Square Head, and Queen Meg varieties of winter wheat, which head the lists in average yield per acre among the varieties grown for three years, for two years, and for one year, respectively, are very similar in all characteristics.

5. Among eighty-one varieties of winter wheat tested in 1896, the Dawson's Golden Chaff, American Bronze, New Columbia, Early Genesee Giant, Giant Square Head, and Queen Meg produced the stiffest straw.

6. In the average of four years' experiments in seeding winter wheat on different dates, it is found that when the wheat was sown later than September 9th, the crop was much poorer than when the seeding took place on or before that date.

7. In the average results from growing winter wheat for seven years in succession, it is observed that the white grained varieties have given the largest yields per acre in those seasons when there was but little rust, and the red grained varieties in those seasons in which the rust was abundant.

8. The varieties which have given the best average results in the experiments at the College are the varieties which have also given the best satisfaction throughout Ontario.

Distribution of Seed for Testing Purposes.

In the following table will be found three sets of winter wheat varieties, which will be sent free by mail, in half-pound lots of each variety, to farmers applying for them, who will carefully test the three kinds in the set which they choose and report the results after harvest next year. The sets will be sent out in the order in which they are received, as long as the supply lasts.

Three Sets of Winter Wheat for Co-operative Tests.

Set 1.	Set 2.	Set 3.
Dawson's Golden Chaff. Early Genesee Giant. Early Red Clawson.	Dawson's Golden Chaff. Pride of Genesee. Poole.	Dawson's Golden Chaff. Stewart's Champion. Siberian.

Each person wishing one of these sets should write to the Experimentalist, Agricultural College, Guelph, *mentioning which set he wishes*, and the grain, with instructions for testing and blank forms on which to report, will be forwarded free of cost to his address, until the supply of grain for distribution is exhausted.

BULLETIN 104 DECEMBER, 1896.

Ontario Agricultural College and Experimental Farm

RATIONS FOR DAIRY COWS

AND

OTHER MATTERS OF INTEREST TO DAIRYMEN.

By G. E. Day, B.S.A., Agriculturist.

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BULLETIN 104.

RATIONS FOR DAIRY COWS

AND

OTHER MATTERS OF INTEREST TO DAIRYMEN.

By G. E. Day, B.S.A.

At the annual meeting of the Ontario Agricultural and Experimental Union, held in December, 1895, a committee was appointed to collect information of interest to the stock breeders of the Province. The committee decided to make an attempt to collect information of interest to dairymen, and the method employed was as follows: Reply post cards were sent to the proprietors and managers of cheese factories and creameries in Ontario, and to secretaries of Farmer's Institutes, asking for the names of the most successful dairymen in their districts. In this manner a large number of names were obtained, and a circular letter, accompanied by a form containing a number of questions, was sent to each of the gentlemen whose names had been procured. Altogether, 363 forms were sent out, of which 170 were returned with the questions more or less fully answered. Replies were received from thirty-six counties, extending from Essex in the west, to Glengarry in the east, so that the different districts of the Province are well represented.

As director of the Committee, I have taken the liberty of arranging the results of inquiries in bulletin form, together with matter, compiled from various sources relating to the principles of feeding, composition of fodders, etc. This bulletin is not designed for scientific readers, but every effort has been made to simplify the subject of scientific feeding, and many details which might tend to confuse the average reader have been purposely omitted.

The thanks of the committee and of the Experimental Union are due to those gentlemen who so courteously responded to the request for information, the nature of which will be obtained from a perusal of this bulletin.

Length of Time Cows Remain Dry. A wide variation existed in this particular, the shortest time reported being 10 days, while the average for all replies was 57 days. By far the largest number lay between 6 and 12 weeks, and 8 weeks occurred in the reports more than twice as often as any other one time.

Dehorning. Sixty-eight out of the 170 dairymen report cows dehorned; and, with very few exceptions, they express themselves satisfied with the result. One man states that the cows do not sell so readily, owing to difficulty in determining the age; another partially regrets dehorning pure-breds, fearing that it will operate against them in the show ring, while a third states that his dehorned cows bunt each other, sometimes causing abortion. On the other hand, several whose cows are not dehorned, express approval of the practice, while others condemn it as cruel, unsightly, unnecessary, etc. The fear that it would interfere with success in exhibiting has deterred a considerable number from dehorning pure-breds. Only four report that they are dehorning calves, and the following two methods are recommended as very effective and satisfactory:

1st. When the calf is from four to six days old, the hair is clipped from around the horn, and some butter of antimony is rubbed on the budding horn, with a thin piece of wood. It is then rubbed over again with the same quantity of oil of vitriol (sulphuric acid). Less than a drop of each substance will do the work.

2nd. When the calf is three or four days old, the skin where the horn grows is scarified, and a little of Gillett's lye applied to the scar.

In this connection it may be noted that caustic potash is frequently used instead of the substance mentioned above.

Horn Fly. Out of 170 replies, 142 reported horn flies troublesome, 23 reported them not very troublesome, aud 5 reported them not troublesome. Those who reported the fly not troublesome represented the counties of Essex, York, Addington and Leeds; while replies of "not very troublesome" came from the counties of Kent, Elgin, Middlesex, Perth, Bruce, York, Dufferin, Victoria, Northumberland, Hastings, Addington, Stormont and Dundas. From some of these counties, however, reports were received of a directly opposite character, and hence this information is rather unsatisfactory.

The remedies employed for the horn fly are exceedingly varied, and range all the way from kerosene emulsion down to applying tar to the horns, and even dehorning, the advocates of the latter evidently forgetting that when the fly rests upon a cow's horn it occasions her less annoyance than at any other time. For convenience sake, the remedies have been arranged under four heads, and the number of persons who have tried the different classes of remedies, are as follows:

Twenty-two employed different kinds of oil and grease with carbolic acid, 19 tried kerosene emulsion, 6 experimented with the Guthrie horn fly trap, and 40 resorted to various other remedies.

Opinions regarding the merits of different remedies are anything but unanimous, one man commending and another expressing unqualified condemnation of the same remedy. The main source of dissatisfaction seems to be the frequency of application necessary to secure good results. The following conclusions have been deduced from the replies received:

Oil and carbolic acid mixed in proportion of one ounce crude carbolic acid to one quart oil, is a very effective repellant, but requires to be applied all over the cow's body every week. The kinds of oil used include fish oil, sturgeon oil, tanner's oil, and linseed oil, besides whey grease and almost any other kind of grease or oil. An objection to using strong smelling repellants is urged by some on the ground that there is danger that the odors may taint the milk where cows are milked in the stable.

Kerosene emulsion does very well for a short time, but requires to be applied every day; and for this reason it is very generally condemned.

The Guthrie horn fly trap is both commended and condemned by those who have used it, the favorable reports rather outweighing the unfavorable. Its most effective use would seem to be at the stable door, to clear the cows of flies as they enter the stable.

Among the more important of other remedies mentioned occur the following:

One pint coal oil, 1 quart soft soap, 1 ounce carbolic acid, 3 gallons soft water, applied twice a week.

Whey grease, applied twice a week.

Oil of tar and raw linseed oil, applied once a week.

Lard and pine tar, applied twice a week.

Equal parts fish oil and coal oil, with a little coon oil.

"Mexican Fly Exterminator," "Horn-fly Ointment," and "mixtures obtained from drug stores," receive but scant commendation.

Of the various repellants, probably the first mentioned, viz., oil or grease and carbolic acid, is the simplest and most effective, though it is not without objectionable features. Keeping the cows in the stable during the heat of the day is highly recommended by several prominent dairymen; and no doubt this method, coupled with the use of the Guthrie fly traps, could be made very effective.

Summer Feeding. Only one reply stated that complete soiling was practised, but 140 out of the 170 stated that the pasture was supplemented by some kind of green fodders, while 53 stated that meal was fed, either throughout or during some part of the summer.

The following figures represent the number of times that the various supplementary fodders occurred in the reports:

Green corn	129	Ensilage	5
Green oats and peas	62	Green alfalfa	4
Green rye	10	Green millet	2
Green clover	10	Green buckwheat	2
Green oats and tares	7	Green tares	2

A glance at these figures will show that out of 140 who used green fodders only 11 did not use corn. The most common combination consisted of oats and peas, or oats and tares for summer feeding, with corn for autumn. A large number used corn alone, and, hence did not commence feeding until late in the season, while the early soiling crops, rye, alfalfa and clover, were comparatively little used. Those who are in need of an early soiling crop, especially for light or gravely soils, would do well to give alfalfa a trial.

Winter Feeding. Some difficulty has been experienced in obtaining accurate information regarding winter rations, as the majority of farmers do not weigh feed. From the 170 replies, 75 rations have been selected, and are given below. A larger number might have b-en given, but those selected illustrate fairly well the principal characteristics of Ontario rations, and it has not been deemed advisable to make the list any longer. The weight of the cows has been stated wherever this information has been furnished in the report. It was also thought advisable to include the summer ration, and to state, when possible, the results obtained from the different systems of feeding. It is only fair to say, however, that many of the records do not represent the actual returns from the cows, since no account has been kept of milk, butter and cream consumed by the family, besides milk fed to calves and hogs. The rations given below are not intended as models, but they are worth reading carefully.

Some Ontario rations for dairy cows.

1. Perth Co. Shorthorns, Jerseys, and Jersey grades. Average weight of cows, 1,000 lbs.

Record : Sold 6 200 lbs. butter from 22 cows.

Winter Ration : 6 lbs bran, 3 lbs. oil meal, 50 lbs. ensilage, 4 lbs. timothy hay, 4 lbs. oat and vetch hay.

Summer ration : 6 lbs. bran to best cows, fall rye, clover, oats and vetches, and green corn, with pasture,

2. Northumberland Co. Ayrshires. Average weight of cows 1,000 lbs.

Record : 64,734 lbs. milk, and 700 lbs. butter from 11 cows.

Winter ration : 4 lbs. bran, 2 lbs. peas, 2 lbs. oats, 1 lb. oil meal, 24 lbs. timothy and clover hay, and 10 lbs, roots.

Summer ration : 2 to 5 lbs. peas, oats, and bran, equal parts by weight, green peas and oats, and green corn, with pasture.

3. Oxford Co. Grade Shorthorns and Jerseys. Average weight of cows 900 lbs.

Record : 110,316 lbs. milk, averaging 3 9 per cent. fat, from 20 cows.

Winter ration : 4 lbs. oats, 1 lb. oil meal, 40 lbs. ensilage, 30 lbs. roots, with cut hay and straw.

Summer ration : Green oats and peas, with pasture.

4. Dundas Co. Grade, Ayrshires. Average weight of cows 1,000 lbs.

Record : 30 cows averaged $45 each.

Winter ration : 8 lbs. bran, 6 lbs. corn and cob meal, 6 lbs. mixed peas, oats, and barley, 20 lbs. corn fodder, 20 lbs. mangels, and all the hay and straw they will eat.

Summer ration : Green peas and oats, and green corn, with pasture.

5 PEEL Co. Jerseys. Average weight of cows, 800 lbs.

Record : Average of 325 lbs. butter per cow.

Winter Ration : 9 lbs. bran, 1 lb. peas, 24 lbs. ensilage, 6 lbs. hay, 10 lbs. straw, and 20 lbs. roots.

Summer Ration : Small quantity of bran and oats, green oats and peas, and green corn, with pasture.

6. GLENGARRY Co. Grade natives. Average weight of cows, 950 lbs.

Record : 70 cows, average from 5,000 to 6,000 lbs. milk each.

Winter Ration : 2½ lbs. cotton seed meal, 2½ lbs. linseed, 50 to 60 lbs. ensilage, and 4 to 5 lbs. hay. Sometimes meal ration is, 2 lbs. cotton seed meal, and 4 lbs. shorts.

Summer Ration : Pasture, with green corn in October and November.

7. LANARK Co. Ayrshires. Average weight of cows, 900 lbs.

Record : Cows average $56 per head for butter sold.

Winter Ration : 8 lbs. mixed oats, peas, barley, and bran, in proportion of 6, 3, 3, and 1, 50 lbs. ensilage, 10 lbs. mixed clover and "beaver-meadow" hay, with an occasional feed of straw and roots.

Summer Ration : Pasture.

8. YORK Co. Jerseys. Average weight of cows, 750 lbs.

Record : $97.60 per cow for cream sold in Toronto.

Winter Ration : 9 lbs. oats, 60 lbs. ensilage, 6 lbs. hay, with what straw they will eat.

Summer Ration : 2 lbs. oatmeal, green corn, with pasture.

9. OXFORD Co. Holsteins. Average weight of cows, 1,200 to 1,300 lbs.

Records : Fresh cows, 50 to 85 lbs. milk daily; two year old heifers, 35 to 45 lbs. milk daily. All below this go to butcher.

Winter Ration : 6 lbs. oats, 2 lbs oil meal, 3 lbs. bran, 35 lbs. ensilage, 10 lbs. timothy and clover hay, 8 lbs. oat and barley straw, 30 lbs. mangels and turnips. Bran is scalded and fed as slop.

Summer Ration : 3 to 6 lbs. oats and bran when pasture is poor, green peas and oats, green corn, white turnips, and sugar beets, with pasture.

10. STORMONT Co. Grade Ayrshires. Average weight of cows, 900 lbs.

Records : 40 cows averaged $50 per head for milk sold in Montreal.

Winter Ration : 2 lbs. linseed meal, 5 lbs. bran, 3 lbs. mixed peas, oats, and corn, 25 lbs. clover hay, 10 lbs. corn fodder, and 20 lbs. mangels or carrots.

Summer Ration : Green peas and oats, and green corn, with pasture.

11. MIDDLESEX Co. Grade Holsteins. Average weight of cows, 1,100 lbs.

Record : 24 cows averaged $46 per head for cheese and milk.

Winter Ration : 8 lbs. oats, 40 lbs. ensilage and about 10 lbs. straw.

Summer Ration : 2 lbs. bran, green peas and oats, with pasture.

12. LEEDS Co. Holsteins. Average weight of cows, 1,000 lbs.

Records of different individuals. 7,400 lbs. milk in seven months, 9,020 lbs. in seven months, 5,620 lbs. in seven months, 4,300 lbs. in four months.

Winter Ration: 5 to 6 lbs. bran, 2 to 3 lbs. corn meal, 40 to 50 lbs. ensilage, 10 lbs. corn fodder, 5 lbs. timothy hay. Sometimes same quantity pea meal substituted for corn meal.

Summer Ration: 5 lbs. bran (when pasture is scarce), green corn, with pasture.

13. OXFORD Co. Holsteins. Average weight of cows, 1,200 lbs.

Record: From 10,000 to 15,000 lbs. milk per cow. Have averaged $71 per cow for 6½ months at cheese factory.

Winter Ration: 8 lbs. oats, 2 lbs. bran, 40 lbs. ensilage, 10 lbs. straw, and 6 lbs. hay. Sometimes a little oil meal is fed, but meal ration never exceeds 10 lbs.

Summer Ration: Green rye, oats and peas, and millet, with pasture.

14. YORK Co. Jerseys. Average weight of cows, 800 lbs.

Records of individuals: Butter made in seven days, 26 lbs. 1 oz, 22 lbs. 4 oz., 18 lbs. 9 oz., 15 lbs. 6 oz.

Winter Ration: 12 lbs. equal parts oats, bran, and corn meal, 1 lb. oil meal, 20 lbs. corn fodder, 5 lbs. hay, 24 lbs. roots, with straw *ad lib.*

Summer Ration: 1 lb. oil meal, 2 lbs. peas, 2 lbs. bran (with 4 lbs. oat meal added in fall), clover, green peas and oats, and green corn, with pasture.

15. BRANT Co. Holsteins. Average weight of cows, 1,200 lbs.

Record: 10,000 lbs. milk per cow, averaging 3.75% fat.

Winter Ration: 4 lbs. oats, 3 lbs. peas, 3 lbs. bran, 40 lbs. ensilage, 5 lbs. hay, and 10 lbs straw. Sometimes 1 or 2 lbs. oil meal.

Summer Ration: 3 lbs. oats, 2 lbs. bran (when pasture is dry), and green corn.

16. WENTWORTH Co. Ayrshires and Jersey grades. Average weight of cows, 800 lbs.

Record: Cows average $55 per head.

Winter Ration: 2 lbs. bran, 4/5 lb. oats, 4/5 lb. barley, 2/5 lb. peas, 1/2 lb. oil cake, 25 lbs. ensilage, 6 lbs. mangels, 1 oat sheaf between two cows, with straw *ad lib.*

Summer Ration: Green corn with pasture, and sometimes 1½ lbs. bran and oil meal.

17. DUNDAS Co. Jerseys. Average weight of cows, 850 lbs.

Record: $55 per cow for butter sold.

Winter Ration: 8 lbs. bran, 1½ lbs. oil meal, 40 lbs. ensilage, and 7 to 10 lbs. hay.

Summer Ration: 5 to 6 lbs. bran (when pasture is dry), green oats, peas and tares, with pasture.

18. YORK Co. Jerseys. Average weight of cows, 900 lbs.

Record: $118 per cow for cream sold in Toronto.

Winter Ration: 5 lbs. corn meal, 5 lbs. oats, 5 lbs. oil meal, 20 lbs. corn fodder, 5 lbs. roots, 5 lbs. hay, and about 5 lbs. straw.

Summer Ration: Green corn with pasture.

19. NORTHUMBERLAND Co. Grade Ayshires.

Record: 78 500 lbs. milk and 1,200 lbs. butter from 25 cows, including two year old heifers.

Winter Ration: 3½ lbs. shorts, 1½ lbs. oil meal, 30 lbs. ensilage, 4 lbs. hay, 5 lbs. straw.

Summer Ration: Green clover, green oats and peas, green corn, and white turnips, with pasture.

20. STORMONT Co. Ayrshires. Average weight of cows, 800 lbs.

Record: $35 per cow for milk and butter.

Winter Ration: 2 lbs. oats, 2 lbs. peas, 2 lbs. shorts or bran, 2 lbs. oil meal, 12 lbs. clover hay, 1 peck of roots, with straw *ad lib.*

Summer Ration: Green oats and tares, with pasture.

21. FRONTENAC Co. Grade Shorthorns. Average weight of cows, 900 lbs.

Record: 15 cows average over $40 per head.

Winter Ration: 7 lbs. mixed oats, peas, goose wheat, and bran, in following proportions by measure: 3, 1, ½, 2¼; 40 lbs. ensilage, 5 lbs. clover hay, with straw *ad lib.*

Summer Ration: Green peas and oats, and green corn, with pasture.

22. HASTINGS Co. Ayrshires and Ayrshire grades. Average weight of cows, 1,000 lbs.

Record: Total returns from herd of 20 animals, $696.

Winter Ration: 8 lbs. of corn, oats, and bran, mixed in proportion of 10, 4 and 5, by weight, ½ bushel of roots, ½ bushel corn fodder, some oat hay, with straw *ad lib.*

Summer Ration: 1½ lbs. bran, green rye, clover, and oats, with pasture.

23. OXFORD CO. Ayrshires. Average weight of cows, 950 lbs.

Record: Cows average 36 to 40 lbs. milk per day.

Winter Ration: 3 lbs. oats, 3 lbs. barley, 3 lbs. peas, 8 lbs. corn fodder, 8 lbs. chaff, 5 lbs. straw, and 20 lbs. roots.

Summer Ration: Pasture.

24. BRANT CO. Holsteins. Average weight of cows, 1,200 lbs.

Winter Ration 6 lbs. peas, 40 lbs. ensilage, 15 lbs. corn fodder, 15 lbs. chaff, 10 lbs. hay, 60 lbs. roots, with straw *ad lib.*

Summer Ration: Green peas and oats, Lucerne, and corn, with pasture.

25. NORTHUMBERLAND CO. Holsteins. Average weight of cows, 1,100.

Record: 1,100 lbs. butter in 4 months, from 10 cows.

Winter Ration: 4 lbs. corn meal, 4 lbs. bran, 1 lb. barley, 10 lbs. hay, and 20 lbs. straw.

Summer Ration: Green peas and oats, corn, and turnips, with pasture. Sometimes 4 lbs. bran.

26. WELLAND CO. Grade Shorthorns. Average weight of cows, 1,100 lbs.

Record: 20 cows averaged 250 lbs. butter per head.

Winter Ration: 6 lbs. corn meal, 3 lbs. bran, 5 lbs. hay, with corn fodder *ad lib.* Corn fodder is steeped in hot water.

Summer Ration: Green corn, with pasture.

27. WELLINGTON CO. Grade Shorthorns. Average weight of cows, 1,050 lbs.

Record: $80 per cow for milk sold in city.

Winter Ration: 5 lbs. bran, 45 lbs. roots, 50 lbs. corn fodder, and chaff and straw *ad lib.*

Summer Ration: Green oats and peas, and corn, with pasture. Sometimes 3 lbs. bran.

28. HALDIMAND CO. Grade Shorthorns. Average weight of cows, 1,200 lbs.

Record. 34 cows, including 14 heifers, averaged $42 each.

Winter Ration: 6 lbs. equal parts oats, peas, bran, and oil meal, 35 to 40 lbs ensilage, 10 lbs. roots, with chaff and straw *ad lib.*

Summer Ration: Ensilage and green corn, with pasture. Sometimes bran and oat meal.

29. Elgin Co. Grade Shorthorns. Average weight of cows, 1,100 lbs.

Record : $400 from 12 cows, for cheese and butter.

Winter Ration: 9 lbs. oats, 3 lbs. peas, 20 lbs. hay, 60 lbs. roots, with straw *ad lib.*

Summer Ration : Pasture.

30. Bruce Co. Grade Ayrshires, Holsteins, and natives. Average weight of cows, 900 lbs.

Record : $372 from 12 cows, for cheese and butter.

Winter Ration : 6 lbs. oats, 2 lbs. shorts, 1 lb. bran, 12 lbs. corn fodder, 15 lbs. straw, and 25 lbs. roots.

Summer Ration : Alfalfa, green peas and oats, and corn, together with some oats, bran, and shorts.

31. Northumberland Co. Ayrshire and Ayrshire grades. Average weight of cows, 800 to 1,200 lbs.

Record: 24 cows, including two year old heifers, average 7,000 lbs. milk each.

Winter Ration : 5 lbs. bran, 5 lbs. peas, 35 to 45 lbs. ensilage, 10 lbs. timothy hay. Ration is regulated to suit capacity of cows.

Summer Ration : 5 to 6 lbs. bran, ensilage, green peas and oats, and corn, with pasture.

32. Bruce Co. Shorthorns and grades. Average weight of cows, 1,150 lbs.

Record : 12 cows, average 6,030 lbs. milk each.

Winter Ration : 3½ lbs. oats, 3½ lbs. peas, 24 lbs. ensilage, 4 lbs. hay, 10 lbs. straw, 25 lbs. roots.

Summer Ration : Green corn, with pasture.

33. Bruce Co. Ayrshire and Shorthorn grades. Average weight of cows, 1,000 lbs.

Record: $395 from 10 cows, for cheese and butter sold.

Winter Ration : 10 lbs. mixed oats and corn in proportion of 3 to 1, 10 lbs. chaff, 5 lbs. hay, 15 lbs. potatoes, with straw *ad lib.* Would rather feed oats and peas, in proportion of 3 to 2.

Summer Ration : 3 lbs. oat meal, green oats and peas, oats and tares, corn, and white turnips, with pasture.

34. York Co. Mixed breeds. Average weight of cows, 1,000 to 1,200 lbs.

Record : $1,009.35 from 12 cows, for milk and butter sent to Toronto.

Winter Ration : 15 lbs. equal parts oats and peas, ½ lb. flax seed, 35 lbs. roots, some corn fodder and hay, with chaff and straw *ad lib.*

Summer Ration : Green corn, with pasture. Meal fed all summer, according to pasture.

35. Oxford Co. Grade Shorthorns, Holsteins and Jerseys.

Record: 35 cows averaged $35 per head for cheese and butter. (Lower than formerly.)

Winter Ration: 4 lbs. bran, 1 lb. oil meal, 40 to 50 lbs. ensilage, 4 to 5 lbs. straw. Some potatoes and clover hay fed in spring.

Summer Ration: Ensilage and green corn, with pasture.

36. Dundas Co. Grade Jerseys and Holsteins. Average weight of cows, 900 lbs.

Record: $800 75 from 23 cows. Cream separated and sent to Montreal to be made into butter for city trade.

Winter Ration: 5 lbs. bran, 2 lbs. oil meal, 50 lbs. ensilage, 10 lbs. hay.

Summer Ration: Green peas and oats, with pasture.

37. Leeds Co. Guernseys and grades. Average weight of cows, 1,000 lbs.

Record: Cows average 6,000 lbs. milk per head.

Winter Ration: 9 lbs. bran and shorts as it comes from mill, 3 lbs. corn meal, 10 lbs. clover hay, and 45 lbs. roots.

Summer Ration: Pasture. Intend to feed meal all summer, in future.

38. Durham Co. Grades. Average weight of cows, 800 lbs.

Record: $1,500 from 20 cows, for bottled milk and butter.

Winter Ration: 8 lbs. equal parts bran and oats, 40 lbs. ensilage, 6 lbs. hay, and 6 lbs. roots.

Summer Ration: 3 to 5 lbs. equal parts bran and oats, green oats and peas, with pasture.

39. Hastings Co. Grade Shorthorns. Average weight of cows, 1,000 lbs.

Record: 16 cows averaged $51 per head.

Winter ration: 4 lbs. peas, 4 lbs. bran, 2 lbs. oil meal, 40 lbs. ensilage, 5 lbs. hay, and 5 lbs. straw.

Summer ration: Green peas and oats, and green corn, with pasture. Sometimes bran is fed.

40. Glengarry Co. Ayrshires.

Record: $150 a month from 40 cows, for cream sent to Montreal.

Winter ration: 3 lbs. flaxseed, 3 lbs. shorts, some roots, with hay *ad lib.*

Summer ration: Green corn, with pasture.

41. Addington Co. Various grades. Average weight of cows, 900 lbs.

Record: $999 from 33 cows.

Winter ration: 7 lbs oats and corn and cob meal, mixed in proportion of 1 to 3, 50 lbs. ensilage, 5 lbs. corn fodder, 10 lbs. hay, 5 lbs. chaff, and 10 lbs. straw.

Summer ration: Green corn, with pasture.

42. Victoria Co. Grade Aberdeen-Angus. Average weight of cows, 1,000 lbs.

Record : Cows average 7 to 8 lbs. butter per week, per head.

Winter ration : 3 lbs. oats, 1 lb. buckwheat, 1 lb. peas or barley, 10 lbs. hay, 1 bushel corn fodder, 20 lbs. roots, with straw *ad lib.*

Summer ration : Green peas and oats, and corn, with pasture.

43. Middlesex Co. Grade Natives. Average weight of cows, 1,000 lbs.

Records : In 1893, $50, in 1894, $48, in 1895, $40 per cow, for cheese and butter.

Winter ration : 8 quarts oats, with corn fodder, hay, turnips, and mangels.

Summer ration : Green corn and turnips, with pasture, and 8 quarts oatmeal during May.

44. Grenville Co. Natives. Average weight of cows, 1,000 lbs.

Record : $430.09 from 12 cows, for butter sold.

Winter ration : 2 lbs. bran, 8 lbs. corn refuse from starch factory, 40 lbs. ensilage, 8 lbs. clover hay, 8 lbs. oat straw, and 20 lbs. roots.

Summer ration : Green corn, with pasture.

45. Hastings Co. Ayrshires, Jerseys, Holsteins, and grades of each.

Records : Cows must test 3 per cent. butter fat, and give 6,000 lbs. milk. Best daily flow of milk from cow, 71 lbs. ; weekly, 474½ lbs. Best daily flow of milk from yearling, 32¾ lbs. ; weekly, 216¼ lbs.

Winter ration : Not more than 10 lbs. meal per cow, unless she gives over 50 lbs. milk per day, and, in no case, more than 15 lbs. meal. Meal preferred ; oil meal, cracked oats, cottonseed meal, bran, and malt combings, mixed in proportions, 1/10, 1/5, 1/5, 2/5, and 1/10, but good results obtained without cottonseed meal and malt combings. Also feed ensilage and straw, with 6 to 9 lbs hay.

Summer ration : Cows fed in stable. Green rye, green oats and peas, alfalfa, green corn, and 1 to 2 lbs. bran.

46. Grey Co. Grade Shorthorns. Average weight of cows, 1,100 lbs.

Record : $36.50 per cow, for butter sold.

Winter ration : 2 lbs. peas, 2 lbs. oats, 2 lbs. wheat, 2 lbs. bran, 30 to 40 lbs. ensilage, 5 lbs. hay, 15 lbs. turnips, with chaff and straw *ad lib.* Heavier meal ration to some cows.

Summer ration : Green oats and peas, green corn, with pasture. Ordinary meal ration continued in spring until cows refuse it.

47. York Co. Various crosses. Average weight of cows, 1,150 lbs.

Record : $38 per cow, from creamery.

Winter ration: 8 lbs. equal parts oats, peas, and bran, with a little oil meal, 4 lbs. chaff, 8 lbs. straw, and 40 lbs. roots, turnips, mangels and potatoes.

Summer ration: Green corn, with pasture. Some meal when pasture is poor.

48. MIDDLESEX Co. Grade, Jerseys. Average weight of cows, 900 lbs.

Record: $45 per cow.

Winter ration: 16 quarts oats, ½ pint oil meal, with straw and corn fodder, *ad lib.*

Summer ration: Green corn, with pasture. Bran sometimes fed in August with good results.

49. GRENVILLE Co. Grade, Shorthorns. Average weight of cows, 1,200 lbs.

Winter ration: 6 lbs. bran, 4 lbs. corn meal, 36 lbs. ensilage, 10 to 12 lbs. hay, ½ bushel beets.

Summer ration: Ensilage and green corn, with pasture.

50. GREY Co. Jerseys and Grade Jerseys. Weight of cows, from 700 to 1,000 lbs.

Winter Ration: 9 lbs. oats, 48 lbs. ensilage, 8 lbs. timothy hay, 14 lbs. roots, with straw *ad lib.*

Summer Ration: Green peas and oats, green corn, with pasture.

51. PRINCE EDWARD Co. Jerseys and Ayrshires. Average weight of cows, 900 lbs.

Winter Ration: 3 lbs. peas, 3 lbs. bran, 2 lbs. cottonseed meal, 40 lbs. ensilage, 10 lbs. clover hay, with straw *ad lib.* Sometimes oatmeal is substituted for bran.

Summer Ration: Green oats and peas, green corn, with pasture.

52. STORMONT Co. Ayrshire and Holstein Grades. Average weight of cows, 800 lbs.

Winter Ration: 4 lbs. oats, 2 lbs. bran, 45 lbs. ensilage, 10 lbs. timothy and clover hay.

Summer Ration: Green corn, with clover pasture.

53. DURHAM Co. Shorthorns.

Winter Ration: 5 lbs. of barley, oats and peas, in proportion of 2, 1, and 1, by weight, 7 lbs. corn fodder, 5 lbs. hay, 10 lbs. straw, and 30 lbs. roots.

Summer Ration: Green peas and oats, green corn, with pasture.

54. PERTH Co. Ayrshires, Holsteins, and Jerseys.

Winter Ration: 5 lbs. oats, 1 lb. flax seed, 40 lbs. ensilage, 15 lbs. straw, 30 lbs. turnips.

Summer Ration: Green corn, with pasture.

55. STORMONT Co. Cross-bred Jerseys, Ayrshires, and Holsteins. Average weight of cows, 1,000 lbs.

Winter Ration: 10 lbs. equal parts barley and buckwheat, 40 lbs. ensilage, 10 lbs. straw, 5 lbs. roots.

Summer Ration: Green corn, with pasture.

56. CARLETON Co. Ayrshires, Grade Ayrshires, and Shorthorns. Average weight of cows, 1,150 lbs.

Winter Ration: 2 lbs. oil meal, 4 lbs. bran, 40 to 50 lbs. roots, 15 to 20 lbs. ensilage, 10 lbs. hay, 10 lbs. straw.

Summer Ration: Green corn, with pasture.

57. GRENVILLE Co. Grade Ayrshires.

Record: $700 from cheese factory, from 20 cows.

Winter Ration: 4 quarts oats, barley, and peas, 4 quarts bran, 1 handful of flax seed, 2 bushels ensilage, ½ bushel roots, some hay, with corn fodder *ad lib.*

Summer Ration: Green peas and oats, green corn, with pasture. Sometimes bran is fed.

58. ESSEX Co. Grade Jerseys. Average weight of cows, 800 lbs.

Record: 2,539 lbs. butter from 10 cows.

Winter Ration: 8 lbs. mixed oats and corn and cob meal, 40 lbs. ensilage, 10 lbs. straw.

Svmmer Ration: Green rye, clover, oats and peas, and corn, with pasture.

59. OXFORD Co. Ayrshires. Weight of cows, 800 to 1,000 lbs.

Winter Ration: 5 lbs. oats or bran, 2 lbs. oil meal, 50 lbs. ensilage, 8 lbs. clover hay.

Summer Ration: Green peas and oats, green corn, with pasture.

60. BRUCE Co. Grades. Average weight of cows, 1,100 lbs.

Winter Ration: 6 lbs. oats, 6 lbs. flaxseed, 20 lbs. corn fodder, 20 lbs. straw, 20 lbs. roots.

Summer Ration: Green tares, green corn, with pasture.

61. KENT Co. Grade Shorthorns. Average weight of cows, 1,150 lbs.

Winter Ration: 2 lbs. bran, 7 lbs. equal parts by measure of corn and oats, 24 lbs. ensilage, 12 lbs. corn fodder, 6 lbs. straw.

Summer Ration: Green corn with pasture, and 4 lbs. meal mixture mentioned above.

62. HURON Co. Holsteins. Average weight of cows, 1,300 lbs.

Record: 8,000 to 10,000 lbs. milk per head.

Winter Ration: 1 lb. flaxseed, 2 gallons equal parts peas, oats, barley, and bran, 30 lbs. corn fodder, 10 lbs. hay, 12 lbs. straw, 30 lbs. roots.

Summer Ration : Green oats and peas, green corn, rape, white turnips, with pasture.

63. MIDDLESEX Co. Grade Shorthorns. Average weight of cows, 1,000 lbs.

Winter Ration : 6 lbs. corn, ½ lb. barley, ½ lb. bran, ½ lb. oil meal, 8 lbs. sugar beets or carrots, 2 bushels corn fodder, with straw *ad lib.*

Summer Ration : Green corn with pasture.

64. PERTH Co. Grade Holsteins. Average weight of cows, 1,100 lbs.

Winter Ration : 5½ lbs. oats, 1 lb. oil meal, 21 lbs. timothy and Hungarian hay, 8 lbs. oat and barley straw, 17 lbs. turnips.

Summer Ration : Green corn with pasture.

65. YORK Co. Holsteins.

Record : $228.08 from creamery, for 6 cows.

Winter Ration : 7 lbs. equal parts oats, corn, and peas, 52 lbs. of mixture made up of equal parts hay, pea straw, and other straw, cut and mixed with ensilage in proportion of 4 to 5, 20 lbs. roots.

Summer Ration : Green peas and oats, green corn, with pasture.

66. DUNDAS Co. Grade Ayrshires. Average weight of cows, 750 lbs.

Winter Ration : 4 to 6 lbs. bran and oil meal in proportion of 5 to 2 by weight, 35 lbs. ensilage, 5 lbs. hay, 4 lbs. straw.

Summer Ration: Alfalfa, green peas and oats, red clover, and green corn, with pasture.

67. FRONTENAC Co. Ayrshires. Average weight of cows, 1,000 lbs.

Record : Cows average 6,000 lbs. milk.

Winter Ration : 6 lbs. mixed black barley, peas, and oats, 40 lbs. ensilage, 6 lbs. hay, 25 lbs. roots, with some straw.

Summer Ration : Alfalfa and green corn, with pasture.

68. PERTH Co. Grade Shorthorns and Holsteins. Weight of cows, 1,100 to 1,200 lbs.

Record: $365.24 from 8 cows, for cheese and butter.

Winter Ration : 4 lbs. bran, 4 lbs. oats, 2 lbs. barley, 50 lbs. ensilage, with oat straw *ad lib.*

Summer Ration : Pasture.

69. WENTWORTH Co. Crossbred Ayrshire and Shorthorn. Average weight of cows, 800 lbs.

Record : Average of $45 per cow, for cheese and butter.

Winter Ration : 8 to 10 lbs. equal parts by measure of peas and oats, mixed with equal weight of bran, 20 lbs. ensilage, 15 lbs. turnips, 2 bushels chaff, with straw *ad lib.*

Summer Ration : $1\frac{1}{2}$ lbs. bran, green rye, peas and oats, and corn, with pasture.

70. GLENGARRY CO. Ayrshires. Average weight of cows, 850 lbs.

Winter Ration : 2 lbs. oil meal, 5 lbs. mixed oats and barley, 15 lbs. hay, 5 lbs. chaff, 4 lbs. straw, 15 lbs. roots.

Summer Ration : Pasture.

71. WELLINGTON CO. Grade Shorthorns. Average weight of cows, 1,100 lbs.

Winter Ration : 7 lbs. bran, 3 lbs. mixed oats and peas, 35 lbs. ensilage, 3 lbs. chaff, 6 lbs. straw, 15 lbs. roots.

Summer Ration : Green oats and peas, green corn, with pasture.

72. WELLINGTON CO. Shorthorn grades. Average weight of cows, 1,100 lbs.

Winter Ration : 10 lbs. oats, 3 lbs. peas, 25 lbs. corn fodder, 30 lbs. mangels, with straw *ad lib.*

Summer Ration : Green peas and oats, green corn, with pasture.

73. ELGIN CO. Shorthorns. Average weight of cows, 1,200 lbs.

Record : $45 per cow for cheese and butter.

Winter Ration : 12 quarts equal parts bran and oats, with all they can eat of cut corn fodder $\frac{1}{3}$, straw $\frac{2}{3}$.

Summer Ration : Green peas and oats, green corn, with pasture.

74. PERTH CO. Grade Shorthorns. Weight of cows, 1,000 to 1,200 lbs.

Winter Ration : 6 to 10 lbs. equal parts by weight of peas, oats, and barley, 30 lbs. ensilage, 3 lbs. timothy hay, 14 lbs. straw, 10 to 12 lbs. mangels.

Summer Ration : Green peas and oats, green corn, with pasture.

75. DUNDAS CO. Grade Jerseys. Weight of cows, 800 to 900 lbs.

Record : $59.79 per cow. (Cream shipped to Montreal.)

Winter Ration : A mixture of cut corn stalks with ears on, and cut sheaf oats and barley, all the cows can eat, with one feed clover hay, and $\frac{1}{3}$ bushel mangels.

Summer Ration : Green rye, peas, oats or barley, and green corn, with clover pasture.

It is of interest to note that 73 out of the 170 dairymen, feed ensilage, and under the head of "remarks," will be found some interesting testimony regarding ensilage and the corn plant. These remarks consist of extracts from correspondence, and deal with a variety of subjects.

REMARKS.

Northumberland Co.: In our experience, well cured ensilage is the best summer feed. If you have none, then supplement pasture by peas and oats, with corn for later feed.

Prince Edward Co.: I am of the opinion that a liberal supply of ensilage should be kept on hand at all seasons of the year. It is certainly the cheapest food that can be produced, and can be fed with satisfactory results at any time in the season.

Oxford Co.: If we were asked for our opinion as to what will most help the average dairy farmer, I think we should reply : Knowledge of a balanced ration, the Babcock test, and a summer silo ; then varying the feed of individual animals according to capacity and condition, as shown by scales and close observation.

Grey Co.: Have never built a silo, believing the rank smell bad for dairy cows and their products.

Perth Co.: Fed an exclusive ration of silage, with 5 lbs. bran, in the beginning of the winter for three months. Cows ate from 50 to 70 lbs. of it, but in our climate it is not economical ; it is like burning green wood, and there is not enough protein in it. All animals, including horses, were in good health from start to finish of experiment. (See ration 1.)

Peel Co.: We have learned something this winter. We fed no hay until two weeks ago, and our cows have done splendidly all winter. Fed 30 tons timothy hay and 500 bushels wheat last winter, and was in trouble more than once. Will never feed hay and wheat again if I can get a good crop of corn, and bran is not more than $13 a ton. (See ration 5.)

Glengarry Co.: On 65 acres (30 acres corn and 35 acres hay) I have grown sufficient coarse feed for 150 head of cattle for entire winter, or seven months. (See ration 6.)

York Co.: My herd has done well this season, and I like corn ensilage better every year. (See ration 8.)

Stormont Co.: I have ensilage of the best quality, but am unable to feed it to milkers, as it affected the milk unfavorably for city trade. Milk from ensilage fed cows is produced at much less cost than from others. (See ration 10.)

Wentworth Co.: We are feeding cheaply, but have been obliged to do so, owing to a heavy stock and a light crop, excepting corn, which is our main reliance. The silo, with a stable at 60°, is the secret of our cheap feeding. (See ration 16.)

Middlesex Co. I think corn is a good crop for the dairy business, but it should be put in the silo to get the best results.

Russell Co: I fed turnips and mangels during November and December with good results. I find ensilage the best and cheapest food for winter, and all live stock will eat it.

Hastings Co.: Last season was dry and pasture scarce, but we were fortunate in having a large quantity of ensilage left over, and fed about half the usual winter feed during the summer.

Grey Co.: There are not many silos in this locality, a great many preferring to cut their corn and shock it in some place convenient to the barns.

Northumberland Co.: In future we shall grow corn enough to feed cows in the stable during summer. By growing more ensilage we can keep the cows more cheaply and get better returns than when pastured all the time. Cows are turned out at night.

Dundas Co.: I do not use a silo, as the milk company with which I am dealing will have nothing to do with the products of ensilage.

Perth Co.: We all like the silo. I have had one for five years, and have had nothing wrong with a cow during that time. We also feed ensilage to horses, and find it very satisfactory and economical winter feed. The drouth, frosts, and grasshoppers during the past two seasons have taught us that corn is a cheap and satisfactory substitute for hay.

Durham Co.: I have not seen a silo as yet. I think there are two in this township.

Leeds Co.: Intend to build a silo this summer. Think they are a grand thing.

Stormont Co.: Tares and oats are the best green fodder for milch cows that I have tried. Tares have no equal as green fodder for pigs, when fed with skim milk.

York Co.: Never fed potatoes until this year. Am feeding 6 lbs. per day, and cows are fond of them and seem to do well on them.

Bruce Co.: Last year was a severe one with us. Green fodder killed by frost ; very poor pasture. Corn was our salvation and brought us through.

Perth Co.: I find that dairying all the year round pays very well. I have my cows "come in" in October, November, December, April and May.

Durham Co.: I consider that the cows pay better than anything else on the farm.

Hastings Co.: Feed some meal in summer, but think it hardly pays where one has plenty of green feed and grass.

Hastings Co.: We endeavor to keep our cows and heifers in lactation to within three weeks of calving. Most of our cows "come in" during the winter. Each animal is fed in proportion to its wants—no set rules, except rigid exactness in the hours of feeding. (See ration 45.)

Dundas Co.: I believe in winter dairying, and in milking cows at least ten months. Have some cows that have been dry only four weeks that are now giving 40 lbs. milk per day on winter ration. (See ration 4.)

Oxford Co.: We feed twice a day. We stopped feeding three times a day about ten years ago and would never think of resorting to it again. (See ration 59.)

Bruce Co.: The people in this section have not gone into dairying in the proper manner, but the scarcity of grass will cause more green fodders to be grown in future. (See ration 60.)

Huron Co.: We think meal in summer for cows would not pay in our locality.

Brant Co.: I generally feed hay at noon, but this year hay was dear and straw plentiful, so cows were fed straw, and did nearly or quite as well as formerly.

Frontenac Co.: I feed some alfalfa and intend to sow more.

Wentworth Co.: Can make farm pay 6 per cent. interest on an investment of $100 per acre, after allowing myself a salary of $500 a year and paying all hired help.

Dundas Co.: Am using pure bred bulls on native stock, and breeding up. Started nine years ago. Use Babcock test, and weigh each cow's milk, keeping records.

Leeds Co.: I believe it pays to feed meal regularly and to keep it up during the whole season.

Principles of Feeding.

In the first place, we must understand that plants contain substances almost identical in composition with the substances which comprise the animal body. Animals eat plants, digest a portion of them, and use the digested portion in building up the different parts of their bodies, in producing milk, or in producing heat and energy. Thus, some of the substances form bone, some form flesh, muscle, blood, or milk; some form fat; while others are consumed in the production of heat, which is necessary to sustain animal life and energy.

The substances of which plants are composed may be grouped under five heads, as follows:

1. Water.
2. Ash, or mineral matter.
3. Protein (sometimes spoken of as "proteids," or "albuminoids.")
4. Carbohydrates, (also called "nitrogen free extract.")
5. Fat (sometimes called "ether extract.")

It is impossible to estimate accurately the value of the water which foods contain. In many cases the water seems to increase very materially the feeding value of the fodder, which fact is strikingly illustrated in the case of pasture grass and roots; and, apart from this feeding value, such succulent fodders have a beneficial effect in keeping the animal system in good working order.

Ash, or *mineral matter*, is used in the formation of bone, and is therefore of importance in feeding young growing stock. The high value of oats in feeding young animals is due to the fact that oats are especially rich in mineral matter, and are therefore good bone formers, while it is well known that an exclusive grain ration of corn is injurious to young stock, simply because corn is deficient in ash.

Protein contains nitrogen, and is concerned in the formation of flesh, muscle, blood, milk, hair, wool, horn, etc., and, probably to some extent fat. It may also supply heat and mechanical force, enabling the animal to do work. By work is meant any kind of muscular exertion.

Fat undergoes combustion in the body, producing heat which is necessary to create mechanical force. It is also stored up in the body as fat, to be used when required. Thus fat animals can live a long time without food, the fat that has been stored up supplying heat.

Carbohydrates are concerned chiefly in the production of heat and fat. They form the largest part of vegetable foods.

If an animal is fed upon protein alone, it cannot live long, but will become sickly and die in a comparatively short time. Protein is also more expensive than carbohydrates, and therefore it is a wasteful practice to feed more protein than is necessary. At the same time, in order to obtain the best results, a certain amount of protein is necessary, as is also a certain amount of fat; and the object of the feeder is to compound a ration whith contains these three substances (protein, carbohydrates and fat) in the most suitable proportions. Such a ration is called a "balanced ration."

The relation which the digestible protein bears to the digestible carbohydrates and fat is called the "nutritive ratio" of a fodder. Thus, if we say that the nutritive ratio of a fodder is 1:7, we mean that there is one part of digestible protein to seven parts of digestible fat and carbohydrates.

The value of a fodder depends upon its composition and its digestibility. No fodders are entirely digestible, though roots and milk are very nearly so. We cannot therefore determine the nutritive ratio of a fodder from its composition only, but we must know what portion of each constituent is digestible.

The only basis upon which the different nutrients can be compared is in respect to their capacity for producing heat. In the production of heat, fat has about 2.2 times the value of carbohydrates; therefore, if we multiply any given amount of fat by 2.2, the product will represent the amount of carbohydrates which the given amount of fat is equal to. By some the fat is multiplied by 2.5, and by others by 2.29, or 2.3, but the factor 2.2 may be regarded sufficient for all practical purposes.

If we wish to find the nutritive ratio of a fodder, we must first find the digestible nutrients which it contains. Then the amount of fat is multiplied by 2.2 to express the amount of carbohydrates that it is equal to. The product thus obtained is then added to the amount of carbohydrates, which gives the total amount of carbohydrates which the fat and carbohydrates are together equal to. Then this number is divided by the amount of protein. For example, we will determine the nutritive ratio of barley. According to the table, it contains digestible nutritients in 100 pounds as follows: Protein, 9.5; carbohydrates, 66.1; fat, 1.2. Then, multiplying the fat by 2.2 we get $1.2 \times 2.2 = 2.64$. Adding this product to the carbohydrates we get $66.1 + 2.64 = 68.74$; therefore nutritive ratio = 9.5 to 68.74. But it is customary to express the digestible protein as 1, therefore we must divide by the amount of protein, which gives nutritive ratio, 1 to 7.23.

By means of many experiments, feeding standards have been compiled for different classes of stock. To German experimenters belongs the credit of first investigating the matter, and Dr. Emil Wolff, a noted German scientist, proposed the following feeding standard for dairy cows.

A dairy cow in full milk should receive per day and per 1,000 pounds live weight:

Total organic matter	24 lb.
Digestible protein	2.5 "
" carbohydrates	12.5 "
" fat	.4 "
Total digestible nutrients	15.4 lb.
Nutritive ratio	1 to 5.4

The German standard given above does not correspond with the practice of American dairymen; and, after obtaining information regarding the rations fed by a great many leading dairymen in the United States and Canada, the Wisconsin Experiment Station recommends the following standard, which is sometimes called the American standard ration for dairy cows:

Total organic matter	24.51 lb.
Digestible protein	2 15 "
" carbohydrates	13.27 "
" fat	.74 "
Total digestible nutrients	16.2 lb.
Nutritive ratio	1 to 6.9

It is possible that the American standard may prove more satisfactory than the German.

Composition of Fodders.

Below is given a table representing the amount of digestible nutrients in 100 lbs. of the most important fodders. The figures given in this table have been selected from various sources, and in some instances they will be found to differ from those of other tables which have been published; but, on the whole, the variations are slight, and do not affect the practical value of the table.

The column under "Total Organic Matter," contains the total amount of digestible and indigestible protein, carbohydrates, and fat, in the different fodders.

POUNDS OF NUTRIENTS IN 100 POUNDS OF FODDER.

Fodder.	Digestible protein.	Digestible carbohydrates.	Digestible fat.	Total organic matter.
Pasture grass	2.6	10.6	.5	18.0
Green fodder corn	1.3	11.8	.7	19.5
Green clover	2.9	14.1	.4	27.1
Green rye	2.1	14.1	.4	21.6
Green oats	2.7	22.7	1.0	35.3
Corn silage	1.3	14.0	.7	24.2
Fodder corn, dry	3.7	40.4	1.2	66.8
Red clover hay	6.5	34.9	1.6	78.5
Alfalfa hay	7.6	37.8	1.3	84.2
Timothy hay	3.0	43.9	1.2	82.4
Oat straw	1.6	41.4	.7	85.7
Pea straw	4.3	32.3	.8	79.8
Potatoes	1.4	16.1	.1	20.1
Sugar beets	1.1	9.3	.1	12.6
Mangels	1.1	4.8	.2	8.0
Turnips	.6	5.5	.2	8.7
Carrots	1.0	7.1	.3	10.4
Corn	7.1	62.7	4.2	87.6
Corn and cob meal	6.5	56.3	2.9	83.4
Oats	9.1	44.7	4.1	86.0
Barley	9.5	66.1	1.2	86.7
Wheat	9.2	64.9	1.4	87.7
Wheat bran (roller)	12.6	44.1	2.9	82.4
Wheat bran (stone)	10.1	47.5	2.6	83.1
Wheat shorts	11.6	45.4	3.2	83.6
Wheat middlings	12.2	47.2	2.9	84.5
Rye	8.3	65.5	1.2	86.5
Buckwheat	7.7	49.2	1.8	85.4
Pea meal	18.0	56.0	.9	86.9
Malt sprouts	19.8	36.2	1.7	84.5
Brewers' grains	3.9	9.5	1.3	23.3
Brewers' grains, dried	16.2	35.5	5.3	88.7
Gluten meal	25.0	49.4	5.6	89.7
Starch feed, wet	5.5	21.7	2.3	34.3
Cotton seed meal	36.9	18.1	12.3	84.6
Linseed meal, old process	28.3	32.8	7.1	85.1
Linseed meal, new process	27.2	32.9	2.7	84.1
Skimmed milk	3.1	4.7	.8	8.9
Buttermilk	3.9	4.0	1.1	9.2
Whey	.8	4.7	.3	5.9
....	3.5	4.8	3.7	12.0

N.B.—Linseed meal is the American name for oil cake, or oil meal.

Formulating Rations.

If we wish to formulate a ration, we must first make a trial ration of the foods we wish to use, find out how much of the different nutrients it contains, and, if the nutrients are not in the right proportion, we can add to or take away from the quantities of foods used in the trial ration. Suppose we wish to form a ration from clover hay, ensilage, and bran. For a trial ration we might take, bran, 8 lb.; clover hay, 6 lb., and ensilage, 40 lb.

By referring to the table we can find the amount of digestible nutrients in 100 lb. of each food, and therefore to find the amount in 1 lb. we must divide the numbers given in the table by 100. Thus we get :

—	Protein.	Carbo-hydrates.	Fat.	Total organic matter.
1 lb. bran contains	.126	.441	.029	.824
1 lb. clover hay contains	.065	.349	.016	.785
1 lb. ensilage contains	.013	.140	.007	.242
Therefore				
8 lbs. bran contain	1.008	3.528	.232	6.792
6 lbs. clover hay contain	.390	2.094	.096	4.710
40 lbs. ensilage contain	.520	5.600	.280	9.680
Total	1.918	11.222	.608	21.182

Comparing our trial rations with the American standard, we see that it is too low in all its constituents, especially in carbohydrates and total organic matter. If we try to make up the deficiency by means of ensilage or clover hay, our ration will become too bulky; while if we attempt to make it up with bran, the protein will be unduly increased. This would indicate that it is impossible to make a well balanced ration from the food stuffs selected, and the simplest way out of the difficulty would be to select some grain that is rich in carbohydrates and organic matter, with only a moderate amount of protein and fat. Looking over our list of food stuffs, we find that barley fulfils these conditions, while we might also slightly increase the amount of ensilage. We shall therefore add to our trial ration 2 lb. barley and 5 lb. ensilage.

Referring to our composition table we find :

—	Protein.	Carbo-hydrates.	Fat.	Organic matter.
lb. barley contains	.095	.661	.012	.867
Therefore				
2 lb. barley contain	.190	1.322	.024	1.734
5 lb. ensilage contain	.065	.700	.035	1.210
Trial ration contained	1.918	11.222	.608	21.182
Total	2.173	13.244	.667	24.126

As it now stands, the ration is intermediate between the German and American standards, and may be accounted approximately correct.

If we wish to find the nutritive ratio of the above ration, we first multiply the fat by 2.2 and add the result to the carbohydrates, thus: $(.667 \times 2.2) + 13.244 = 14.711$. Therefore nutritive ratio is 2.173 to 14.711, or 1 to 6.75.

The above is only an example of how the standard may be used in formulating a ration, and, from what has been said, it will be seen that a great variety of rations may be compounded which are practically the same in composition, and which will give equally good results. In every case the feeder must be guided by the kinds of food which he has at his disposal.

The digestibility and nutritive value of a food may vary very much, and the feeder must take this into consideration. Especially is this true of coarse fodders, such as hay, straw, ensilage, etc., the grain being more constant. For example, hay that is well cured is more nutritious than that which has become very ripe, or that has been too much exposed to the weather.

Then again, animals vary with regard to the amount of food which they are able to assimilate, making it necessary for the feeder to study the individual animals under his care, and to modify his methods according to results.

It will therefore be understood that while a feeding standard is valuable as a general guide, it cannot be blindly followed, and a great deal must be left to the intelligence of the feeder.

Discussion of Some Rations Furnished in Report.

For the purpose of comparing some of the rations used by Ontario dairymen, with the German and American standards, a few of the more definite ones have been selected, and their digestible nutrients ascertained. Too much importance must not be attached to the composition of these rations, since, in some cases, the quantities of feed given are simply approximations. However, the rations are sufficiently definite to be of interest and value to the careful student.

For convenience of reference, the German and American standard rations for dairy cows are placed at the head of the list. It must be borne in mind that these standards represent the amounts of organic matter, and of digestible nutrients required per 1,000 lbs. live weight of the animal; and that the term "total organic matter" means the total amount of dry matter furnished in the ration, including both the digestible and indigestible constituents of the food.

The constituents of the rations analyzed below have all been calculated per 1,000 lbs. live weight of cows, and the number opposite each ration corresponds with its number in the report, so that it can readily be referred to.

Table Showing Constituents of some Ontario Rations for Dairy Cows.

Number of ration.	Total organic matter.	Digestible matter.				Nutritive ratio.
		Protein.	Carbo-hydrates.	Fat.	Total.	
	lbs.	lbs.	lbs.	lbs.	lbs.	
German Standard	24.00	2.50	12.50	.40	15.40	1 : 5.4
American Standard	24.51	2.15	13.27	.74	16.16	1 : 6.9
No. 1	25.47	2.27	12.83	.81	15.91	1 : 6.4
" 2	29.80	2.07	15.12	.32	17.31	1 : 7.6
" 5	27.64	2.34	19.20	.71	22.25	1 : 8.8
" 6	21.21	1.90	11.00	.84	13.74	1 : 6.6
" 8	32.19	1.90	17.68	1.06	20.64	1 : 10.5
" 9	27.52	2.04	14.72	.73	17.49	1 : 8.0
" 11a	22.30	1.13	11.58	.60	13.31	1 : 11.4
" 11b	25.01	1.99	12.56	.81	15.36	1 : 7.2
" 12a	26.46	1.69	14.71	.73	17.13	1 : 9.7
" 12b	26.47	1.96	14.26	.62	16.84	1 : 8.0
" 13	26.35	1.50	13.16	.65	15.31	1 : 9.7
" 14	29.84	2.29	17.05	.85	20.19	1 : 8.3
" 15	25.56	1.56	13.15	.56	15.27	1 : 9.2
" 17	28.31	2.25	14.30	.74	17.29	1 : 7.5
" 18a	29.82	3.30	18.41	1.20	22.91	1 : 6.4
" 18b	24.93	2.95	13.58	1.06	17.59	1 : 5.4
" 19	18.52	1.31	9.60	.45	11.36	1 : 8.1
" 20	23.42	2.77	11.12	.66	14.55	1 : 4.5
" 23	28.17	1.65	15.15	.41	17.21	1 : 9.7
" 25	31.57	1.35	16.05	.42	17.82	1 : 12.6
" 31	25.94	2.07	13.73	.57	16.37	1 : 6.7
" 32	23.99	1.45	12.70	.44	14.59	1 : 9.4
" 35	19.43	1.27	9.95	.54	11.76	1 : 8.8
" 36	28.18	2.10	14.42	.85	17.37	1 : 7.7
" 37	24.83	2.40	13.26	.69	16.35	1 : 6.1
" 39	26.17	2.29	13.36	.65	16.30	1 : 6.4
" 46	28.00	1.60	15.05	.55	17.20	1 : 10.1
" 49	25.55	1.76	14.25	.63	15.88	1 : 8.9
" 50	26.54	1.59	14.39	.82	16.80	1 : 10.2
" 51	26.66	2.88	11.52	.86	15.26	1 : 4.7
" 72	26.14	2.13	14.92	.68	17.73	1 : 7.7

Criticisms and Suggestions Regarding Rations Shown in Table.

Ration No. 1 : A well-balanced ration, though the value of the oat and vetch hay had to be approximated.

Ration No. 2 : Also a fairly well-balanced ration, but it is probable that the quantity of hay has been over-estimated, making the *total organic matter* too high.

Ration No. 5 : Too high in *organic matter* and *carbohydrates*, but *protein* and *fat* satisfactory. No doubt straw has been over-estimated. Reducing the quantity of straw would narrow the ratio and make the ration very well-balanced.

Ration No. 6 : Estimated on basis of 2 lbs. cotton seed meal, 4 lbs. shorts, 50 lbs. ensilage and 5 lbs. hay. Too low in all constituents except fat, though nutritive ratio is satisfactory. Slightly increasing the shorts, and adding a little clover hay, would tend to remedy the fault.

Ration No. 8: No doubt there is some mistake here in estimating the quantities of fodder, as the ration appears abnormal.

Ration No. 9 : The straw has probably been over-estimated, as the ration is high in *organic matter* and *carbohydrates*. A less quantity of straw would also tend to balance the ration. Making this allowance, the ration looks like a very good one.

Ration No. 11a : Low in all constituents, especially protein. The protein could not be materially increased by feeding more straw, though the *organic matter* and *carbohydrates* could thus be made satisfactory. *No. 11b* shows the same ration with 3 lbs. old process oil meal added. The improvement will be noted.

Ration No. 12a: By referring back to Ration No. 12 as given in the report, it will be seen that 3 lbs. pea meal is sometimes fed in place of 3 lbs. corn meal. *No. 12a* represents ration with corn meal, and *No. 12b* with pea meal. The pea meal has made the ration better balanced, though it is still deficient in protein.

Ration No. 13: The main fault of this ration is that it is too low in *protein*. If the oil meal mentioned is fed in place of part of the oats, it will make an improvement.

Ration No. 14 : Abnormally high in *organic matter* and *carbohydrates*. It is quite probable that the rough fodders have been over-estimated. Reducing the corn fodder would balance the ration very well.

Ratio No. 15 : Very low in *protein*. The addition of the oil meal mentioned would improve the ration.

Ration No. 17 : Rather high in *organic matter* and *carbohydrates*, though it may be called a fairly well-balanced ration. The weight of rough fodders has likely been over-estimated.

Ration No. 18 : *No. 18a* represents the ration as given in the report, and it will be noticed that it is abnormally high in all its constituents. This indicates that there must be some mistake in describing the ration, and therefore it was calculated again, with 20 lbs. ensilage instead of 20 lbs. corn fodder, and numbered *18b*. The change has made an improvement, though it is still very high in *protein* and *fat*, which would indicate an expensive ration.

Ration No. 19: Very low in all constituents except fat, which indicates that quantities of fodder have been under-estimated.

Ration No. 20: In calculating this ration the straw has not been taken into account, which renders the nutritive ratio very narrow. The most marked feature of the ration is the large amount of *protein*, which indicates an expensive ration.

Ration No. 23 : Low in *protein*. If bran were substituted for barley, it would make an improvement.

Ration No. 25 : Extremely low in *protein*, and high in *carbohydrates* and *organic matter*. Corn and barley are both low in *protein*.

Ration No. 31 : Apparently a very well balanced ration.

Ration No. 32 : Very low in *protein* The addition of a few pounds of bran would improve the ration.

Ration No. 35 : Low in all constituents except *fat*. Cows probably eat more straw than is estimated, but this would not sufficiently increase the *protein*. The need of more bran or oil meal is indicated.

Ration No. 36 : A very well balanced ration. It has been calculated for timothy hay, but if clover hay is fed, the ration would be still better balanced.

Ration No. 37 : A well balanced ration, indeed. The 9 lbs. mixed bran and shorts have been calculated as shorts, but this makes very little difference.

Ration No. 39 : Also an exceptionally well balanced ration.

Ration No 46 : Too low in *protein*, and high in *carboydrates*. Could be made better balanced by increasing the amount of peas and bran. It has been assumed that cows eat 10 lbs. straw, which is probably too high an estimate.

Ration No. 49 : Rather low in *protein*. This could be remedied by increasing the amount of oil meal, or by adding bran.

Ration No. 50 : Low in *protein*. Substituting some bran or oil meal for part of the oats, would increase the *protein*.

Ration No. 51 : Very high in *protein*, which indicates an expensive ration. In calculating ration, no allowance was made for straw, which makes the nutritive ratio narrower than it would otherwise be.

Ration No. 72 : A fairly well balanced ration, though containing a large amount of meal.

Conclusion.

As stated before, no standard of feeding can be blindly followed, and it may be quite possible that some of the suggestions offered above will prove impracticable for the dairyman using the ration. A farmer must make the best possible use of the fodders at his disposal, and he may sometimes find that it pays him better to use a comparatively poorly balanced ration, rather than sell the grain he has on hand in order to purchase fodders with which to form a balanced ration. The suggestions and criticisms, therefore, may be taken for what they are worth, as they are intended merely as helps to those who may decide to copy any of the rations mentioned. Considerable variety is offered, and a study of the table, in connection with the study of the rations represented therein, will be a help in making an intelligent selection.

Another very important point must not be overlooked. Feeding is only one side of the question, and, though it may do much, it cannot do all. The value returned for the food consumed depends upon the cow, and a *good* cow fed upon a poorly balanced ration, will do better for her owner than a poor cow fed in the most scientific manner. *Feeding*, *breeding*, and *weeding* are inseparably connected in the successful maintenance and improvement of a dairy herd.

APPENDIX.

The Live Stock Committee is indebted to the following gentlemen, for information:

Abbott, Wm ...... Lakefield.
Anderson, Jas..... Guelph.
Anderson, J........ Alsfeldt.
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Collins, O.......... St. George.
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Clow, J........... Whitechurch.

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Eastern Ontario Dairymen's Association.

R. G. Murphy, Elgin, Ont., Secretary.

The annual meeting will be held at Brockville, on January 6th, 7th and 8th. The principal speakers will be Hon. Sidney Fisher. Hon. John Dryden, Ex-Governor W. D. Hoard of Wisconsin, and Profs. Robertson, Dean, Fletcher and Ruddick.

The Ontario Creameries' Association.

Mark Sprague, Ameliasburg, Ont., Secretary.

The annual meeting will be held at St. Marys on January 13th, 14th and 15th. Principal speakers, Hon. W. D. Hoard, of Wisconsin, Hon. John Dryden, Hon. S. A. Fisher, Prof. Robertson, Dr. James Mills, Prof. Dean, Prof. James Fletcher.

The Dairymen's Association of Western Ontario.

J. W. Wheaton, London, Secretary.

The next meeting will be held at Brantford, on January 19th, 20th, 21st. Principal speakers, Hon. W. D. Hoard, of Wisconsin ; J. H. Monrad, of Illinois ; Hon. A. S. Hardy, Premier of Ontario ; Hon. Sidney Fisher, Minister of Agriculture for Canada ; Hon. John Dryden, Minister of Agriculture for Ontario ; Hon. Thos. Ballantyne, Stratford ; Andrew Pattullo, M.P.P., Woodstock ; Prof. J. W. Robertson, Dominion Dairy Commissioner ; Prof. H. H. Dean, of the Agricultural College, Guelph.

The Poultry Association of Ontario.

Thos. A. Browne, London, Ont., Secretary.

The twenty-third annual meeting and exhibition will be held at Guelph, in the Drill Shed, January 11th to 16th. A public meeting will be held on Thursday, January 13th, at 8 p. m. Addresses by Hon. John Dryden, Dr. James Mills, Mr. Thos. Gowdy, A. G. Gilbert and others.

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Ontario Agricultural College and Experimental Farm

INSTRUCTIONS IN SPRAYING.

By J. H. Panton,

Professor of Biology, Ontario Agricultural College.

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THE ONTARIO AGRICULTURAL COLLEGE

AND

EXPERIMENTAL FARM, GUELPH, ONT.

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BULLETIN No. 105.

INSTRUCTIONS IN SPRAYING.

By J. Hoyes Panton, Professor of Biology, Ontario Agricultural College.

SOLUTIONS RECOMMENDED.

1. Bordeaux Mixture.

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

Suspend the copper sulphate in five gallons of water. This may be done by putting it in a bag of coarse material, and hanging it, so as to be covered by the water. Slake the lime in about the same quantity of water. Then mix the two and add the remainder of the 40 gallons of water.

Warm water will dissolve the copper sulphate more readily than cold water. If the lime is at all dirty strain the lime solution.

If the lime is good the above amount is likely to be sufficient. It is an easy matter to know how much lime is required by using what is termed the ferrocyanide of potassium test. This substance can be got at any druggist's, and very little is required. Take a small bottle (2 oz) and get it filled with a saturated solution of this compound. If there is not plenty of lime in your mixture, a drop of the test added to it, turns brown. Add more lime and stir. As soon as the test fails to color in coming in contact with your mixture, it indicates there is sufficient lime present to neutralize the effects of the copper sulphate. Use wooden vessels in preparing the Bordeaux mixture.

2. Ammoniacal Copper Carbonate Solution ("Cupram").

Copper carbonate	1 ounce.
Ammonia sufficient to dissolve the copper carbonate.	
Water	10 gallons.

This solution is not much used, and is recommended only in cases where the fruit is so far advanced that it would be disfigured by using the Bordeaux mixture.

3. Paris Green Mixture.

Paris green	1 pound.
Water	200 to 300 gallons.

Use 200 gallons of water in a mixture for apple trees, 250 for plum trees, and 300 for peach trees. When Paris green is added to Bordeaux mixture, so as to form a combined insecticide and fungicide, add four ounces to every 40 gallons of the Bordeaux mixture.

4. Hellebore.

White hellebore (fresh).....................	1 ounce.
Water	3 gallons.

5. Pyrethrum.

Pyrethrum powder (fresh)	1 ounce.
Water	4 gallons.

6. Kerosene Emulsion.

Hard soap .... ½ pound, or soft soap,	1 quart.
Boiling water (soft)	1 gallon.
Coal oil	2 gallons.

After dissolving the soap in the water, add the coal oil and stir well for 5 to 10 minutes. When properly mixed, it will adhere to glass without oiliness. A syringe or pump will aid much in this work. In using, dilute with from 9 to 15 parts of water. Kerosene emulsion may be prepared with sour milk (1 gallon), and coal oil (2 gallons), no soap being required. This will not keep long.

Notes.

1. When there is danger of disfiguring fruit with the Bordeaux mixture use the ammoniacal copper carbonate solution.

2. Experience in spraying during the past two years indicates that it is best to use the combined insecticide and fungicide, commencing as soon as the buds begin to swell, again when the leaves appear, and continue it at intervals of 10 to 15 days, until the trees have been sprayed, 3 to 5 times, which will depend upon the weather. In the case of a rainy season, it may be necessary to spray at least five times, while if dry, and the mixtures have been allowed to remain on the foliage, then three or four times may be sufficient.

In no case spray while the trees are in bloom, but immediately after.

3. The combined insecticide and fungicide, containing Paris green and Bordeaux mixture, is to be used for insects that chew, and injurious fungi, but kerosene emulsion alone for those insects that suck the juices of plants, such as aphis, thrip, red spider, etc.

4. A stock solution for the preparation of Bordeaux mixture may be prepared as follows: Dissolve 25 pounds of copper sulphate in 25 gallons of water. One gallon of this contains one pound of the copper sulphate. In another barrel slake 25 pounds of good lime, and add 12½ gallons of water. One gallon of this contains two pounds of lime. To make the mixture, take four gallons of the copper sulphate solution and two of the lime. If there is any doubt about there not being sufficient lime try the test already referred to under Bordeaux mixture. Now fill up the amount to 40 gallons with water.

5. Prepare the mixtures well, apply them at the proper time, and be as thorough as possible in the work.

TREATMENT.

1. Apple.

Treatment for destroying *codling moth*, *bud moth*, *tent caterpillar*, *canker worm*, *apple spot* and *leaf blight.*

First spraying: Bordeaux mixture and Paris green (4 oz. to the barrel of the mixture) when the buds are swelling.

Second spraying: Bordeaux mixture and Paris green before the blossoms open.

Third spraying: Bordeaux mixture and Paris Green when the blossoms have fallen.

Fourth and fifth spraying: Bordeaux mixture and Paris green at intervals ten to fifteen days, if necessary.

2. Pear.

Leaf blight, *scab* and *codling moth*, the same treatment as for the apple.

3. Plum.

Curculio, *brown rot* and *leaf blight.*

First spraying: Bordeaux mixture before the flower buds open.

Second spraying: Bordeaux mixture and Paris green as soon as the petals have fallen.

Third spraying: Bordeaux and Paris green in seven to ten days after.

Fourth spraying: Bordeaux mixture in ten to fifteen days after.

4. Peach.

Brown fruit rot, *leaf blight* and *plum curculio.*

First and second sprayings: Same as for the treatment of the plum.

Third spraying: Bordeaux mixture in two to three weeks.

Fourth spraying: Ammoniacal copper carbonate if any danger of disfiguring the fruit with Bordeaux mixture.

5. Cherry.

Aphis, *slug*, *brown rot* and *leaf blight.*

First spraying: Bordeaux mixture as the buds are breaking; if the *aphis* appears use kerosene emulsion alone.

Second spraying: Bordeaux mixture and Paris green, as soon as the blossoms fall.

Third spraying: Bordeaux mixture and Paris green ten to fifteen days after.

6. Grapes.

Mildew, *black rot* and *flea beetle.*

First spraying: Bordeaux mixture and Paris green when leaves one inch in diameter.

Second spraying: Bordeaux mixture and Paris green when flowers have fallen.

Third and fourth sprayings: Bordeaux mixture at intervals of ten to fifteen days.

Paris green alone when the beetle is attacking the buds in the spring.

7. Raspberry.

Anthracnose and *leaf blight.*

First spraying Bordeaux mixture just before growth begins.

Second spraying: Bordeaux mixture about when first blossoms open.

Third spraying: Bordeaux mixture when the fruit is gathered.

8. Currant and Gooseberry.

Worms and *mildew.*

First spraying: Bordeaux mixture and Paris green as soon as the leaves expand.

Second spraying: The same ten to fifteen days later.

For worms alone, hellebore or Paris green will be effective.

9. Tomato.

Rot and *blight.*

Spray with Bordeaux mixture, as soon as rot or blight appears, for three times, if necessary at intervals of ten to fifteen days.

10 Potato.

Blight and *beetles.*

First spraying: Paris green as soon as the beetles appear (one pound to 100 gallons of water).

Second spraying: Bordeaux mixture and Paris green, when plants six inches high.

Third and fourth sprayings: Bordeaux mixture at intervals of ten to fifteen days, if necessary.

11. Cabbage.

Pyrethrum applied in solution (one ounce to four gallons of water) or dusted on (one part pyrethrum to seven parts flour) for the cabbage worm.

12. Strawberry.

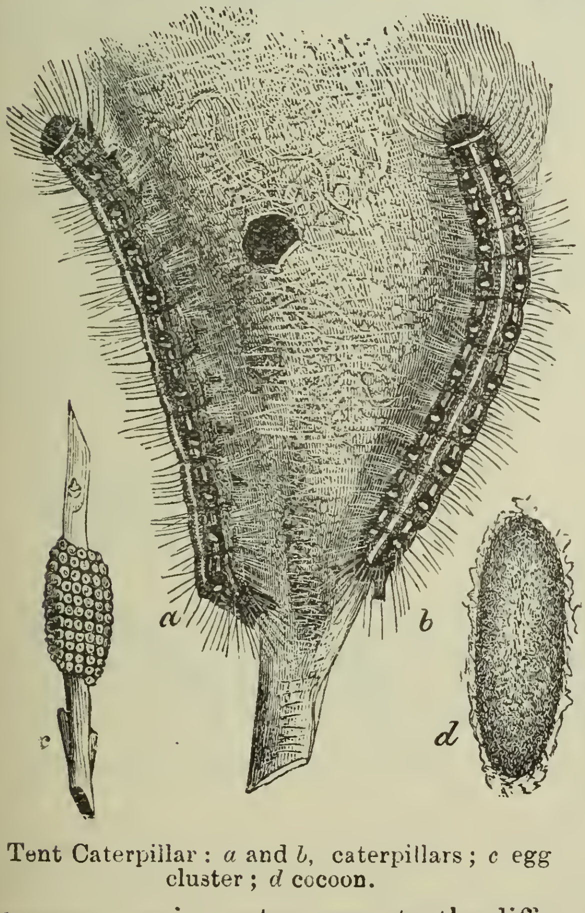
The *rust* or *leaf-blight.*

Bordeaux mixture when it can be applied without disfiguring the fruit will control this disease. Apply at intervals of two or three weeks on new beds after they begin to make runners.

INJURIOUS INSECTS.

The following are some of the most common injurious insects that are troublesome in the garden and orchard. To destroy these, spraying as directed will be effective. To destroy insects only use an insecticide, but if treating for a fungoid pest at the same time use a combined fungicide and insecticide.

1. Tent Caterpillars —*Clisiocampa Americana*, and *C. Sylvatica.*



Tent Caterpillar: *a* and *b*, caterpillars; *c* egg cluster; *d* cocoon.

Tent Caterpillar moth.

These insects weave large webs in the branches of the apple tree and do much damage feeding upon the foliage of the trees. It also attacks the plum and cherry. The eggs—200 to 300— are laid in rings upon the twigs of the trees and can be readily seen, so that many of them might easily be destroyed during the winter. The caterpillars grow rapidly. *Americana* has a white stip down the back, and *Sylvatica* a series of white spots, and thus they are readily distinguished from each other. Both develop into brown moths. The accompanying cut represents the different stages of the insects. *C. Americana.*

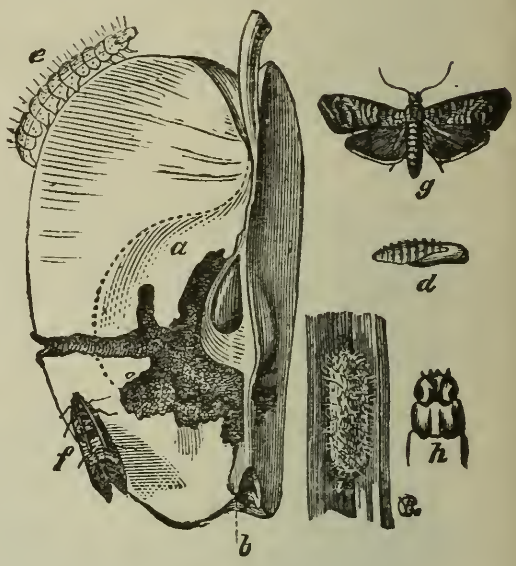
Remedy.—1. Collect the egg clusters in winter. 2. Crush the "tents when full of caterpillars. 3 Apply Paris green alone or with Bordeaux mixtur

2. Codling Moth.—*Carpocapsa pomonella*

The eggs of this tiny moth are laid on the calyx of the young apple, while it is turned up. As soon as hatched the larva burrows into the apple, where it feeds until fully developed. Affected apples fall to the ground, and often contain the worm in them. The cocoons are frequently under the bark and in other sheltered spots.

The moth appears about the time the trees are in bloom, and is one of the worst pests that attacks the apple.

Remedy.—1. Feed to hogs the fallen apples which may contain larva. 2. Spray with Paris green, as directed for the treatment of the apple.

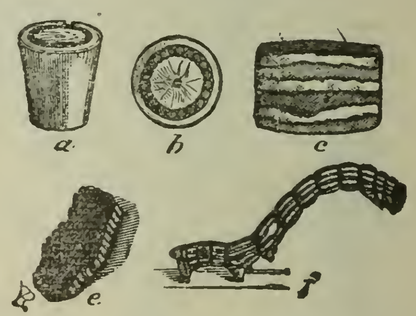


Codling moth: *a*, burrow; *b*, entrance hole; *d*, pupa; *e*, larva; *f*, moth.

3. Canker-Worms.—*Anisopteryx vernata* and *A. pometaria.*

The spring canker-worm was very common in 1896. Both worms are much alike, about an inch long, of a darkish brown color, slender, and move with a

Canker Moths: *a*, male; *b*, female.



Canker Worm (*f*), and eggs (*a b. c.*)

loop-like motion; hence, sometimes called "measuring worms." They can drop from a tree by a silken thread.

A. vernata, the imago, appears in spring, the female is wingless, the male is ash-colored and has wings. *A. pometaria* is much the same, but the imago appears in the fall. The wingless females in both species crawl up the trunks to lay their eggs upon the twigs.

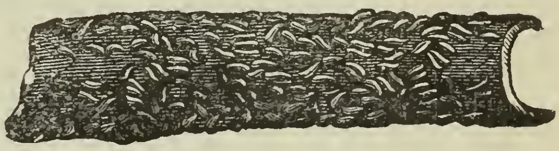
These insects attack the plum, cherry and apple. The accompanying cuts illustrate *A. vernata.*

Remedy.—The females may be trapped by putting a band of some adhesive material around the tree.

2. Paris green is an effective remedy, as directed in the treatment of the apple.

4. Oyster-shell Bark-louse.—*Mytilaspis pomorum.*

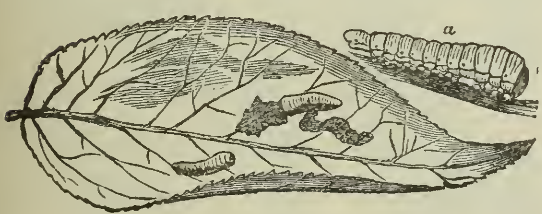
This insect appears in the form of minute brown scale upon the bark of the apple tree, and being much the same color is difficult to distinguish. The eggs are beneath the scales. They hatch about the end of May or the beginning of June. The young lice are almost invisible; they suck the ends of the young twigs, where they become fixed, and continue to suck the juice from the twigs. Soon a scale forms over them. All under the scales, the shape of an oyster-shell, are females, that lay their eggs under the scale. The scale of the male is more oblong and is rarely seen.


Oyster shell Bark-Louse.

Remedy.—1. In winter, or early spring, scrape off the rough bark from the trunk and large limbs, and rub in with a scrubbing-brush the following solution: One quart soft soap, or one-quarter pound hard, in two quarts boiling water; take seven parts of this and add one part carbolic acid; then, when the young lice are moving (May or June), spray with kerosene emulsion, diluted with ten parts water.

5. Pear-tree Slug.—*Eriocampa cerasi.*

This insect may be found attacking the pear, plum and cherry.



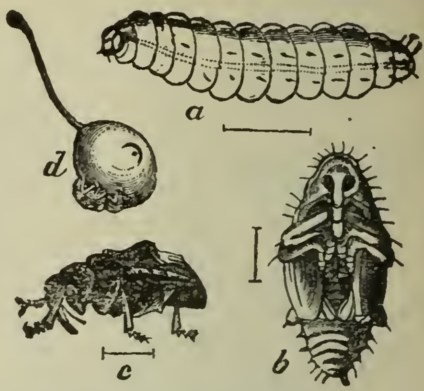
Pear tree slug, various sizes.

The eggs are laid about June. The larva is about one-half inch in length and is thicker towards the head, of a somewhat greenish-black color and slimy. It has many legs. The pupa stage is spent in the ground and lasts two weeks. The imago is a small, four-winged black fly. The slug feeds on the upper surface of the leaf. It was quite common during 1896.

Remedy.—Spraying with Paris green, hellebore or pyrethrum, in the common proportions.

6. Plum Curculio.—*Conotrachelus nenuphar.*

There is no insect better known than this little beetle. The egg is deposited in the plum, where it hatches. The affected fruit soon falls to the ground, and the larvæ leave the plums, pass into the ground, where they remain for about six weeks. The imago is a small grayish beetle one-fifth of an inch long, with a black lump on the middle of each wing case. It has a curved snout and a stout body. The beetles hide themselves during the winter, in sheltered spots, and appear in spring about the time the trees are in bloom. This insect is also found upon the cherry, peach, and even apple.



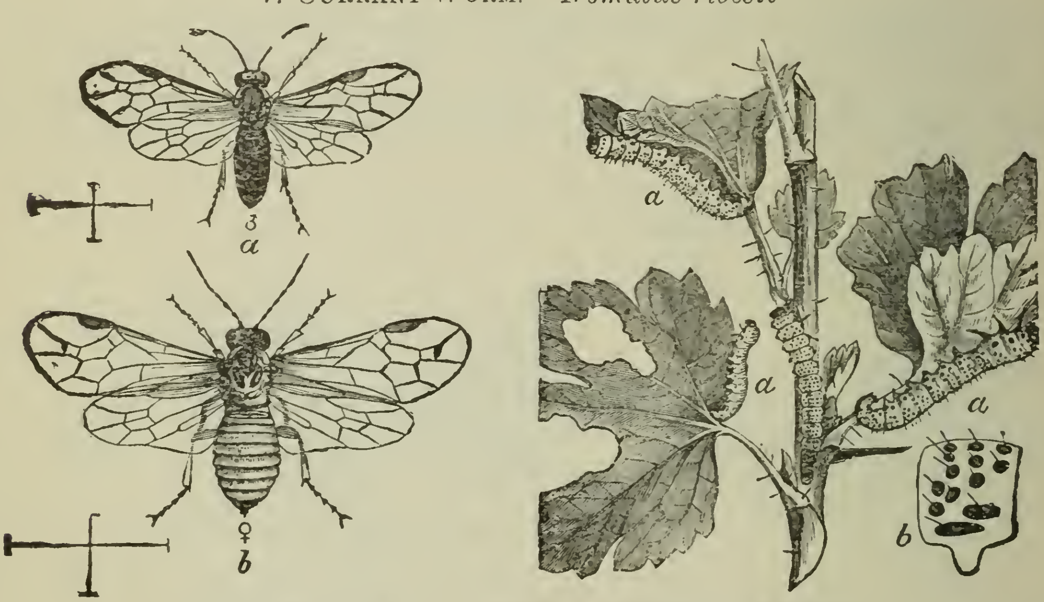
Plum Curculio: *a*, grub; *b* and *c*, beetle; *d*, egg laying on plum.

Remedy.—1. Jarring the trees morning and evening. At this time many beetles will drop and may be collected upon a sheet placed below.

2. Gather and destroy the affected plums, as they fall.

3. Spray Paris green as directed for the treatment of the plum, or Paris green may be applied alone (1 pound to 250 gallons of water, if the foliage is tender add 2 lbs. of lime). Spray once before the trees bloom, as soon as the foliage is well started, again as soon as the petals fall, and repeat about a week after.

7. Currant Worm.—*Nematus ribesii*



Currant Worms and the Saw Flies to which they change.

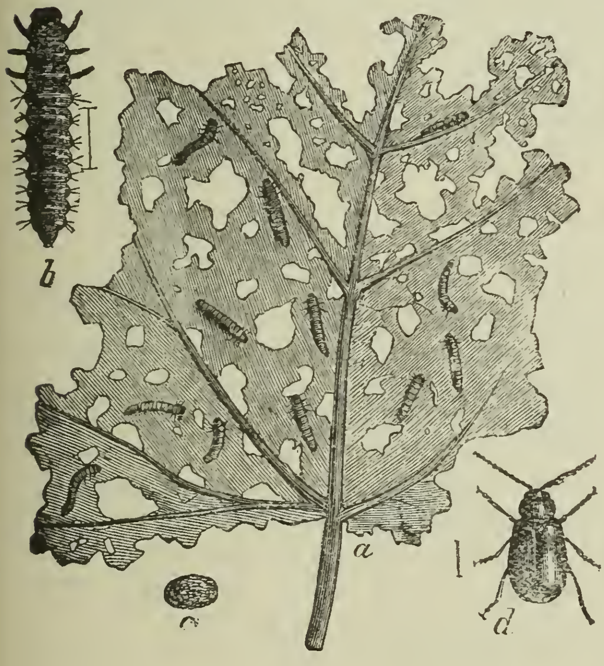
This insect is very troublesome upon currant and gooseberry bushes. It lays its eggs early in the spring, on the under side of the leaves, in rows along the veins. These hatch in about ten days, and the young worms appear. The larva, when full-grown, is about three-quarters of an inch in length, of a greenish color, with dark spots, and has many legs. It spins a brown cocoon, of paper-like texture, which is found sometimes on the ground among the dried leaves, or on the bush, attached to the stems or leaves. This represents the pupa condition.

The imago appears in about two weeks after the pupa stage has been entered. The male is much smaller than the female, the body black, with some yellow spots above, while in the female the body is mostly yellow. Both have four membranous wings. A second brood is of common occurrence.

Remedies.—1. Hellebore, one ounce in three gallons of water. It may also be applied as a dry powder, mixing it with three or four parts flour.

2. Paris green for the first brood, but care must be taken not to continue this if the fruit is likely to be affected.

8. Grape-Vine Beetle.—*Haltica chalybea.*



The eggs are deposited on the under side of the leaves. The larva is about one-third of an inch long, brownish, with several black dots on the body. The pupa condition is passed in the ground, and continues for about three weeks.

The imago is a small, polished beetle, about one-fifth of an inch long. It passes the winter in sheltered spots, under leaves, or around the roots, and is very destructive in the spring to the young buds, and afterwards, in the larval condition, to the leaves.

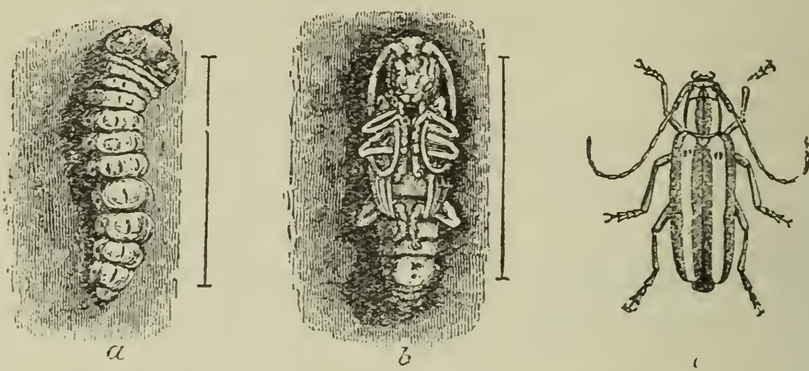
Remedies.—1. Paris green, three ounces to fifty gallons of water, or combined with Bordeaux mixture as directed under treatment of the grape.

2. Dust pyrethrum powder upon the vines attacked.

3. Jarring the vines in the morning and collecting the beetles.

Round-Headed Borer (*Saperda candida*).

The *eggs* are deposited about June, near the base of the trunk of the apple tree. The *larva* eats its way through the outer bark to the inner, and takes about three years to develop. It works in the sapwood, where it forms flat, shallow cavities, filled with sawdust-like castings. These are often seen on the bark, and indicate where the "borer" is at work. As it reaches maturity, it cuts a passage upwards into the solid wood, and then curves towards the bark. In



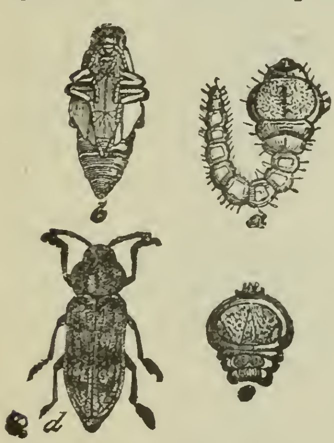
Round headed Apple Tree Borer, *Saperda candida* : *a*, larva; *b*, pupa; *c*, beetle.

this channel it enters the *pupa* stage, about spring. When fully developed, it is an inch long, with a round head that distinguishes it from the flat-headed borer, which also affects the apple tree.

The *imago* is a slender beetle, one inch long, with two broad, whitish stripes on the wing covers, and long jointed antennæ. It appears about June.

10. Flat-Headed Borer (*Chrysobothris femorata*).

This insect also attacks the trunk of the apple tree, but lays its *eggs* higher up the tree than the preceding one. The *larva* is a pale yellow, an inch long, and has a well-marked flat head, much wider than the body. It is sometimes found even in the limbs, and is not so long in developing as the round-headed borer. It cuts flat channels in the sapwood, and sometimes girdles the tree. Castings and discolored bark indicate its presence. It finally bores into the solid wood, and becomes a *pupa* for about two weeks, and then emerges as an *imago* about half an inch long, somewhat flat, and of a greenish black color, with three raised lines on each wing cover. The legs and under side of the body present a coppery lustre.



Flat Headed Apple Tree Borer, *Chrysobothris femorata* Fabr: *a*, larva; *b*, beetle.

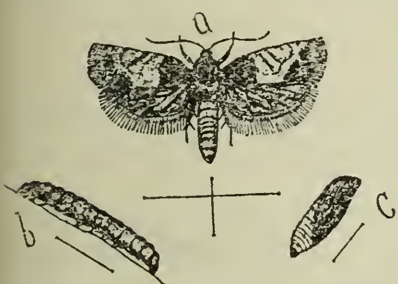
Remedies.—1. Examine the trees in autumn, and where the sawdust-like castings indicate the presence of the "borer," a stiff wire may be pushed in and the larva killed, or sometimes the larva can be cut out with a knife.

2. About the beginning of June, apply the following mixture to the trunk of the tree :—One pound of hard soap, or one quart soft, in two gallons of water;

heat to boiling, and add one pint crude carbolic acid : make a second application in three weeks. This can be well done by using an old scrubbing-brush to rub it in.

11. Bud Moth *(Tmetocera ocellana).*

This insect is found attacking the buds upon the apple, and sometimes proves very injurious. The half-grown *larva* winters over, and appears in spring as a small brown caterpillar, just about the time the buds begin to open, and feeds upon them. It measures about half an inch when full grown. By rolling up one side of a leaf, and securely fastening it with silken threads, it forms a tube in which it enters the *pupa* stage, having lined the little chamber with a closely woven layer of silk. This condition lasts ten days. The *imago* is a small moth, resembling the codling moth in size and form. It is of an ash gray color. The front wings have a whitish-gray band across the middle; the hind wings are a dusty brown. The expanded wings measure half an inch across.



Apple Tree Bud Moth, *Tmetocera ocellana* : *a*, moth ; *b*, larva ; *c*, pupa.

Remedy.—Paris green added to Bordeaux mixture as directed for the treatment of the apple.

12. The Grape-leaf Hopper or Thrip *(Erythroneura vitis.).*

This small insect, about an eighth of an inch long, of a white color, marked by three dark bands, is sometimes troublesome on grape vines.

They feed upon the juices of the plant, and are usually upon the underside of the leaves, where they are difficult to reach in spraying.

Remedy.—1. Remove fallen foliage at the close of the season, so that the insects cannot find shelter during the winter.

2. Spray with kerosene emulsion diluted with ten parts water, on the under side of the leaves in the cooler part of the day.

13. Red Spider (*Tetranychus telarius*)

The red spider is a very small insect—a true mite—and in some places is very destructive. It sucks the juices of the plants attacked, and causes the color of the leaf to change from green to a grayish-white. It flourishes in a dry atmosphere and in sunny places ; shade and moisture are not favorable to its development.

Remedy.—Spray with clear water, and keep the atmosphere about the plants moist.

2. Spraying with kerosene emulsion should also be followed by good results.

Plant Lice (*Aphidae*)

These minute, greenish insects affect the foliage of many plants by sucking the juice, and thus injure the leaves.

They can be controlled by spraying with kerosene emulsion.

INJURIOUS FUNGI.

The following are among the most injurious fungi that affect the products of the garden and orchard. They can be readily controlled by the proper application of Bordeaux mixture, as directed.

The usual life history of a parasitic fungus is, that it arises from a spore which is microscopic; this germinates and gives rise to thread-like structures which penetrate the plant upon which the fungus grows and derives its nourishment. Upon these structures in time spores are produced, as new sources from which the fungus may develop and continue to be injurious to the vitality of the plants attacked.

1. Apple Spot or "Scab" (*Fusicladium dendriticum*).

This fungus attacks the leaves and fruit of the apple, causing the "spots" on the fruit. The vegetative portion of the fungus is chiefly around the edge of the spots where the spores are produced in great numbers.

2. Leaf Spot (*Entomosporium maculatum*).

This disease attacks the pear, causing the leaves to show reddish spots with small pimples in the centre. When the fruit is attacked it cracks and appears stunted.

3. "Brown Rot" (*Monilia fructigena*).

Attacks plums, cherries and peaches. The fruit affected becomes brownish at first, then shrivels and appears dried. In this condition it is termed "mummified," and is often seen upon the trees in that form. All "mummified" fruit should be gathered and burned, as they contain spores that will perpetuate the disease.

4. "Anthracnose" (*Gloeosporium venetum*).

This fungus appears on the canes of raspberries as small round or oval patches, with a purple border, and sometimes upon the leaves as small yellowish spots with dark border. The affected canes should be cut out and destroyed by burning.

5. " Leaf-blight," " Sunburn " (*Sphœrella fragariæ*).

This disease produces very conspicuous spots on the upper surface of the leaves of the strawberry. The spots are reddish at first, then the centre becomes somewhat grayish.

6. " Powdery Mildew " (*Sphaerotheca mors uvae*).

This mildew is the well-known blight on the gooseberry. It thrives in a warm, dry atmosphere, and sometimes is very destructive.

At first the berries are covered with a grayish substance, and later assume a brown color.

7. " Potato blight " (*Phytophthora infestans*).

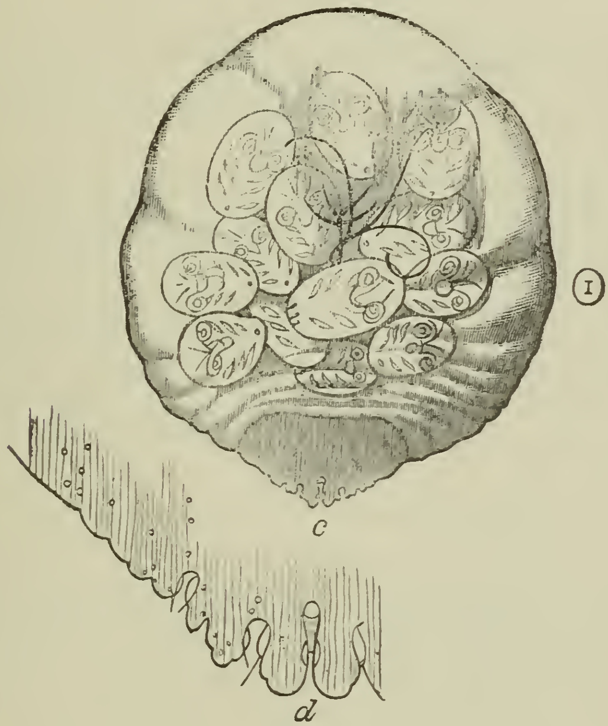
This fungus attacks the potato, commencing with the leaves and finally affecting the tubers.

BULLETIN 106. JUNE, 1897.

Ontario Agricultural College and Experimental Farm

THE SAN JOSE SCALE.

(Aspidiotus perniciosus).



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BULLETIN 106.

San José Scale.

(Aspidiotus perniciosus.)

The discovery of the fact that the San José Scale has appeared in one of the most important fruit growing districts in Ontario demands that we furnish at as early a date as possible information regarding its habits, etc. For the past four years it has excited much alarm among fruit growers in the Eastern States, and a wealth of literature has been published concerning it, so that all information needed is readily obtained from the numerous bulletins already issued from the Agricultural Department at Washington and experiment stations in the United States. No insect is more fitted to menace the fruit-growing interests of our Province than this San José Scale.

Why the Insect Causes Alarm.

1. It possesses marvellous powers of reproduction. A single female that has wintered over may be the progenitor of millions in a single season ; some have computed that her progeny may reach the incredible number of 3,000,000,000. There may be four generations in a season, the adult females of each giving birth to living young for five or six weeks, the progeny of these bearing young when about thirty days old. Each female brings into existence 100-500 insects during her lifetime. Thus it will be seen that a great confusion of generations will soon exist, as there may be upon a plant at one time the young of several generations.

2. Infested young trees perish in two or three years.

3. The range of food plants is extensive, and all parts of the plant may be attacked : leaf, stem, twig and fruit. The scale has been found upon the peach, pear, plum, apple, cherry, apricot, quince, currant, gooseberry, raspberry, rose, hawthorn and even elm.

4. The insect and scale are exceedingly minute. The scale is often much the same color as the bark of the infested trees. Most are less than one-sixteenth of an inch in diameter, and are thus almost invisible to the naked eye.

5. It is readily introduced by nursery stock and fruit from infested trees.

Its Present Distribution.

Although first observed in 1893, it has now been located in Alabama, Florida, Georgia, Louisiana, Virginia, Delaware, Idaho, Indiana, Massachusetts, Maryland, New York, Ohio, New Jersey and Pennsylvania; in 1894 it was reported in British Columbia, and now unfortunately in June of 1897 we have to announce it as present in Southern Ontario. Some specimens are reported to have been found last winter near Chatham.

When and Whence it Came.

The general consensus of opinion after much investigation is, that it came originally from California, where it was noticed as a pest in the San José Valley as far back as 1873. In 1880 Prof. Comstock described it, and named the insect *Aspidiotus perniciosus*, on account of its serious character as a scale. It is believed to have been introduced into the East in 1886-7 by two New Jersey nurseries, one at Burlington, the other at Little Silver. These firms imported from the San José Valley a variety of Japanese plum, the Kelsey, which was claimed to be curculio proof. In 1889 or 1890 the first scaly stock from this importation began to be distributed, and in August of 1893 the San José Scale was first observed on the eastern side of the Rocky Mountains. It was located in an orchard of Charlottesville, Virginia, and since then each season has extended the list of infested districts.

How it may be Distributed.

In the work of distribution, the insect itself can do but little, as it is quite helpless to move from place to place. Its life of active movement is very brief—a few hours, at most, a day or two. It moves only a few inches from its birthplace, then settles, becomes covered with a scale, and in the case of the female, remains fixed for life, and begins producing young in about thirty days. After becoming fixed, it lives by sucking the sap of the plant upon which it is located. The males have wings and may fly about at maturity, but the females are always wingless. During the few hours or days the tiny lice are moving about, they may get upon birds, such insects as ants and small beetles, and by them be carried to other trees. One observer has noticed that in infested districts, the scale is often more common near a bird's nest. As trees in a nursery grow close together, they present favorable conditions for being infested. Fruit from infested trees may have the scale upon it; even wind may assist in spreading these insects that appear at first so comparatively helpless to travel by their own efforts. Thus *birds, insects, fruit, scions* from infested trees, infested *trees*, and *wind* may all be important factors in the distribution of the scale.

The Life History of the Insect.

The nearly fully grown insect passes the winter beneath its wax-like scale. About June the young begin to appear, as exceedingly minute, six-legged insects, like yellowish specks moving about. They creep about only for a few hours, at most a day or two, then settle but a few inches from their birthplace, and become attached to the spot from which the females never move. During their sedentary life the females lose their feelers and legs, and have neither eyes nor wings. The males, however, have legs, feelers (antennæ) eyes and wings in the adult condition. The scale of the female is circular, with a small nipple in the centre. This scale is from a twelfth to one-twentieth of an inch in diameter, and may be of a light or dark gray color, and usually is much the same color as the bark ; the nipple in the centre may be a pale yellow or blackish color. The scale of the male is oblong, with the nipple near one end, and is thus readily distinguished from that of the female. The female brings forth living young, and does not lay eggs, as is usually the case with scale insects, such as the oyster shell and scurfy scales She may bring into existence from 100 to 500 young during the six weeks of her existence after reaching the adult stage.

The males develop about a week sooner than females, the latter taking about five weeks, and emerge from their scales as exceedingly minute two-winged fly-like insects. From June, when the young appear, a constant succession of generations is observed.

The scale of these insects is formed from a waxy secretion which commences soon after they come into existence, and forms a protective covering as development proceeds. In the earlier stages of growth the scale presents a somewhat grayish-yellow color, and gradually becomes darker.

The general appearance upon affected twigs is that of a grayish, slightly roughened scurfy deposit This hides the natural reddish color of the young limbs of the peach, pear and apple. They sometimes even look as if sprinkled with ashes. If the soales are crushed, a yellowish oily liquid will appear from the crushed soft yellow insects beneath the scales. Examined in summer, many show orange-colored larvæ, snowy-white young scales, mingled with old brown or blackened matured scales. This insect produces a peculiar reddening effect upon the skin of the fruit and of tender twigs. An encircling band of reddish discoloration around the margin of each female scale is very marked on the fruit of pears. The cambium layer of young twigs where scales are massed is usually stained deep red or purplish. Where the scales are few the purplish ring surrounding each is quite distinguishable.

Remedies.

The remedies for this scale present three forms : *Corrosive washes*, such as whale oil soap ; *penetrating substances*, such as gases or kerosene emulsion, and *varnishes or resin washes* which cover the scale so as to prevent the escape of the young.

1. The use of hydrocyanic acid or the gas treatment is very effectual, but it is only practicable in certain cases, especially in the treatment of imported nursery stock. The following method is given in Bulletin 87, of the New York Experiment Station, Geneva : " This gas is lighter than air, hence will work better if the generator is placed below the pile of trees to be treated. A convenient way would be to make a rack a little less than six feet long, five feet wide, four feet

high. The bottom of the rack could be made of loose slats raised a few inches above the ground to allow room to place the gas generator under the rack. When the rack is filled with trees, a piece of gas-tight canvas thrown over the whole and fastened down at the sides by throwing dirt on the margins would complete the apparatus. One side could be left open till the water and chemicals are placed in the dish and the dish slipped beneath the rack. This gas is a deadly poison, and great care should be used not to breathe it while placing the dish under the rack.

"To generate the gas pour three fluid ounces of water in a glazed earthenware vessel, to this add one fluid ounce of sulphuric acid; place under the trees and then add one ounce by weight of fused cyanide of potassium. This will make gas enough to fill a space of 150 cubic feet." An hour's exposure will likely kill all the scale insects.

2. One of the most effectual remedies, and one readily applied, is the use of whale-oil soap, two pounds in one gallon of water. Apply this in the fall just as the leaves drop off, before the scales harden, and again in spring just before the trees bloom. Some recommend a weaker solution in the fall, one pound to one gallon of water, then just before the buds swell in spring, the stronger solution, two pounds to one gallon of water. Even the use of common soap has been followed by good results, but whale-oil or fish oil soap is preferable. Kerosene emulsion, diluted with nine parts water, or whale-oil soap, one pound to four gallons of water, is good for summer treatment, as soon as the lice are moving. Three or four applications of this at intervals of ten days will destroy many insects, but as the females are continually producing young throughout the summer, the spraying should be kept up to be effectual. Fall or winter treatment with strong solutions is decidedly the most successful.

3. Pure kerosene is destructive to the scales, but will kill the trees unless great care is observed in its application.

The use of resin washes, though successful in California, has not given very decided results in the east.

There are two enemies to the scale among insects, both of which are reported to aid very materially in keeping the scale in check. One, the "Twice-stabbed Ladybird" (*Chilocorus bivulnerus*), is very common on infested trees, apparently feeding upon the scale; the other is a chalcid parasite (*Aphelinus fuscipenius.*)

Suggestions.

1. Examine carefully sickly trees and trees or scions brought from nurseries in infested districts.

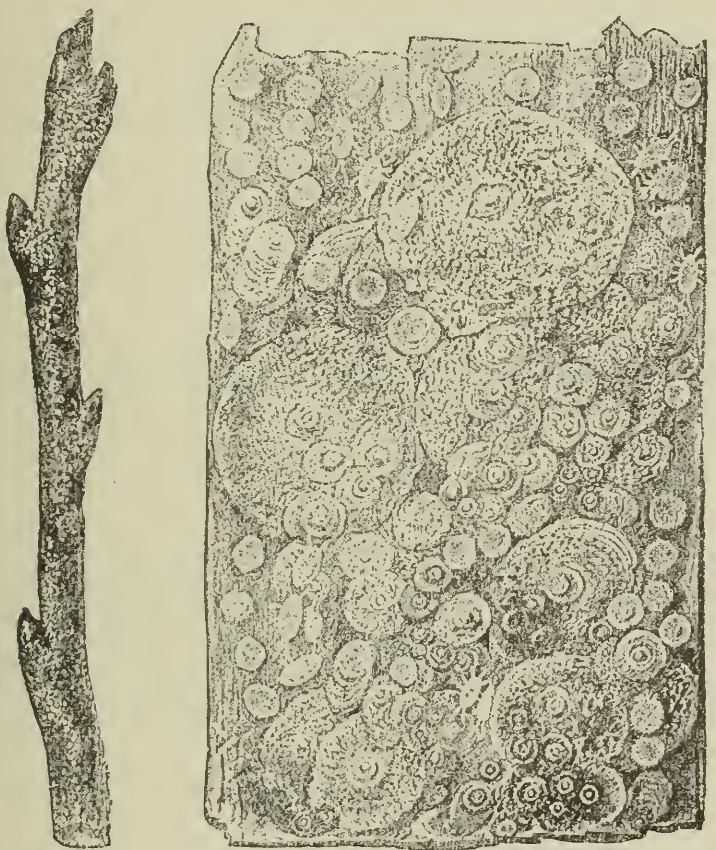
2. If only a few trees are infested destroy them.

3. Trees infested, if well cut back and treated with whale-oil soap, as directed, may be largely saved.

4. Orchards set out within the last six years with trees from infested States, may be suspected. They should be carefully examined.

5. Examine fruit from infested localities.

This most excellent cut taken from Bulletin 3, U. S. Department of Agriculture, represents exactly what the writer of this bulletin has seen in the Niagara District.



A. B.

Appearance of scale on bark ; *a*, infested twig—natural size ; *b*, bark as it appears under hand lens, showing scales in various stages of development and young larvae.

Newspapers receiving this Bulletin will please notice it in their columns, calling attention to the presence of a new enemy to fruit growing, and advising all interested to apply to the Department of Agriculture at Toronto for a copy of the Bulletin.

BULLETIN 107. May, 1898.

ONTARIO AGRICULTURAL COLLEGE AND EXPERIMENTAL FARM.

DAIRY BULLETIN

BY THE

DAIRY SCHOOL, GUELPH.

PUBLISHED BY THE ONTARIO DEPARTMENT OF AGRICULTURE, TORONTO.

INTRODUCTION.

BY H. H. DEAN, B.S.A., PROFESSOR DAIRY HUSBANDRY.

A very important factor in the production of cheese or butter is the healthful condition of the factory and its surroundings. The building should have good drainage and a plentiful water supply. Hot water must be used in large quantities in order to keep everything clean. Where plenty ot water is used, it is necessary to provide means to carry the water and its impurities to a safe distance from the factory. The practice of allowing whey, skim-milk, buttermilk and wash water to go through leaking floors, underneath the building, or to run on top of the ground near the factory, near a dwelling place, or near a public road, is one which cannot be longer tolerated. As these by-products decompose in the hot weather, the most objectionable flavors are produced, and at the same time a breeding ground for the worst types of bacteria is provided. Neither will it do to send this waste matter into a stream, or onto a farm, as it causes offence to owners of stock, and the maker runs the risk of tainting the milk supplied.

METHODS OF SEWAGE DISPOSAL.

1. By running it through drains into a creek or ditch, or on top of the ground in a neighboring farm, swamp or waste land.

At the Black Creek factory, near Stratford, the waste water is forced through pump-logs into a ditch some distance from the factory, at which place the water filters through the natural soil into a creek. This plan is said to work very well. The danger of polluting the water or grass if dairy cows have access to the stream or pasture makes this plan, without filtering, very objectionable, although experiments made at Rugby farm, England, showed that the productive capacity of an acre of grass was increased three or four fold by applying sewage, and no bad effects on the milk given by the cows was reported.

2. By Irrigating a Field near the Factory or Creamery.

To do this properly a storage tank is needed in order that the sewage may be applied when needed by the crop. In cases where the building is above a sloping, sandy or gravelly field the sewage may be profitably applied for the growing of such crops as corn, potatoes, mangels, beets, grain, fruit trees, nursery stock, grass, hay and garden truck. Italian rye grass is said to be specially benefited by the application of sewage, and this grass has the power of absorbing large quantities of it.

3. The sewage may be run into a tank and thence be pumped and applied to the soil. In most cases this is too expensive. Where the soil is sandy or gravelly much of the liquid may soak away, but owing to the danger of polluting the water in the well, and the air about the factory, this plan is not to be recommended. Makers should be very careful not to use impure water for setting the vats, washing butter, or for any other purpose, if it can be avoided. It is a safe plan to have the sides of the well cemented, to guard against possible pollution from impure water in the surface soil. If there is any doubt about the purity of the water send a sample to Guelph or Ottawa to be analyzed.

4. The sub-earth system works well for private houses and is used at some public institutions. A portion of land is thoroughly underlaid with a system of drain tiling. The sewage is conducted into these tiles, and allowed to soak away in the sub-soil. As there is danger of polluting the well, unless the tiling is a long distance from the building, this plan can be recommended only where the water supply comes from a distant spring through iron piping, or where the water supply comes from town or city waterworks.

5. The filter bed system seems to be the best and most practicable plan where drainage from the bed can be obtained. After the sewage has been properly filtered it is safe for animals to drink. Town sewage water, after being filtered, has been found to be purer than the water in wells of the same town which was used for drinking purposes by some of the people. A properly constructed filter bed is more than a strainer. In addition to causing mechanical changes in the sewage, the process of filtration involves biological and chemical changes whereby the water becomes purified. The intermittent downward filtration system has been proved to be a success.

Points to Observe in the Construction of a Filter Bed.

1. Make a tight connection between the gutter and the drain outside.
2. Have a "trap" on the drain to prevent smells coming from the drain.
3. Ventilate the drain.
4. Make the drain as straight as possible

5. Use four or five inch glazed tiling with tight joints from the factory to the bed. These should be laid below frost. Ordinary drain tile may be used where there is no danger of polluting the water. A pump-log, or a tight wooden trough above ground may be used in summer to convey the liquid from the building.

6. Locate the filter bed as far as possible from factory—at least 300 feet.

7. A bed 20x20 would be ample for a factory making 150 to 200 tons of cheese, and also butter in winter. Two beds, 10x20, which could be used alternately would be more satisfactory than one bed.

8. Excavate about two feet below the surface of the ground, and use the dirt for banking the sides.

9. Place a row of five inch drain tile in the bottom and at the centre of the bed. They should extend through the outlet side of the bed with a clear fall of three or four inches to the ditch or stream below. The joints of the tile should be covered to prevent the sand getting inside.

10. Fill from three to five feet of coarse sand on top of the tiling. About fifty loads of sand would be needed.

11. If two beds are made, have the top surface slant six or eight inches towards the outlet side of the bed. If one bed is used have it slope from both sides towards the centre, and place the tiles at the bottom and in the centre.

12. A wooden trough placed at the outlet of the factory drain should have wooden slides or gates to run the water on one side or on one bed at a time. Alternate them daily or weekly. The distributing trough should scatter the material over the whole length of the bed.

13. Keep the bed clear of weeds. Rake the top surface occasionally.

14. In winter furrow the top of the bed and cover the furrows with boards in order that the water may get below the snow and ice.

15. The top three or four inches may have to be removed and fresh sand applied in four or five years.

16. If the bed receives a small amount of attention it will improve in purifying power each year, and will do service for many years.

17. To remove grease and dirt from an underground tile drain connect the "blow-off" of the boiler with the mouth of the drain. Where this is not practicable run plenty of hot water into the drain after cleaning up each day.

MILK TESTING.

By J. W. Mitchell, B.A., Instructor.

By the term "milk-testing" we usually mean the testing of milk to determine its richness in fat or other solids, and for the detection of adulterations.

The two instruments most commonly made use of in the testing of milk are the Babcock tester for the purpose of determining the percentage of fat, and the lactometer to determine the specific gravity of milk.

The Babcock Test.

While the Babcock test has other equally important fields of usefulness, there are two that we would make special reference to at the outset, as their importance is so frequently overlooked or underestimated.

One use is on the farm. Every dairy farmer should use the test in weeding out and raising the standard of his herd. If our farmers would only make free use of the test, many of them would be greatly surprised to find how many profitless, or worse than profitless, cows they are keeping.

A second use of the test is to ascertain the loss of fat in skim-milk, buttermilk and whey. Where no test of these bye-products is made, there is frequently a great and *unsuspected* loss of butter-fat, which could and would be avoided, were the maker only aware of the loss by his present careless and faulty methods.

The following is a brief explanation and outline of the Babcock test :

The scale on the neck of the ordinary test bottle is graduated to give a reading of the percentage of fat only when eighteen grams are used in a test, i.e., the fat extending over one of the larger divisions of the scale weighs *one per cent*, or the hundredth part, of eighteen grams. This fact borne carefully in mind will explain the various rules for determining the per cent. of fat when eighteen grams cannot be taken in a test—as in the case of cream or cheese, in which the percentage of fat is high.

Note.—The capacity of that part of the neck over which the scale extends is two cubic centimetres (c. c.), and of that of one of the larger divisions of the scale is .2 ($\frac{2}{10}$) c. c. As the specific gravity of the fat at the high temperature of reading is .9 ($\frac{9}{10}$), the weight of the fat extending over one of the larger divisions of the scale is .9 x .2 = .18 of a gram, which weight is the hundredth part, or one per cent. of 18 grams.

To Test Milk.

1. By means of a 17.6 c. c. pipette take 18 grams of milk. Have the milk at a temperature of sixty to seventy degrees.

2. To this add 17.5 c. c. of commercial sulphuric acid with a specific gravity of 1.82 to 1.83, and thoroughly mix the acid and milk by giving the bottles a gentle rotary motion.

3. Place the bottles in the tester and turn for from four to five minutes, at a speed varying from 700 to 1,200 revolutions per minute, according to the diameter of the machine (700 revolutions per minute with a machine twenty inches in diameter).

4. Add hot water at a temperature not lower than 140 degrees F. to float the fat into the neck of the bottle.

5. Turn the machine again for about two minutes and take the reading before the fat cools. If troubled with burnt readings add the water twice instead of all at once, filling the bottle just to the neck the first time, then turning the machine about a minute, filling to about the eight per cent. mark the second time, and turning for another minute.

Notes.

1. Be sure that the scale on the bottle is properly graduated. The most convenient way of knowing this is to test the same milk in the different test

bottles and compare the readings. A bottle that differs by more than .2 ($\frac{2}{10}$) in its reading from the rest should be discarded. As the capacity of that part of the neck over which the scale extends should be 2 c. c., the accuracy of the scale may be tested by filling the bottle to the bottom of the scale with water at the temperature of the room, and then adding 2 c. c. of water at the same temperature by means of a 2 c. c. pipette.

2. Mix the milk well to obtain a representative sample. Mix by pouring from one vessel to another, as violent shaking tends to churn the milk and does not ensure so thorough mixing.

3. Be very careful to measure the exact amount of milk for a test, and to blow out the pipette well.

4. The amount of acid used must be varied to suit its strength. The right amount is being used when the fat presents a bright golden appearance. Acid that is much too strong or too weak should be discarded, as satisfactory results cannot be obtained from its use.

5. Hold the test bottle at a slant when pouring in the milk and acid, to avoid choking the neck of the bottle.

6. Mix the milk and acid thoroughly.

7. If the temperature of the room be low, it is necessary to pour hot water into the tester to keep up the temperature.

8. The water added to the test bottles should be soft or distilled. If hard water be used add a little sulphuric acid (half an acid measure, or a little more to a gallon of water) to soften it; this will prevent foam above the fat.

9. Correct readings cannot be taken after the fat has cooled. In such cases set the bottles in hot water before reading.

Always do this when you have several readings to take. Adopt a fairly constant temperature of the water—130 to 140 degrees F.—for this purpose.

10. A pair of dividers or compasses is excellent for taking the length of the column of fat in reading. Measure from highest to lowest point in column.

11. The following are the causes of cloudy or burnt readings:

(1) The use of too much or too strong acid.

(2) Allowing the acid to fall directly upon the milk.

(3) Having the milk at too high a temperature when adding the acid—the higher the temperature the less acid is required.

(4) Allowing the sample to stand too long, after adding the acid, before mixing the milk and acid.

12. Light colored readings and floating particles of curd are due to—

(1) The use of too little or too weak acid.

(2) Having the milk or the acid at too low a temperature—the lower the temperature of either the more acid is required.

Note.—It is always better to bring the milk to the right temperature—about seventy degrees.

(3) Insufficient shaking of the bottles to completely unite the milk and acid.

13. See that your pipettes and test bottles are clean before using.

14. After using bottles, rinse them at least twice with *hot* water—the nearer to boiling the better. Rinsing with sulphuric acid before rinsing with water, or the use of a little sal soda in the first water, is often necessary.

15. Care and attention to details are the great requisites for accurate milk testing. Carelessness on the part of the operator has frequently thrown suspicion upon the accuracy of the Babcock test.

16. A sample of milk that has soured and thickened can be prepared for sampling by adding a small amount of some alkali to neutralize the lactic acid, and cause the curd to redissolve. A small amount of powdered concentrated lye is very suitable; add just a small amount of lye at a time, and pour the milk from one vessel to another to mix the lye with the milk, which causes the casein to become dissolved.

17. Milk that has been partially churned can be prepared for sampling for a Babcock test by heating it to about 110 degrees F. and pouring it from one vessel to another to mix it; then take sample as quickly as possible.

18. If the scale on the test bottle becomes indistinct, it can be much improved by rubbing over it some black paint and wiping the neck with a cloth. The paint should be quite viscous, as thin paint will run.

Skim-milk, Buttermilk and Whey.

1. Skim-milk, buttermilk and whey may be tested in the ordinary bottle just as whole milk is tested, taking 17.6 c. c. (or 18 grams) in a test.

Note.—It is not necessary to use quite the full amount of acid with whey.

2. As the percentage of fat in skim-milk, buttermilk and whey is so small, the best method of testing these is by the use of the double-necked skim-milk bottle. The usual amount of milk or whey is taken and the test is carried on in the usual way. Very fine readings can be taken, as a very small amount of fat will extend over quite a length in the small neck. Each division on the scale indicates half a tenth (.05) of one per cent. of fat.

After adding the water to the test bottle it is advisable to set the bottle in hot water before whirling in the machine for the last time; this heating of the small neck enables the fat to rise more freely by keeping it melted and preventing it from adhering to the neck.

If the fat does not rise sufficiently in the small neck, it can be raised by pressing gently with the finger on the mouth of the large neck.

To Test Cream, Using the Ordinary Test Bottle.

1. By means of a 6 c. c. pipette take six grams of cream, and to this add 12 c. c. of water. Add the usual amount of acid (17.5 c. c.) and proceed as in testing milk. Multiply the reading by three to obtain the percentage of fat.

2. Another way is by using the ordinary pipette. Take 17.6 c. c. of cream and to this add two pipettes, or twice 17.6 c. c. of water, and mix thoroughly. Take 17.6 c. c. of the diluted cream and put into the test bottle; add the usual amount of acid and proceed as in testing milk. Multiply the reading by three to obtain the per cent. of fat in the cream. This method is not strictly accurate, as 17.6 c. c. of cream will not weigh quite 18 grams; but it will give sufficiently close results for most purposes.

Weighing any suitable number of grams of cream for a test is the most accurate method.

To Test Cheese.

Obtain a representative sample of cheese by taking a plug extending from the outside well to the centre of the cheese ; cut this into small strips extending from end to end of the plug—strips that will easily pass through the neck of the test bottle. Weigh out from four to five grams and put into the test bottle, and to this add 12 to 15 c. c. of hot water to dissolve the cheese. After shaking the bottle sufficiently to dissolve the cheese, cool the sample down and add 17.5 c. c. or the usual amount of acid, and proceed as in the testing of milk.

To obtain the percentage of fat in the cheese, multiply the reading by eighteen and divide by the number of grams taken in the test. If other than six grams of *cream* be taken in a test, apply this rule to determine per cent. of fat.

The Lactometer and the Detection of Adulterations in Milk.

The lactometer is a specific gravity measure for milk. There are different kinds of lactometers ; but as the Quevenne is the most suitable for milk testing, it is the one that we shall here describe.

By means of the Quevenne lactometer we compare the density at sixty degrees F. with that of pure water at sixty degrees. It has a scale graduated from 15 to 40, and indicates a specific gravity of from 1.015 to 1.040. For example, milk with a lactometer reading of 32 has a specific gravity of 1.032, or a vessel which would hold 1,000 pound of pure water (at 60° temp.) would hold 1,032 lbs. of this milk. As it is not always convenient to have milk at a temperature of sixty degrees when taking a lactometer reading, corrections for temperature are made as follows : To obtain the *corrected* lactometer reading, or reading at sixty degrees, add .1 ($\frac{1}{10}$) to the lactometer reading for each degree in temperature above sixty, and subtract .1 ($\frac{1}{10}$) from the reading for each degree in temperature that the milk is below sixty degrees. Thus, if the lactometer reading of milk at a temperature of sixty-five degrees be thirty-one, the corrected reading is 31 x .5 = 31.5 ; if the lactometer reading be 32.5, and the temperature fifty-seven, the corrected lactometer reading is 32.5 – .3 = 32.2. This rule is practically correct, if the temperature be kept within a range of from fifty to seventy degrees.

The lactometer reading of whole milk usually ranges from 30 to 32.5, although it may fall as low as 27, or go as high as 34. The lactometer reading of skim milk varies from 33 to 38.

The composition of milk is about as follows :

Water	86 to 88 per cent.
Fat	3 per cent. and upwards.
Solids not fat	8.5 to 9.5 per cent.

Solids-not-fat (Or Solids Other Than Fat.)

In determining the percentage of solids-not-fat in milk, we require both its corrected lactometer reading and the percentage of fat in it. It is the solids-not-fat of milk that cause its specific gravity to exceed that of water, and consequently its lactometer reading to be greater than that of water. Since the presence of fat in milk lowers its lactometer reading, the first step in determining the percentage of solids-not-fat is to obtain what the lactometer reading of the milk would be if the fat were not present to interfere, i. e. the first step is to determine the lactometer reading of the milk when skimmed. As each per cent. of fat in milk makes its lactometer reading lower by about eight-tenths (.8) of a degree than it would be if this fat were not present, we obtain the lactometer reading of the skim milk by adding the lactometer reading of the milk and eight-tenths of the percentage of fat together. Next, since each per cent. of solids-not-fat in skim-milk gives it a reading of about four on the lactometer, we obtain the percentage of solids-not-fat in it by dividing its lactometer reading by four.

RULE: To determine the percentage of solids-not-fat (S. N. F.) in milk, add its corrected lactometer reading (L) and eight-tenths (.8) of the per cent. of fat (F) together, and divide by four. Briefly expressed thus:

$$\frac{L + .8\ F.}{4} = \text{S. N. F. (per cent. of solids-not-fat.)}$$

L = Corrected lactometer reading, or reading at sixty degrees.
F = Per cent. of fat.

The following rule for determining the per cent. of solids-not-fat is sufficiently accurate—excepting when unusually close results are required—and has its simplicity to recommend it:

To determine the per cent. of solids-not-fat in milk add its corrected lactometer reading and per cent of fat together and divide by four.

$$\frac{L + F}{4} = \text{S. N. F.}$$

EXAMPLE: Let the lactometer reading of a sample of milk at a temperature of 64 degrees be 32, and the per cent. of fat be 3.6. Find the per cent. of solids-not-fat.

Corrected lactometer reading = 32.4.

From the first rule we have,

$$\frac{L + .8F}{4} = \frac{32.4 + .8 \times 3.6}{4} = \frac{32.4 + 2.88}{4} = 8.82 \text{ per cent. S.N.F.}$$

From the second rule we have,

$$\frac{L + F}{4} = \frac{32.4 + 3.6}{4} = 9 \text{ per cent. S.N.F.}$$

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 substracted 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 mllk in the watered sample.

$$\text{Per cent. of pure milk in watered sample} = \frac{7.2 \times 100}{9} = 80 \text{ per cent.}$$

$$\text{Per cent. of extraneous water} = 100 - 80 = 20 \text{ per cent.}$$

NOTE: When a sample of the pure milk cannot be obtained, use 8.5 in the early part of the season, and 9 in the latter part, for the per cent. S.N.F. in pure milk.

The term "pure milk," as used in the foregoing, may mean either whole or skim milk, as the per cent. of solids-not-fat in milk is not materially affected by skimming.

Notes.

1. Have the temperature of the milk uniform throughout, and as near to sixty degrees as possible when taking a 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 small.

4. A lactometer reading should not be taken when the milk contains air. Milk fresh from the cows is saturated with air and should be allowed to stand an hour at least before a lactometer reading of it is taken.

5. Have the lactometer free from the side of the vessel, and perfectly still, when taking a reading.

6. A high lactometer reading accompanied by a low per cent. of fat indicates skimming, e. g., L = 34, F = 2.4.

7. A low lactometer reading accompanied by a low per cent. of fat, is indicative of watering, e. g., L = 22, F = 2.4.

8. A normal lactometer reading with a *very* low per cent. of fat indicates both watering and skimming. Also, if the lactometer reading of a sample of milk be low, yet not so low accordingly as the per cent. of fat, this is indicative of both watering and skimming. Both of the following indicate watering and skimming: L = 31, F = 2; L = 26, F = 1.8.

COMPOSITE SAMPLES.

In many of the more advanced creameries and cheese factories the patron receives payment, not in proportion to the amount of milk, but in proportion to the butter or cheese value of the milk supplied by him. Such a system, of course, necessitates the use of the Babcock test. A test of the milk cannot be made daily, but to overcome this difficulty a small sample of the milk supplied by each patron is taken at each time of delivery and put into a bottle, called a *composite sample bottle*, which contains a small amount of some kind of preservative—such as bichromate of potash or corrosive sublimate. It is not advisable to use the latter alone, as it is quite poisonous and imparts no color to the sample to indicate its presence in it. An excellent preservative is a mixture composed of about seven parts bichromate of potash to one part corrosive sublimate. We are using it with very satisfactory results. From what can be taken on a five-cent piece to what can be taken on a ten-cent piece will usually be found sufficient to preserve a sample for two weeks in summer, when an ounce of milk is taken daily. The amount of preservative required depends upon the weather, the size of the sample, and the length of time it is to be kept before testing. A Babcock test of the sample is made at the end of two weeks or a month, and if the daily sampling and the testing of the sample both be carefully done, this gives the average quality of the milk supplied by the patron during the time over which the test extends. It is not necessary to test oftener than twice a month; and we know factories in which, by keeping the samples in a fairly cool place, they are obtaining satisfactory results from testing but once a month.

Notes on Composite Sampling and Testing.

1. For holding composite samples use pint bottles with long corks.

2. The bottles should never be left uncorked, as the samples dry on the surface when left exposed to the atmosphere.

3. Write each patron's name plainly on a label with a pen; paste the label on the bottle fastening its edges down well, and give it at least two coatings of shellac to prevent it from washing off when cleaning the bottles. A label will easily remain on a bottle for an entire season when coated properly with shellac.

4. Racks are necessary for holding the bottles. A very satisfactory rack is one made to hold a single row of bottles, with partitions between. It is advisable to make a rack large enough to hold a sufficient number of bottles for a single route. Have a shelf above the weigh stand to set the racks on.

5. Add the preservative to the composite sample bottles at the beginning of the test period, *and before any milk has been put into them.*

6. Pour the milk into the weigh can and have it well mixed before taking a sample. Either an ounce or a half-ounce dipper may be used for this purpose. An ounce dipper is too large when testing but once a month.

7. Give the bottle a gentle rotary motion each time a sample is taken, to mix with it the cream that has risen, and also to incorporate the new sample with the part containing the preservative.

8. Place the composite samples in a cool place each day when through using them.

9. When the time for testing comes set the bottles in warm water, at about 110° F, to loosen the cream adhering to the sides of them, and also to sufficiently warm the samples to cause the cream that has risen to mix properly with the milk. Give each bottle a gentle rotary motion to wash the cream from its wall. and then complete the mixing by pouring from one vessel to another.

10. After preparing the samples proceed with a Babcock test of them just as you would with ordinary milk. Usually not quite so much acid is needed when testing samples containing bichromate of potash as with milk containing no preservative. When testing composite samples, it is a good plan to set the Babcock test bottles, as they are filled, into a vessel containing about an inch in depth of water at a temperature of about 60 degrees; they will then all be at about the same temperature when the acid is added.

11. Add the water to the test bottles at twice rather than all at once, filling each bottle just to the neck the first time, and to about the eight per cent. mark the second time. Turn the machine for a minute after each addition of water.

12. Set the test bottles in hot water, at 130 to 140 degrees, before taking readings. Have the water deep enough to rise to the top of the fat.

13. Wash the composite sample bottles well after testing the samples. It is a good plan to have a vessel of very coarse gravel, or rather minute pebbles, at hand when washing the composite sample bottles. After rinsing a bottle put into it some more water and a small handful of the gravel. Simply rinsing the gravel around the bottle will scour and clean it thoroughly. Finish by rinsing with specially clean water. Turn the bottles mouth downwards to drain.

If troubled with mould on the samples, it is wise, after washing the corks, either to place them under some inverted vessel and turn a jet of steam into it, or else place them in boiling water under an inverted pan with a perforated bottom, putting a weight upon the pan to sink it.

14 Too great care cannot be exercised in sampling the milk, in preparing the composite samples for testing, and in making a Babcock test of them. Carelessness is sure to create dissatisfaction with the test system.

Payment for Milk According to its Butter or Cheese Value.

While in creameries payment according to quality is always made in proportion to the amount of fat furnished by each patron, in cheese factories two different methods exist:

(1) According to the amount of fat in the milk, as in creameries.

(2) By taking into consideration the casein, as well as the fat, of the milk. As the per cent. of casein in milk is fairly constant, some constant number, usually 2, is added to the per cent. of fat as an allowance for the casein.

Extended experiments carried on at this station all go to prove that the second is the much preferable method to adopt in cheese factories. (For information on this question write the Dairy Department for a bulletin entitled "Experiments in Cheesemaking.")

To make a division of money according to the second, or fat-casein method, taking 2 to represent the per cent. of casein in the milk: During a certain month three patrons supply milk to a factory, as follows:

A, 3,462 pounds milk, testing 3.1 per cent. fat.
B, 5,220 " " 3.6 "
C, 8,371 " " 4.0 "

From the above milk are make 1,650 pounds cheese. The cheese sells for $9\frac{3}{4}$c. a pound and it costs $1\frac{1}{4}$c. per pound to manufacture it.

Net value of a pound of cheese, $(9\frac{3}{4} - 1\frac{1}{4}) = 8\frac{1}{2}$c.
Net value of 1,650 pounds of cheese $= 1,650 \times 8\frac{1}{2}$c. $=$ \$140.25.

As seen below, there are 971 lbs. fat and casein.

971 pounds fat and casein are worth \$140.25

1 pound " is " $\frac{140.25}{971} = 14.44$c.

Name.	Pounds milk.	Per cent. fat.	Per cent. fat and casein.	Pounds of fat and casein.	Value at 14.44c. per pound.
					\$ c.
A	3,462	3.1	5.1	176.5	25 48
B	5,220	3.6	5.6	292.3	42 20
C	8,371	4.0	6.0	502.2	72 51
Total				971.0	140 19

Method of Constructing Tables for Use in the Secretary Work of a Factory.

In making a division of the proceeds of a cheese factory or creamery, a simple table can be readily made out which will materially lessen the labor of the secretary, and also the chances of making mistakes. The method is equally applicable, whether a division of the proceeds be made upon the fat basis, or the fat-casein basis, or according to the weight of the milk, and can probably be best explained by taking an example. Let us suppose that in a creamery, for a certain month, the net value of a pound of fat is 19.74 cents. This makes the net value of 100 pounds of fat equal \$19.74.

Multiplying $19.74 by 2, 3, etc., we obtain the value of 200 pounds, 300 pounds, etc., to be $39.48, $59.22, etc., which we place in a column in the left of a sheet of paper.

Next, dividing the value of 100 pounds, 200 pounds, etc., by 10 we obtain the value of 10 pound, 20 pounds, etc, which we place in another column to the right of the first: next, dividing the value of 10 pounds, 20 pounds, etc., by 10 we obtain the value of 1 pound, 2 pounds, etc.; and, lastly, dividing the value of 1 pound, 2 pounds, etc., by 10 we obtain the value of .1 ($\frac{1}{10}$) of a pound; 2 ($\frac{2}{10}$) of a pound, etc., which we place in still another column.

NOTE.—We divide any number by 10 by simply shifting the decimal point one place to the left; thus 19.74 divided by 10 gives 1.974.

Making use of the foregoing we can readily construct such a table as the following, the method of using which will be illustrated after the table:

Value of 1 pound fat = 19.74c.
Value of 100 pounds fat = $19.74.

Weight.	Value.	Weight.	Value.	Weight.	Value.	Weight.	Value.
	$ c.						
100.......	19 74	10.......	1.974	1.......	.197	.1.......	.019
200.......	39 48	20.......	3.948	2.......	.394	.2.......	.039
300.......	59 22	30.......	5.922	3.......	.592	.3.......	.059
400.......	78 96	40.......	7.896	4.......	.789	.4.......	.078
500.......	98 70	50.......	9.870	5.......	.987	.5.......	.098
600.......	118 44	60.......	11.844	6.......	1.184	.6.......	.118
700.......	138 18	70.......	13.818	7.......	1.381	.7.......	.138
800.......	157 92	80.......	15.792	8.......	1.579	.8.......	.157
900.......	177 66	90.......	17.766	9.......	1.776	.9.......	.177

EXAMPLE.—Using the foregoing table find the value of 375.4 pounds of fat.

Value of 300 pounds	$59.22
" 70 "	13 818
" 5 "	.987
" .4 of a pound	.078
Value of 375.4 pounds	$74.10

Permanent tables can be constructed on a similar plan for determining the amount of fat or fat and casein in milk.

CREAM-GATHERING CREAMERIES AND THE OIL TEST.

In many sections of country which are sparsely populated, creameries are conducted on the cream-gathering plan, *i.e.*, the cream instead of the milk is collected, the patrons doing the creaming of the milk.

The cream gatherer's outfit consists of a covered spring wagon, insulated cream cans, or a tank, for holding the cream, a cream book, a cream pail twelve inches in diameter, a rule scaled to inches and tenths of an inch, a "card" or rack of test tubes for holding samples of cream, a small ounce dipper for sampling the cream, and a case for carrying the "card" or rack.

Upon receiving cream from a patron the cream-gatherer pours it into his cream pail, measures its depth in the pail in inches and tenths of an inch, records opposite the patron's name in the cream book the amount received from him, and after mixing the cream properly puts a sample of it into the test-tube whose number on the card or rack corresponds to the patron's number in the cream book. The samples of cream are afterwards churned at the creamery in a churn known as an "oil-test" churn. The test is known as the "oil test."

To Make an Oil Test.

Upon their arrival at the creamery, place the samples in a warm place, as over the boiler, and leave over night to ripen thoroughly. They will not churn properly unless well ripened.

The next morning, place the samples in water at a temperature of about 90 degrees; and as soon as the cream will flow freely from one end of the tube to the other, place in the oil test churn and begin the churning. Should the cream at any time cool and thicken, place the samples in warm water to liquefy the cream again. Continue churning until there is evidence of a clear separation of the fat; then place the samples in hot water, at a temperature of from 160 to 170 degrees, for from fifteen to twenty minutes.

If the separation be complete, the fat will be clear and yellow, and there will be three distinct columns with sharp lines of division between them, viz., a column of clear fat on top, one of whey next, and one of curdy matter at the bottom. If there be not a clear separation, cool to about 90 degrees, churn again, and proceed as before.

To Take a Reading. There is a chart prepared for the purpose. Placing the bottle in an upright position on the "base line" of the chart, move it along until, when looking by the right side of the bottle, the top of the column of fat comes even with the uppermost slanting line on the chart. Next, still looking by the right side of the bottle, observe the line to which the bottom of the fat comes; the number on this line gives the reading.

Meaning of the Reading. Cream that gives a reading of 100 in the oil test will make one pound of butter for every inch of such cream in a cream pail, twelve inches in diameter; cream testing 120 will make 1.20 pounds of butter.

Notes.

1. Sometimes the fat, though clear, is somewhat open. In such cases, or when the fat is not clear, allow the samples to become cold, and then place in water at a temperature of about 120 degrees before taking a reading. About 120 degrees is a very suitable temperature at which to take readings.

2. An inch of cream, testing 100, (or its equivalent in cream of another grade) in a pail twelve inches in diameter, is what is known as a *standard or creamery inch.*

3. The cream gatherer should exercise great care in measuring and sampling the cream. He should make sure to have the cream properly mixed before sampling, and should fill the test tubes carefully to the mark. The test tube is about nine inches long and the mark referred to encircles the tube at a distance of five inches from the bottom.

The butter-maker should exercise equally great care in churning the samples and in taking the readings; also there must be no undue loss of fat in the butter-milk.

4. Carelessness on the part of either the cream-gatherer or the butter-maker will lead to a considerable difference between the actual yield of butter and the yield as calculated from the oil test; while the actual and calculated yields will correspond closely if all parts of the work have been carefully done.

Where wide differences occur on account of carelessness on the part of some one or more of the cream-gatherers, it is advisable for the butter-maker, if possible, to churn the different loads of cream separately in order to locate the carelessness.

CARE OF MILK FOR CHEESE FACTORIES AND CREAMERIES.

By J. H. Findlay, Instructor in Home Dairy.

Patrons should exercise great care in the handling of milk supplied to cheese and butter factories. The cows should be kept in clean, light, warm and well ventilated stables during the winter. Food likely to taint the milk should not be fed at anytime. They should have access to pure water and salt at all times. The cow's udder should be brushed with a damp cloth or with a soft brush before commencing to milk. The milking should be done with clean, dry hands, and as quickly as possible, care being taken to get the "strippings," which are the richest part of the milk.

The main points to observe in caring for milk are:

1. Immediately after milking strain through a fine wire and cloth strainer.

2. Remove the milk as soon as possible to a place where the air is pure.

3. Aerate by using a dipper, by pouring, or by an aerator.

4. Keep the night's and morning's milk separate as long as possible. Use pails hung on hooks fastened to a pole under roof to hold each cow's milk separate over night.

5. Do not cool milk for cheese-making, unless when holding Saturday night's and Sunday morning's milk until Monday. In hot, muggy weather, or at any time when it is likely to be over-ripe, milk should be cooled.

6. Cool milk for the creamery to 60° or below after aerating.

7. Protect the milk from rain and sunshine by having covered stands with latticed sides to allow a free circulation of air around the milk can or pails.

8. Wash all cans, pails, etc., immediately after use, in warm water; then with scalding water; and where possible, steam them. Wash cans at the factory or creamery wherever practicable.

9. Do not return whey, sour skim-milk, or buttermilk in the milk can.

Care of Cream for Cream-Gathering Creamery.

Either deep-setting in ice water or the hand cream separator may be used in creaming milk for the cream-gathering creamery. Cream from deep-setting cans should be placed in cold water and be kept sweet until the driver calls for it. Cream from the hand separator ought to be cooled to the temperature of the cream in the can before it is mixed with the older cream in order to prevent souring, which would be likely to occur if the warm cream from the separator were mixed with previous skimmings. At each addition of fresh cream the whole should be well stirred to insure uniformity of test and to save time.

A STARTER.

By R. W. Stratton, Assistant Instructor in Cheese-making.

The first step in making a starter is to provide a suitable can, one having double walls with an airtight, hollow space between, and tight fitting covers, is preferred, as with such a can a more even temperature can be maintained. Care should be taken that all seams in the can are well soldered, so as to leave no lodging place for bad germs.

We believe that the time has come when the pasteurizing method of preparing a starter should be adopted, as by this method, if proper care be taken, a good starter can be propagated for an indefinite period, and a good, uniform flavor be insured. In making a pasteurized starter, it can be done only after you have secured something to propagate the lactic acid, as the process of pasteurizing kills all the lactic acid germs. So in making a start, heat a small quantity of good flavored milk to a temperature of ninety degrees and allow it to sour. If a good flavored starter cannot be secured in this way, which is sometimes the case in certain localities, it may be necessary to procure a commercial starter or lactic ferment.

After selecting the milk, add from 15 to 20 per cent. of pure, cold water and heat to 158°, stirring constantly while it is being heated. Allow the heated milk to stand for twenty to thirty minutes at this temperature; then cool to 80° and add from two to three per cent. of the old starter. Stir well, cover up, and do not disturb it until it is required for use.

Before using, it will be better to remove from one to two inches of the milk from the surface of the can, as the flavor of the surface will be found not so good as that which is below. Then break up the remainder by stirring it well in the can, take out what is required and pour from one pail to another a few times, until it has a creamy consistency, when it will be ready for use. The indications of a good starter are, that the whole mass is firmly coagulated and no water is found on the top; and the flavor is pleasant to both taste and smell.

A starter may be used to advantage when the milk is maturing slowly, and when it is tainted or gassy. One per cent. of starter is the most that should be used at any time, and this quantity should be used only after you have ascertained the acidity of the milk by the rennet test, and have found it necessary. Do not ripen the milk so low by two or three seconds when using a starter. Bear in mind that a starter may be used to advantage only when it has a good flavor, and when the milk is in such a condition that its use is a necessity. The practice of using a starter when not needed, or of using one with a poor flavor, should be avoided.

1. Don't prepare your starter in a haphazard manner by leaving it in an open can or vessel while in a room where the air is impure.

2. Don't propagate your starter with anything but one having a good flavor.

3. Don't use a starter when it is not needed.

4. Don't use too much starter.

5. Don't use a poor starter—rather put it into the whey tank.

6. Don't forget that the flavor of the starter used will largely determine the flavor of the cheese made.

7. Don't disturb your starter while it is ripening—if you do, it will separate.

8. Don't use a starter without using good judgment. This combination is very essential.

SEPARATORS AND THE SEPARATION OF MILK.

By Mark Sprague, Instructor.

As cream separators are coming more into use every day in the creameries of the Province, we feel that a few hints as to their care and management will be welcomed by all who are interested in butter-making.

As there are six or seven kinds of separators on the market, differing very much in construction, it would need as many sets of directions to make this part of our bulletin complete ; but space will not permit of so full a treatment.

The principle of separation in each machine being the same, we shall divide our separators into two classes, viz., belt separators, and steam or turbine separators, the latter being driven by steam direct from the boiler.

1. *Belt Machines.* A stone foundation is not required for those makes of separators that are built with a rubber ring around the upper bearing, but the best results are got from having all separators solidly placed or set. First, place the intermediate, or jack, in position. Level it and put it in line with the driving shaft. Then fasten it in a position with bolts or lag-screws, bearing in mind that it may be placed immediately under, or several feet either way from the centre of the driving shaft, as best suits the requirements, and taking care that the pulley on the driving shaft be of sufficient width to carry the belt and allow of its being shifted from the tight to the loose pulley of the intermediate, and *vice versa*, and of the proper size to give the exact speed required.

Next, place the frame of the separator in position, far enough from the intermediate to give the proper tension to the endless belt. Level the machine both ways by placing your level on the top of the cast frame, which is turned true for this purpose. Line the separator with the intermediate by bringing the right hand outside surface of the spindle pulley in line with the centre of the face of the large intermediate pulley, having the vertical centre line of the spindle level with the under side of the intermediate pulley ; then bolt the separator securely to the floor or foundation, unless it be one that has the spindle and bowl connected by a socket-joint. If the spindle is so connected, bolting down will be unnecessary.

Bear in mind that the separator bowl should revolve or turn to the right, or with the sun, and that the intermediate should run from the separator. Never put the idler or tightener on the drawside of the belt. Where only one separator is used, put on all the belting and start the separator with the engine, taking from ten to fifteen minutes to reach the proper speed. Wipe all bearings to free them from dust or dirt, and see that all oil tubes are cleaned and free to allow the oil to flow to the bearings. Look after this matter from day to day.

2. *Steam or Turbine Separators.* In setting a steam or turbine machine you have only to decide on the place to set it. This separator also must be set solid so as to be free from the possibility of vibration, and must be levelled in the same way as the belt machines. Turbine separators are all fitted with three-

quarter steam fittings, but if the separator be placed so that more than twenty feet of pipe is required to reach to the boiler, use a larger pipe to insure sufficient steam to drive it properly, adding one-quarter of an inch in size of pipe for every twenty feet in distance. Take care to remove all scales and cuttings from pipes before placing them in position.

The exhaust pipe is usually made of galvanized iron, four inches in diameter. It may be conducted through the side of the building, provided it is placed so as to drain well, or it may be put through the roof. The latter method is to be preferred, as the danger of frightening horses is thus done away with. It should be long enough to reach higher than any point of the roof, in order that the draft may not be interfered with. When it is put through the roof, a drain pipe must be connected with the elbow at the lowest point to carry away the condensed steam. This in most cases may be put through the floor or be allowed to run into a pail. Next, put the bowl and spindle in place, being sure to have all bearings cleansed and oiled. Then fill the bowl with water, if it be a separator that has steam turned directly against the bowl. This will keep the bowl cool until sufficient speed has been reached to cause a current of air around the bowl, which will keep it cool thereafter. Apply steam gradually, having the regulating valve set so that it will keep the pressure at from forty-five to fifty pounds on the steam guage. If there is no safety valve, the pressure will have to be regulated by the globe valve.

After speed has been reached in either the turbine or the belt separator, the milk should be turned on full feed, until both the cream and the skim-milk flow freely; then it should be closed off till the cream is the desired thickness.

Milk separates best when fresh or new, and at a temperature of 90 to 100 degrees. But in creameries the usual practice is to bring the night's and morning's milk together to the factory. In such cases, if the temperature has fallen below eighty-five degrees, the milk should be heated to eighty-five or ninety degree or higher, at least eight or ten minutes before going into the separator. This is done by means of a tempering vat, holding about 400 pounds, and attached to the receiving vat, so as to have a regular flow to the separator.

Heating increases the difference in the specific gravity between the serum and the fat of milk, and thus facilitates the separation of the latter. Frozen milk separates better when heated five to eight degrees higher than that which has not been frozen.

After all the milk has been separated, the cream left in the bowl may be forced out by putting in some skim-milk or warm water; about two pailfuls will be needed for this purpose. Shut off the feed tap for a few seconds when about one pailful has gone through; then turn it on again.

Always allow the bowl to stop of its own accord after the power has been taken off—never apply any brake or fricton to it. Wash in tepid water the bowl and all parts that come in contact with the milk or cream, cleaning all foreign substances from the skim-milk tubes, etc. Then scald with steam or boiling water and allow to dry, after which the parts may be put together.

Two thicknesses of quarter-inch rubber packing placed under the outside edge of the base, before bolting the separator down, improves the running of any separator. Four rubber rings, one under each corner, also have a beneficial effect in making the separator run smoothly and quietly.

In conclusion, we would say to anyone who gets a separator : If you are not familiar with it, get some person who has had experience to assist you in setting it up. The very high rate of speed at which cream separators run makes them somewhat dangerous in the hands of inexperienced operators.

BUTTER-MAKING IN THE CREAMERY.

By T. C. Rogers, Instructor.

Cleanliness.—Every butter-maker should be clean. All are not clean. Some of our creameries and cheese factories are not so clean and orderly as they should be. There is room for much improvement, both outside and inside. There is no good reason for lack of cleanliness. None should disgrace the dairy industry by careless, dirty habits. All should determine to clean up and be clean.

First, improve the outside appearance of the creamery by removing all stones and rubbish that may be lying around. Straighten the fences and wood-pile. Improve the approaches to the factory. Plant shade trees. Rake the yards, and keep them clean and orderly. The appearance of many old buildings may be improved by applying a coat of whitewash to the outside. A coat of thin whitewash on the inside is a good disinfectant and improves the appearance. Paint all the appliances a light color. A bright yellow looks well. Use something in the paint to give it a hard finish when dry. If you cannot get this work done for you, do it yourself. The rooms will have a more orderly appearance if everything, not in daily use, is removed from the shelves and tables.

Use plenty of salt and boiling water to clean the churn and other wooden utensils. First, rinse the inside of the churn to remove any butter that may be sticking to the sides ; then scald three times with boiling water. Use a dipper of salt in the last water. Steam the churn frequently and scour with salt to keep it sweet and clean. A tablespoonful of borax in the last water is recommended. Do not cool the churn with cold water after cleaning it, but give it plenty of fresh air, and you will not be troubled with mould, nor with a foul smell in the churn. A rubber hose connected with a steam pipe in the centre of the room is very convenient. Use lye in the hot water occasionally when cleaning the floors and gutters. A rubber scraper is handy for drying the floors. Give the rooms plenty of fresh air.

Separator Creameries.

Flavors.—As flavor has the greatest influence on the market value of butter, it is necessary for the butter-maker to refuse in a courteous manner all milk tainted with bad flavors.

If troubled with bad flavors which cannot be overcome by the use of a good starter and ripening at a low temperature (60° F.), nor by appealing to the patrons, then pasteurization of either the whole milk or the cream may be practised.

Pasteurization is the heating of any liquid to a temperature of 155° to 160° F. and holding at that temperature for twenty to thirty minutes, and afterwards cooling it. Its use in butter-making is to remove bad flavors due to bacteria, feed, drink, or absorption by the milk from the surrounding atmosphere.

This process is reliable when a good flavored starter is used to ripen the cream. But if the starter is not good, it will seed the purified cream with bacteria which will produce undesirable results in flavor. The butter made from pasteurized milk or cream has a mild, uniform flavor ; it has good keeping qualities but lacks the high aroma characteristic of butter made from raw cream which has been separated from good milk.

The system may be adopted also in cream-gathering creameries in the late fall months when there is trouble with bad flavors. If the cream is delivered sweet it may be pasteurized with the same good results as in the separator creamery.

Points to Observe when Pasteurizing.

1. Stir the cream constantly while heating to 158°.

2. Do not have the temperature of the water surrounding the vat holding the cream above 180° F., or it will give the milk a cooked flavor.

3. Remove the hot water as soon as the cream has reached the proper temperature.

4. Allow it to stand twenty minutes and then cool rapidly to the ripening temperature.

5. Add 15 to 20 per cent. of starter as soon as the cream is cooled to 95°

6. Stir often while cooling.

7. Use a starter in pasteurized cream, or ripening will not take place, except very slowly.

Cream may be pasteurized in the ordinary cream vat, in a channel vat, or in the more costly but excellent pasteurizers that are now for sale.

Separating.

When the milk arrives at the creamery strain it through a cloth or fine perforated tin strainer.

(Note.—Boil the cloth strainer after the milk is washed out of it and give it plenty of sunlight and fresh air to keep it clean.)

Heat the milk to the temperature at which the separator will do the closest skimming, make smooth cream, and do the most skimming per hour. If the separator whips the cream heat the milk to a higher temperature before separating. Have the cream contain 30 to 33 per cent. of butter-fat. Rich cream gives less volume to cool and handle, and it can be churned at a lower temperature.

Ripeneng the Cream.

Have a good starter ready at all seasons of the year to put into the cream when separating commences. This hastens the ripening and controls undesirable flavors that may develop from the presence of undesirable forms of bacteria that may be in the milk. When the cream is to be ripened and churned in 24 hours, cool it to about 70° or 75° temperature, and use a starter in it equal to about two per cent. of the milk separated, or from 15 to 25 lbs. of starter for each 1,000 lbs. of milk. If the cream is to be pasteurized, do not put in the starter until after the cream has been heated and cooled again to 95°.

The quantity of starter used varies according to the ripeness of the milk, the time allowed for the cream to ripen and the temperature at which it is ripened. Less starter is required in summer than in winter.

As soon as the cream commences to thicken (which should be in about four hours after the starter is added) be ready to cool quickly to at least 55° temperature before leaving it at night. The sweet flavor of the butter may be injured by over-ripening, if the cream is allowed to stand at higher temperature over night. At high temperatures the cream can be well ripened and properly cooled in time for churning any hour the next morning. While equally good and sometimes better results in flavor can be had by ripening at lower temperatures than those here recommended, the high ripening temperatures are possibly best adapted for creamery work.

If the cream is to be held for two days before it is churned, use five to eight lbs. of starter for each 1,000 lbs. of milk; to ripen the cream cool quickly to about 52° and hold at this temperature until churned. The cream in this case should coagulate in about 24 hours after it is separated.

When the cream is cooled quickly to 60° to ripen, use more starter than when ripening at higher temperatures.

Sufficient lactic acid should develop in the cream to cause it to coagulate in at least six to eight hours before it is churned. Always stir the cream frequently while ripening it, to ripen it more uniformly and improve the flavor.

Properly ripened cream will have a smooth, glossy, mirror-like surface. It will pour like thick molasses, and have a sharp but pleasant acid taste and smell, and will show about .65 per cent. of lactic acid by the alkaline test.

Starters.

A good starter will show its strength by causing rapid and uniform coagulation of the cream from day to day. It is important that the starter have a good flavor. If it go wrong from some cause, a fresh culture may be had from the buttermilk of a lot of cream that has ripened by natural souring and produced good flavored butter. It may be had from a neighboring creamery or private dairy; from fresh milk or skim-milk that has been allowed to sour; or from some of the commercial cultures. Sometimes it is difficult to get the right flavor in the starter, even when the commercial cultures are used.

Butter-makers can co-operate with mutual advantage by passing from one creamery to another a small quantity of a choice starter that may be found in some one creamery as a culture, to make fresh starters in the others.

Churning.

In a warm room, prepare the churn with cold water only. If the churn is not in daily use rinse it with hot water, and then cool it with plenty of cold water. In a cold room, or if the cream is a little too cold, scald the churn and do not cool it. If there is more than one churning all that is necessary to prepare the churn for the next lot of cream is to rinse down the inside of the churn with cold water to remove any butter that may be sticking to the sides.

Strive to have the cream at the proper churning temperature at least two hours before it is churned in order to secure a firmer body and better texture in the butter. Churn at 52° to 54° in the fall and winter months, and at 48° to 52°

in the summer months. If the cream conains 27 per cent. or over of butter-fat, it will churn at lower temperatures than these; but if it contains only 18 to 20 per cent. it cannot be churned satisfactorily unless at higher temperatures.

The reasons for cream being difficult to churn in a creamery are :

1. The cream contains too much skim-milk and is churned at too low a temperature. Make richer cream.

2. Too much cream in the churn ; it should be only one-third full.

3. The temperature is too low.

4. Adding too much cold water too soon after the butter begins to gather.

If the cream contains too much skim-milk or churned at too low a temperature, the butter forms into round, smooth granules, and considerable difficulty is sometimes experienced in gathering the butter properly. To overcome this difficulty, and when the same trouble results from adding too much cold water, draw off half the buttermilk, or a sufficient quantity to cause the butter to gather as desired in five minutes or less. Butter should always gather in less than ten minutes after it breaks.

When ready, strain the cream into the churn. Add butter coloring before starting, if the market demands it. Half an ounce of butter color per 1,000 lbs. of milk separated will be sufficient for the Canadian markets. Use one-eighth of an ounce or less for the British markets in the winter months. None should be used for either market in the summer months.

It should take 30 to 60 minutes to churn, according to the quantity of cream in the churn. The churn should run from 55 to 60 revolutions per minute.

If the cream thickens and concussion stops when churning (this will be known by sound of the churn) dilute it with some cold water, at about 55° temperature. Enough water should be added when the butter breaks, or when half gathered, to prevent the butter from gathering too soon or before the cream is properly churned.

The granules should be about the size of wheat grains, and not too small, or the butter will retain too much moisture.

If small particles of butter are seen on the first buttermilk drawn oft the churning should be continued for a few turns.

Washing the Butter.

The volume of water used to wash the butter once should be equal to the amount of cream churned. A less amount may be used at each time when washing twice. The temperature of the water used should be at from 54° to 58° in the fall and winter months, and from 45° to 50° in the summer months. If the room is warm, and the water not cold enough, put some salt into the water and let the butter remain in it for 10 to 15 minutes to cool. If the butter is to be salted in the churn, it should be washed with water cold enough to prevent it from massing together too readily when the salt is being mixed in. Wash the butter twice when it is likely to be held in cold storage for some time. Wash once when it is known that the butter is to be consumed in less than two months. Use plenty of water; if the butter is forwarded weekly for immediate consumption it is not necessary to wash it. This method works well in the cold weather and where water is scarce or impure. When not intending to wash the butter put three or four pails of the coldest water at hand into the churn, after the butter granules are the size of wheat grains, and revolve the churn quickly for 6 or 8 turns before drawing off the buttermilk. The cold water cools the butter and dilutes the buttermilk, so that it will give less trouble on the worker. Rinse the buttermilk from the worker when the butter is about half worked.

Salting and Working.

The salt should be kept in a clean, cool place, free from foul odors. It should be fresh, of good flavor, and have a fine even grain. About $\frac{3}{4}$ to 1 ounce of salt per lb. of butter is required for the Canadian markets, and $\frac{1}{2}$ to $\frac{5}{8}$ of an ounce for the British market, when the butter is washed, and when it is salted on the worker. When making unwashed butter or when salting in the churn, use $\frac{1}{8}$ to $\frac{1}{4}$ of an ounce more salt per lb. of butter. Salt the butter to suit the market.

To find the weight of salt required when salting the butter in the churn, multiply the weight of cream by the per cent. of butter fat in it, and divide by 84 to find the lbs. of butter.

Or, find the pounds of milk required to make one pound of butter on previous days, and divide this number into the weight of milk that represents the cream churned. The result will be the pounds of butter in the churn.

Sift on half of the salt that is to be used to salt the butter; give the churn a quarter turn and sift on some more; then give the churn a half turn back, and sift on the rest. (Note.—A fine, perforated tin-bottomed seive is the best and most durable). Mix the salt through the butter with a wooden fork or spade. The butter may remain in the churn after it is salted, if the room is the right temperature. But if the room is too cold or too warm it may be put into a large box made for the purpose, or into tubs, and be removed to a room at a suitable temperature, and there remain two to four hours. Salting the put into this way improves the texture for working, and less working is required to give it an even color. Do not allow the butter to become too warm or too cold before it is worked. About 10 to 16 revolutions of the Mason worker will give an even color and expel sufficient moisture. The amount of working required will depend on the length of time the butter has been salted before it is worked.

When the butter is salted on the worker and finished at one working, it will require at least 24 revolutions of the worker to remove sufficient moisture and give an even color. The lowest roller should be nearly two inches from the table. If the butter is soft and the room warm, it will be better to pass it about eight times under the rollers, and then put it in a cool room for a few hours and work a second time, in order to make the color even.

Working the butter twice may be the best method for the inexperienced butter-maker to adopt; but more butter can be handled in the same time when the butter is finished at one working. Butter is generally in its best condition for working as it is taken from the churn. Its temperature should be above 55° in the winter months, and below 54° in the summer months, when it is finished at one working. Too many make the mistake of not working the butter enough when adopting the one working method. This method requires more working than any other to give an even color and to remove the moisture.

Do not wait until a buyer or commission merchant tells you what defects are in the butter. Some of them will give you no useful information, but will cut the price. Examine it yourself the day after it is made, and see if the flavor, salt and color are right. If defects are found, then corrections can be made, and a loss avoided in a larger quantity of butter.

Mottled or an uneven color in butter is caused largely by an uneven distribution of the salt. More working will correct this defect, but too much working will give the butter a greasy texture.

Packages and Parchment Paper.

Ash or spruce tubs should be steamed for a few minutes, and then be soaked with a strong brine for about 36 hours. Then they should be washed clean and be lined with parchment paper before packing butter in them.

The square, spruce box lined with paraffin wax and parchment paper is the neatest and most suitable package. It should be 12 in. square and 12½ in. deep to hold 57 lbs. of butter, a thin coat of salt paste, and a loose lid.

The lumber used to make these boxes should be wide enough to make the sides without jointing, and it should be free from knots. The boxes should be well waxed in the corners and on the sides, and the loose lid needs to be well waxed on both sides and edges.

The parchment paper should be of the proper thickness (say 40 to 50 lbs. to the ream), should be sweet to the taste, and should tear more easily where it is dry than where it is wet. Each box should have two sheets of paper. One sheet should be 12 inches wide and 50 inches long, and the other should be 12 inches wide and 40 inches long.

Narrow strips of paper 2 inches wide and 12 inches long should be put in the corners. Some prefer having the long sheet 12½ inches wide and do without the strips in the corner.

As some of the dealers object to having salt on the top of the butter, and as salt is necessary to protect the butter from mould, this difficulty can be overcome by putting a sheet of paper 12½ inches square on top of the butter to hold a thin coating of wet salt and brine. If the edges of the paper are left so as to point upwards at the sides of the box, salt can be removed without coming in contact with the butter.

To Prevent Mould.

1. Soak the paper for a few hours in a strong brine before using it.
2. Reject boxes and lids that are not properly coated with the wax, and notify the manufacturer of this defect.
3. Rub a little wet salt around the sides and bottom of the box before putting in the paper.
4. Put an eighth of an inch of salt paste and a loose lid (well waxed on both sides) on top of the butter.
5. Keep the butter in a dry cool room.

Packing.

Stretch a thin rubber band around the outside of the box and over the paper, to hold it in position while packing the butter. Have a packer about six inches square, and commence packing the butter at the centre of the box to drive out the air. Have another packer two inches thick and eight inches wide to pack the butter closer to the sides and corners. The latter is highly recommended by those who use it. Be sure to pack the butter close to the sides and corners, so that it will look close and solid when turned out in the retail stores. Do not have the butter too cold when packing.

Have a straight-edge notched at both ends to let it down, in order to take out what butter is required to have the right weight and leave a level top.

A sharp, wide wooden spade will do this work fairly well. Put three-quarters to one pound extra into each 56 lb. box to make it hold out the marked weight when it reaches the market.

After the butter is sealed and covered properly, put it into a cold room where the temperature is at least 56°, and as much lower as the temperature can be kept uniform. Changes in temperature have an injurious effect on the flavor.

Fresh brine should be used occasionally to keep the salt moist on top of the butter, when using tubs.

When the butter is put into pound prints, make the butter close and uniform in shape, and wrap the paper around it so it will look neat when it reaches the market. Handle the prints carefully until the butter becomes firm. If the paper is too wide take a straight-edge and cut a strip off one side, or off both sides if the paper is printed.

Shipping.

Protect your reputation and that of your creamery by having your butter turned out in clean, neat packages. Have the lids well fastened on, and the net weight of butter marked on the side. Have the same weight of butter in each package. The date and weight may be marked thus : 5/24—56, which means May 24, 56 lbs.

See that plenty of ice is used in warm weather to preserve the proper temperature of the butter until it reaches the market.

Cream-Gathering Creameries.

The managers of these creameries would be doing themselves and their patrons good service if they required their cream-gatherers to study the points necessary to be observed to get all the cream out of the milk and how cream should be cared for on the farm. There is enough cream or butter fat left in the skim-milk through carelessness and a lack of knowledge of the proper temperatures and right method of skimming, to pay the entire cost of manufacturing the butter. If the cream-gatherers understood this work, they could give valuable instruction to many of the patrons.

The cream should be stirred frequently by the patron, and then by the cream-gatherer, so as to get a just sample for testing.

The waggons should be covered to protect the tanks or cans from the sun, so that the cream may be delivered at the creamery as cool as possible in warm weather.

After the cream is strained into the vats, the butter-maker should examine its condition regarding temperature and lactic acid. A safe rule in warm weather is to cool the cream to 56° or 58° immediately after it is delivered, and hold it at this temperature over night. Churn at 58° or lower if the cream churns easily.

When the cream comes in cold and sweet, raise the temperature to 60°, and use some buttermilk as a starter to hasten the ripening process.

Thermometers.

When purchasing a thermometer, ask your dealer for a dipper of water, then put a few thermometers into the water to see what temperature each will register. Then choose the number you want from among those registering the same temperature.

A thermometer in each room will save many steps in a season's work.

Study and observe the influence of temperature to learn what temperatures will give you the best results.

Judging Butter.

In conclusion, a few notes on judging butter may be of some value.

The scale of points used may be as follows :

Flavor	45	points.
Texture, grain and closeness	25	"
Color	15	"
Salt	10	"
Finish	5	"
Total	100	"

Flavor should be so pleasant to the sense of smell, and so sweet to the taste, that it will create a desire for more.

Texture, grain and closeness should be waxy and firm,—not salvy, greasy or crumbly ; should be close in body, not spongy, and should not contain too much or too little moisture.

Color should be uniform and according to the requirements of the market.

Salt.—Judge the salt according to the market for which the butter is intended. Too much salt destroys the sweet taste of the butter for any market. Too little salt makes the butter insipid and tasteless for most Canadian people, but the British people demand light salting.

Finish.—Uniform, neat, clean and attractive in appearance.

BUTTER-MAKING ON THE FARM.

By Miss Laura Rose, Lady Instructor in the Home Dairy Department.

The first essential in the manufacture of any article is good raw material, and perhaps in no realm is this more necessary than in the production of high-class butter, which should be the aim of every farmer's wife or daughter.

More and more attention is being paid to the selection of dairy cows. Have cows whose milk record is good, both in regard to quality and quantity, for the two must be considered together. Contrive to weigh and test occasionally the milk from each individual cow. Discard all which do not reach a certain standard, say, 6,000 lbs. of 3.5 per cent. milk in the year. A Babcock tester, which is simple in construction and easy to use, will determine the per cent. of butter fat in the milk, and may reveal the fact that the cow which you considered your best is the least profitable one in the herd.

The cows must be comfortably housed, and well and regularly fed. If you want milk you must give plenty of good wholesome food and an abundance of pure water. The latter is just as essential as the former.

During milking special care should be exercised. The milkers' hands should be well washed, and the cows' udders thoroughly wiped or rubbed with a damp cloth before milking.

The Creaming of Milk.

As soon as the milk is drawn from the cows it should be taken from the stables, well aerated, and set to allow the cream to rise. If the deep-setting system is used, place the cans in water and cool the milk to 45° or below as soon as possible. Cool below 40° in winter.

Have the water the depth of the milk in the cans, and be sure there is always ice in the water, as this method requires less ice and better results follow. Unless plenty of ice has been put up, or there is a very cold, convenient spring on the farm, the deep cans are not advisable, as the loss in butter fat is very high when the milk is not sufficiently cooled. It is just as important to use ice in winter as in summer.

A thermometer is the only safe guide, and one should be used constantly in determining temperatures. For instance, by any other means it would be hard to tell whether the milk was cooled to 50° or 45°.

If cooled to 50°, the loss of butter fat in the skim-milk would be about one per cent., or one-fourth of the butter would be practically lost; while if cooled to 45°, the loss of butter fat in the skim-milk would be from two to three-tenths of one per cent. or a loss of about one-twelfth of the butter. Test the skim-milk to find out what you are doing. It is the unknown leakages which rob the dairy.

An ordinary box or barrel, which will hold water, answers as well as the most expensive creamer, but there must be room for plenty of ice. The water and tank must be kept sweet and clean. Avoid spilling milk in and around the tank or creamer box.

A can with tap to draw off the skim-milk should have a bottom with a four or five inch slant. This carries away any sediment and allows more skim-milk to be drawn off. When there is no tap use a funnel shaped dipper with no wire around the rim, and a long, straight handle. With a knife loosen the cream from the sides of the can, wet the dipper in water or milk, lower it, point first, into the can, allowing the cream to flow evenly into the dipper. Repeat until all the cream is removed.

If kept at the proper temperature, milk set in deep cans may be skimmed in 12 hours in summer, but in fall and winter it should stand at least 24 hours. The longer it stands, if kept sweet, the thicker and richer the cream.

Always keep the cans covered.

Tests from shallow-pan setting prove that there is no more loss of butter fat in the skim-milk from this method than in the deep setting. This is only the case where the greatest care is taken in skimming. The old fashioned perforated skimmer must be abandoned In using it the thin layer of cream next the milk drips through the perforations and readily mixes with the milk, as do also the large drops of thick cream which fall from the skimmer each time it is lifted to the cream crock or can. The following is the most economical way of removing the cream: Run a thin-bladed knife around the edge of the cream, pressing well to the sides of the pan, set the pan on the edge of the cream crock, tilt it sufficiently to allow a little of the milk to run over, holding back the cream with the knife—this is done to prevent the cream from sticking to the edge of the pan—then with the aid of the knife glide the cream into the cream-crock. Considerable skim-milk may seem to go with the cream, but the cream is so thick that the milk does no harm.

Milk in shallow pans should stand twenty-four hours in summer, and thirty-six hours in winter. Always skim before the milk thickens. Keep in a cool, well-aired room, free from odors of any kind. Remember, nothing absorbs odors so readily as milk and its products; and it is flavor in milk or butter which chiefly determines its value. Avoid having a draft over the milk as it forms a hard, leathery crust on the cream.

Cream Separators.

For a herd of ten or more cows a cream separator will pay. More butter fat is recovered from the milk and the cream is in a sweeter and purer condition than when obtained by any other method. The skim-milk is warm and fresh for the young stock, and the problem of cooling and caring for such a large bulk of milk is solved. If water be scarce, or ice hard to procure, invest in a separator.

Care and Ripening of Cream.

Cream should never set in open crocks or pails in cellars, pantries, or any-place where there are odors or where the air is not pure. The cream crock or can should always be covered, and in summer it should stand in the coolest place in the milk cellar, while in the winter it may be brought into a room where the temperature is from 60° to 70°. Each time the cream can is emptied it should be thoroughly washed, scalded, and put out of doors for an hour or two before being used again.

When starting to collect cream for a fresh churning, add to your first skimming a starter which you know has a clean, good flavor. A pint or two of cream saved from your previous churning, or the same amount of good butter-milk or sour skim-milk answers. The reason for adding the starter is, that the bacteria, which you know produce a fine-flavored butter, get control of the new cream before other germs which might prove unfavorable take possession of it.

Stir well each time new cream is added. Do not add sweet cream shortly before churning. You will have a great loss of butter fat if you do.

Separator cream should be cooled to 60° in winter and to 55° in summer before it is added to the cream crock.

The day before churning examine your cream. If the lactic acid be developing slowly, heat the cream to 65° in winter and 60° in summer by placing the can in a dish of warm water at 100°, and stirring constantly until the desired temperature is reached. In warm weather care should be taken not to overheat the cream or it will become too sour before churning time, and too much acid is injurious to the flavor of the butter. It may not be necessary to warm the cream at all in summer time. Have the cream lowered to churning temperature several hours before churning. It gives a better texture to the butter.

With regard to pasteurization, see "Butter-making in the Creamery" in this bulletin.

Churning.

Before using, the churn should be scalded with boiling water and then rinsed with cold water. After using it should first be rinsed down with hot water, then thoroughly scalded with plenty of boiling water, and occasionally given a scouring with salt. Never allow water to remain in the churn when not in use, and do not leave the lid on. Keep in a cool place to prevent warping.

The ladles and butter printers should be scrubbed with a brush and hot water and then be put to soak in cold water. The worker may be prepared while the butter is draining. Scrub it also and cool well with cold water. A scouring with salt prevents the butter from sticking to wooden utensils.

Always strain the cream into the churn. In winter, if necessary, add just sufficient butter-coloring of a reliable brand to give a nice June tint. Better to err on the pale side than to over color.

No definite temperature for churning can be given; but the necessity for the constant use of a thermometer should be emphasised. The quantity of cream in the churn, the temperature and richness of the cream, the breed of cows, the length of time the cows have been milking, and other circumstances, influence the time required for churning. Try to regulate the temperature and quantity of cream so as to have the butter come in about thirty minutes.

The ordinary farm cream usually contains from eighteen to twenty per cent. of butter fat, and may be churned at from 56° to 60° in summer, but may vary in winter from 60° to 70°. Cream containing twenty-five to thirty per cent. of butter-fat may be churned at much lower temperatures. Low temperatures give a better grained butter and a more exhaustive churning.

Very rich cream is likely to thicken in the churn so that concussion will cease. If this occurs add enough water at the same temperature as the cream to dilute it so that it will churn. When the butter has just come, add the same quantity of water a few degrees colder. This gives the butter sufficient liquid to float in, and allows the buttermilk to run off more freely. When the granules are the size of wheat the butter is churned enough. If small specks of butter appear in the first buttermilk drawn, churning should be continued a short time to prevent loss; only a few turns are necessary sometimes.

Wash with fully as much water as you had cream, regulating the temperature according to the softness of the butter and the mode of salting. If salted in the churn colder water is needed. For butter going into immediate consumption one washing is all that is necessary, but if it is to be kept for a length of time two washings are better.

Allow the butter to drain fifteen minutes before salting. Salt according to the demand of the market, usually from three-quarters to one ounce of salt to the pound of butter. If salting in the churn, from one-eighth to one-quarter of an ounce more salt is required. We strongly recommend salting in the churn, as butter free from specks and streaks can be had with the least possible amount of working by this method, but the churn must be without dashers and the butter granules should be quite firm. The only difficulty in this method is gauging the amount of salt when the exact per cent. of butter-fat in the cream is not known. To salt in the churn tip the churn backward and forward several times, while sifting on the salt. Then revolve the churn slowly to mix in the salt more evenly. After allowing it to stand fifteen minutes gather in a lump and leave it in the churn from two to four hours, or if the room be warm, it may be lifted out into a butter tub and put into the cellar for that length of time.

For the home dairy there is nothing nicer than the V-shaped lever butter worker. Work by means of downward pressure. Avoid a sliding motion, as it injures the grain of the butter. Just work sufficiently to expel the moisture. If salting on the worker, after the butter has drained take it from the churn, weigh and put it on the worker, weigh the salt, sprinkle it over the butter, and give more working than with the other method.

Make into pound prints or any desired form. Have the package neat and attractive. Use parchment paper. Dip it in water before wrapping about the butter, as it prevents sticking.

Keep the butter in a cool, sweet place and get it to market as soon possible.

A Few Don'ts.

Don't be in such a hurry that you lose money for the sake of a little time.

Don't fail to put up ice if you use the deep-setting cans.

Don't put off churning too long. Your butter will have an old taste.

Don't fill the churn quite half full or you will be a long time in churning.

Don't take the temperature of the cream with your finger. You cannot depend on its accuracy.

Don't wash your milk pails, pans, cans, etc., with the dish cloth. Have either a hair or broom brush on purpose for these utensils and give it a boiling once in a while in salt brine.

Don't dry your milk utensils. Put them in a position to drain and allow the heat from the scalding water to dry them ; also give them plenty of fresh air and sunshine.

Don't be satisfied till you have gained a reputation for making the very choicest butter.

Improvement consists in learning what others have done and going beyond that. Let this be your aim.

CHEESE-MAKING.

By T. B. Millar, Instructor.

Spring Cheese.

In the spring, before commencing cheese-making, it is necessary to see that the factory, apparatus, and everything connected with it, is perfectly clean, and in good repair. Then, on commencing, see that the milk delivered is clean, sweet, and free from bad odors. If it is not it is the cheese-maker's duty to instruct his patrons in the care of milk and to reject all milk that is not in good condition. In order to make the quality of cheese demanded at the present time we must get better milk, for we cannot make fine cheese unless we do, and this can be obtained only through the medium of the cheese-maker.

(Bulletins on the care of milk may be obtained by applying to the Department of Agriculture, Toronto.)

For early cheese, heat the milk to eighty-four or eighty-six degrees Fahr., and stir gently while heating, as quick or rough stirring causes a loss of butter-fat. Make a rennet test as soon as possible, and if the milk is ripening quickly set early. To make the test take eight ounces of milk at eighty-six degrees, add one dram of rennet of known strength, and stir rapidly for ten seconds, noting the number of seconds it takes to coagulate. If coagulation takes place in from twenty to twenty-two seconds the milk is matured sufficiently and the rennet should be added at once. It may be necessary to vary the test a few seconds to suit the conditions of different localities, but a few trials should enable the maker to tell when the milk is in the proper condition, care being taken not to mature the milk too far before setting.

If colored cheese is desired use about one and one-half ounces of coloring per 1,000 pounds milk, and have the coloring matter well mixed with the milk before the rennet is added.

Ripen or mature the milk so that sufficient acid for dipping will develop in from two and three-quarters to three hours after setting. When dipped the curd should not show more than one-eighth inch of acid by the hot iron test. Great care should be taken at this point, as the acid develops very rapidly.

Enough rennet should be used (from four to five ounces per 1,000 pounds milk) to coagulate the milk fit for cutting in from fifteen to twenty minutes. Use the horizontal knife first, then the perpendicular, cutting continuously until completed. Commence cutting early, taking plenty of time.

Stir the curd gently with your hands or with agitators for ten or fifteen minutes before any steam is turned on; also see that the curd is free from the sides of the vat before applying the steam.

Rough handling at this stage means a loss both in quantity and quality.

Heat the curd slowly to ninety-eight degrees, taking from thirty-five to forty minutes to do so. After the heat is up to the desired point, continue stirring for fifteen or twenty minutes to insure uniform cooking. Draw off part of the whey early and dip with a small acid, from one-sixteenth to one-eighth inches, having the curd in such condition that it will not require much stirring in the sink, then pack it from four to six inches deep, according to the condition of the curd, and when matted sufficiently, so that it can be turned without breaking, cut in strips from four to six inches wide and then turn every ten or fifteen minutes—or often enough to keep the whey from gathering on the curd. After they are turned once or twice, these strips may be piled two deep.

Keep up the temperature until the curd is ready for milling; then mill as soon as the curd becomes flaky and shows from three-fourths to one inch of acid. Stir often and air well. Salt when the curd becomes mellow, feels like velvet, and smells like newly-made butter. Use some brand of pure dairy salt, salting at the rate of one and one-half to two pounds of salt per 1,000 pounds of milk. The curd should be at a temperature of from eighty-three to eighty-five degrees, and when the salt is thoroughly dissolved the curd is ready to put to press.

Apply the pressure slowly at first. Do not be in a hurry to apply all the pressure until the whey runs clear, then gradually increase it. After the cheese has been in the press forty-five minutes or longer, take them out and pull up the bandages neatly, trimming them so as to leave about three-quarters of an inch on each end.

Turn all cheese in the hoops every morning and see that each cheese is finished perfectly before it leaves the press room.

The curing-room should be kept at an even temperature of from sixty-five to seventy degrees, and should be well ventilated.

Note.—When quick curing cheese (ready to ship in from ten days to two weeks) is not desired, use less rennet and more salt.

Many curing-rooms may be very much improved by placing two thicknesses of building paper on the inside of the present lining. Then nail two inch strapping on the paper and line with one or two thicknesses of matched lumber. The ceiling, as well as the walls, should be lined in this manner. Shutters on the windows, ventilators in the roof, and a supply of ice placed on suitable racks in the curing-room will save many dollars worth of cheese in hot weather. Sub-earth ducts are highly recommended by those who have used them.

For colder weather, a coal furnance which causes a circulation of air and an equal temperature in all parts of the room, night and day, is a necessity. An ordinary wood or coal stove is not suitable for heating a curing-room, as the heat is not evenly distributed among the cheese.

Summer Cheese.

Heat the milk to eighty-four or eighty-six degrees Fahr., and make a rennet test. In very hot weather it is advisable to make a test before the temperature quite reaches eighty-four degrees, and if the acid is developing quickly, set at eighty-four degrees, but if not, raise the temperature to eighty-six degrees.

Set the milk so that the curd will be ready to dip in from two and three-fourths to three hours with about one-quarter of an inch acid by the hot iron test.

If colored cheese is desired, add the coloring as soon as you can get the weight of the milk in the vat.

Use enough rennet to have perfect coagulation fit for cutting in from thirty to thirty-five minutes.

See directions for cutting, stirring and cooking the curd under the heading of Spring Cheese.

Draw off part of the whey early so as to be prepared for the quick development of acid. Dip the curd when it shows from one-eighth to one-fourth of an inch of acid and endeavor to have the curd in such condition that it will not require much stirring in the sink. When matted so that it can be turned without breaking, cut in strips about six inches wide and turn often enough to keep the whey from gathering on the curd ; then pile two or three deep, leaving a space between the columns to allow the whey to escape.

Mill when the curd becomes flaky and shows from one to one and one-fourth inch acid, then air well by stirring immediately after milling and every few minutes until ready for salting.

Mature well before salting. Use at the rate of two and one-half to two and three-fourths pounds of salt per 1,000 pounds of milk, varying the weight of salt according to the amount of moisture in the curd.

In hot weather do not cover the curd after milling, and lower the temperature as much as possible before putting the curd into the press.

Fall Cheese.

In making fall cheese the system is similar to that used in making summer cheese, excepting the following points :—

If the milk is working slowly use some clean-flavored starter.

Use enough rennet to have coagulation take place in from thirty-six to forty minutes.

After dipping, keep the curd warm.

Mill when it is flaky and shows from one and one-quarter to one and one-half inch acid.

Salt at the rate of two and three-quarters to three pounds salt per 1,000 pounds of milk.

Leave the cheese in the press for one hour before bandaging. Use plenty of hot water and make sure that each cheese has a perfect rind before putting on the shelves in the curing-room.

Over-ripe Milk.

When the milk is over-ripe, set as soon as possible at a lower temperature than usual—at from eighty-two to eighty-four degrees. Then, as always, make a rennet test. In a case of this kind more rennet should be used—one ounce extra per 1,000 pounds of milk.

Commence to cut the curd early and cut finer than usual, that you may be enabled to cook the curd more quickly.

Cook quickly, draw off a portion of the whey early, and stir well. Dip the curd, when it can be accomplished, with less acid than usual, and stir well before allowing it to mat in the sink. Turn often, being very careful not to allow any whey to gather on the curd. Mill early, or when the curd will show three-quarters of an inch of acid, and try to have the curd in a flaky condition at this stage. Air and mature well. Do not be in a hurry to salt a curd of this description, for if it has been milled at the proper time and well stirred there is no danger of it getting too much acid in the sink.

Gassy Milk.

In treating gassy milk note the following points :—

The milk should be matured more than usual before setting (some two or three seconds more).

Let the curd become quite firm before cutting, and be careful to leave the cubes large, so as to retain more moisture. Stir for fifteen minutes before turning on any steam.

When cooking, heat slowly to ninety-six or ninety-eight degrees, and be careful not to get the curd hard at this stage. Raise the temperature two or three degrees just before dipping.

Dip the curd with one-quarter inch acid, and if it has been *cooked* properly it will not require much stirring in the sink. Turn frequently, at the same time piling the curd three or four deep in the sink. Mill when it is flaky and shows one and one-quarter inch acid. Air and *mature* well before salting.

Tainted Milk.

Heat tainted milk to eighty-eight degrees and air frequently by dipping or pouring, until the milk is ready for setting. If a sharp, clean-flavored starter is available, use a little extra with milk of this kind.

When the curd is heated to ninety-eight degrees draw off a portion of the whey, and when it is ready for dipping raise the temperature two or three degrees and stir well.

Dip the curd with a small amount of acid, about one-eighth of an inch, endeavoring to have it in such condition that it will not require much stirring in the sink. Keep the temperature at ninety-two or ninety-four degrees until the curd is ready for milling. Mill when the curd is in a flaky condition and shows about one inch acid.

Air by frequent stirring and mature well before salting.

Notes.—When making colored cheese, pour the coloring into a large dipper of milk taken from the vat, then draw the dipper quickly along under the surface of the milk from one end of the vat to the other, and be sure that the coloring is evenly mixed before the rennet is added.

The rennet should be diluted with one gallon of pure *cold* water to each vat, and the milk should be well stirred for from three to five minutes (according to the condition of the milk) after the rennet had been added. In the case of over-ripe milk two minutes will be time to stir after adding the rennet.

Important to Know and Practise : 1. That milk for cheese-making shall not be ripened so that it will dip in less than two and three-quarter hours. 2. That unless the curd is well *cooked*, you cannot make a *fine* cheese. 3. That the maker and factory should be as clean as hot water and scrubbing can make them.

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Ontario Agricultural College and Experimental Farm

EXPERIMENTS

WITH

WINTER WHEAT

By C. A. Zavitz, B.S.A., Experimentalist.

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BULLETIN 108.

EXPERIMENTS WITH WINTER WHEAT.

By C. A. Zavitz, B.S.A, Experimentalist.

A good deal of attention has been given to the testing of winter wheat in the Experimental Department of the Ontario Agricultural College. Varieties obtained from the United States, England, Scotland, Germany, France and Russia have been carefully tested along with those secured from the wheat-growing sections of Canada. Besides testing the varieties, there have been experiments conducted in different dates of seeding, methods of soil preparation, methods of seeding, selection of grain for seed, quantities of seed per acre, application of fertilizers, treatment of smut-infested seed, the yield and quality of wheat cut at different stages of maturity, and the value of seed from wheat cut at different stages of maturity. These experiments have occupied over twelve hundred plots within the last nine years. This bulletin gives a summary report of the principal experiments conducted under these heads in 1898, and the average results of some of the experiments conducted for several years in succession.

Field Conditions.

The two hundred and three plots used for the experiments with winter wheat in 1898 were situated in the southern portion of the large experimental field which lies at the rear of the main College building. The land used for one of the experiments had a gentle slope towards the south, and that used for the other experiments was comparatively level. No manure had been applied to the land since the spring of 1896, when it received a dressing of twenty tons of farmyard manure per acre. Commercial fertilizers had not been used for at least ten years. The land produced a crop of spring grain in 1895, a crop of roots in

1896, and a crop for green manuring in 1897, which was plowed under during the first week in August of that year. No other plowing was done, but the land was well stirred on the surface up to the time of sowing the winter wheat. The land was very carefully measured and divided into plots which were made exactly uniform in size and shape for the separate experiments. The smallest plots were each $\frac{1}{160}$ of an acre in size, and were used for the smut-infested grain which had been treated in different ways ; and the largest plots were each $\frac{1}{25}$ of an acre in size, and were used for the different preparations of soil for winter wheat. The yields per acre have been determined from the actual yields of the plots.

Conditions of Season and Growth.

The seeding of nearly all the experiments took place during the last week of August and the first week of September. The amount of rain-fall at the College in September was very light, there being a total of only $\frac{41}{100}$ of an inch during the month. The germination of the seed was good, but the growth was slow throughout September, but was better in October. Nearly all the wheat wintered well, and made a good steady growth during the spring and early summer. On the 8th of June last there was a heavy rain accompanied by strong wind, which caused many of the weak strawed varieties to lodge badly. Another storm occurred on June the 13th which gave the wheat a second test for strength of straw, thus helping to furnish an excellent object lesson for about thirty thousand farmers who visited the College during that month. Many of the weak strawed varieties were also badly lodged in 1894. In order to ascertain the effect produced by the lodging of the crops, definite determinations were made each year by cutting both lodged and standing grain of the same variety and from equal areas. Four determinations were made in 1894 and five in 1898. Providing the plants which lodged were equal in every respect to those which did not lodge, the results of the tests go to show that the loss to the grain through lodging was 43 per cent. in yield and 9.9 per cent. in weight per measured bushel. The lodged grain had more than twice as much rust as that which was standing. These results show the importance of growing those varieties of winter wheat which possess stiff straw.

Varieties Tested.

Ninety-two varieties of winter wheat have been under test this season. The plots were situated side by side, and were separated from each other by paths three feet wide. All the plots were sown by hand at the rate of two bushels per acre. The varieties were sown on September 3rd, with the exception of Nos. 54 and 57, which were sown on September 4th, and No. 64 which was sown three days later. The ripening of the varieties took place between the 14th and the 21st of July, which was about eight days earlier than in 1896 and four days later than in 1895. The crops were all harvested separately, and threshed with a Little Giant separator remodelled for the purpose.

TABLE 1.—Number of varieties tested and reported on within the past nine years, and also the average yields for each of these years and for the whole period :

Years.	Number of varieties grown each year.	Average weight of grain per measured bushel.	Average yield of	
			Straw per acre.	Grain per acre. (bus. 60 lbs.)
		lbs.	tons.	bus.
1890	15	60 0	2.4	30.9
1891	23	63.3	2.0	52.9
1892	44	60.5	3.2	42.6
1893	52	58.4	2.1	29.9
1894	80	60.8	4.0	46.7
1895	102	60.4	1.2	26.1
1896	81	60.3	2.6	42.1
1897	91	55 0	3.8	41 8
1898	92	63.0	3.4	42.9
Average 9 years	....	60.2	2.7	39.5

The ninety-two varieties tested in 1898 gave an average of 3.4 tons of straw, and 42.9 bushels of grain per acre, and an average weight of grain per measured bushel of exactly 63 lbs. The yield of grain, therefore, is about three and a half bushels per acre more than the average yield of the past nine years. The quality of the grain is excellent in 1898, as it weighs $2\frac{4}{5}$ lbs per measured bushel more than the average of all the varieties grown since 1890. It will be observed that in the nine years there is a variation from 26.1 to 52.9 bushels in average yield of grain per acre; from 1.2 to 4.0 tons in average yield of straw per acre, and from 55.0 to 63.3 pounds in average weight of grain per measured bushel. For some of the reasons of these variations, reference can be made to the bulletins and reports previously issued. From a careful study of the foregoing table and the previous winter wheat bulletins, the reader will readily understand that it is of great importance to have these experiments extend over a period of several years, in order to have the varieties subjected to various climatic conditions. We wish to emphasize the fact that the average results of five years' experimental work should be of much greater value than the results obtained from experiments of only one year.

TABLE 2.—Characteristics and yields of forty-eight varieties of winter wheat grown for five years in succession.

VARIETIES. Arranged in order of their average yield of grain per acre as given in the last column of the table.	Heads bearded or bald.	Grain red or white.	Results for 1898. Per cent. of crop lodged.	Results for 1898. Weight per measured bushel.	Results for 1898. Yield of grain per acre (bu. 60 lbs.)	Average results for 5 years. Date of maturity.	Average results for 5 years. Height of crop.	Average results for 5 years. Per cent. of crop lodged.	Average results for 5 years. Per cent. of rust.	Average results for 5 years. Weight per measured bushel.	Average results for 5 years. Yield per acre. Straw.	Average results for 5 years. Yield per acre. Grain (bu. 60 lbs.)
				lbs.	bus.	July	ins.			lbs.	tons	bus.
1. Dawson's Golden Chaff	Ba	W	65	61.6	49.2	18	47.6	17	26	59.7	3.4	**52.6**
2. Early Genesee Giant	Be	W	45	61.5	43.2	19	49.7	19	30	59.8	3.4	**48.7**
3. Egyptian	Be	R	80	62.4	42.5	19	47.9	42	13	60.6	3.5	**48.6**
4. Imperial Amber	Be	R	50	62.7	47.7	18	48 7	42	12	59.8	3 8	**48.5**
5. Early Red Clawson	Ba	R	88	59.2	39.9	18	47.2	41	29	58.9	3.3	**48.5**
6. Reliable	Be	R	75	62.3	43.3	19	48.8	44	10	61.2	3.7	**48.0**
7. Golden Drop	Ba	R	85	61.8	38.5	18	47.5	39	25	61.2	3.3	**46.9**
8. Russian Amber	Be	R	50	62.4	41.5	19	47.5	39	12	60 9	3.4	**46.7**
9. Egyptian Amber	Be	R	40	63.9	47.8	18	48.7	41	9	61.4	3.7	**45.3**
10. American Bronze	Ba	R	20	62.6	42.3	19	49.5	4	36	60.1	3.1	**44.8**
11. Poole	Ba	R	40	63.8	44.1	18	47.1	33	13	60.9	3.2	**44.7**
12. Tasmania Red	Be	R	75	63.4	38.9	18	45.8	58	15	61.6	3.4	**44.4**
13. Early Ripe	Ba	R	40	63.1	41.9	18	48.1	33	17	61 2	3.3	**43.8**
14. Tuscan Island	Be	R	40	63 4	45 5	18	48.6	45	24	60.6	3.1	**42.8**
15. Rudy	Be	R	25	63.7	47.1	17	46.3	42	19	60 6	2.9	**42.8**
16. Red May	Ba	R	25	65.0	45.8	16	47.1	29	12	62.2	3 1	**42.5**
17. Arnold's Hybrid	Ba	R	25	65.1	45.8	17	47.7	28	12	61.8	3.1	**42.4**
18. Bulgarian	Be	W	45	62.1	40.3	20	49.7	26	19	60.2	3 0	**42.3**
19. Pride of Genesee	Be	R	15	64.6	46.1	19	49.9	30	15	60.8	2.9	**42.1**
20 Emporium	Ba	R	25	63.6	42.1	20	50.7	35	9	59.8	3.5	**41.9**
21. Siberian	Ba	R	40	64.1	38.6	20	48.1	37	13	61.8	3.2	**41.5**
22. Stewart's Champion	Ba	W	45	61.0	36.6	20	50.3	16	22	59.0	3.30	**41.4**
23. Red Velvet Chaff	Ba	R	45	61.6	34.6	19	47.9	30	29	58.3	3.4	**41.3**
24. Zimmerman	Ba	R	15	64.4	46.7	18	46.8	22	14	61.4	2.8	**41.2**
25. Standard	Ba	W	60	60.3	33.1	20	46 8	20	25	58.5	2.9	**41.1**
26. Geneva	Be	R	30	64 5	37.7	17	46.2	40	10	62.4	3.2	**41.0**
27. Bissell	Be	R	35	64.8	39.4	17	46 0	46	9	61.6	3.0	**40.8**
28. New Columbia	Ba	R	12	63.8	39 4	17	46.5	20	15	59.4	3.0	**40.6**
29. McPherson	Ba	R	10	65.5	41.9	16	47.4	27	13	62.1	3.0	**40.3**
30. Bonnell or Landreth	Ba	W	65	59.9	35.3	20	49.3	24	24	58.4	3.1	**40.2**
31. Golden Tankard	Be	R	35	64.0	42.6	17	49.2	42	20	60 8	3.7	**39.8**
32. Longberry Red	Be	R	92	61.8	38.3	19	47.7	63	10	60.8	3.5	**39.8**
33. Golden Cross or Volunteer	Be	R	50	61.5	35.5	21	48.8	35	24	59 5	3.3	**39.5**
34. Andrew's No. 4	Be	R	20	65.0	41.5	20	50.0	26	23	60.1	3.2	**39.3**
35. Kentucky Giant	Be	R	60	63.1	41.3	20	48.0	41	15	60.0	3.0	**38.8**
36. Hindostan	Be	R	65	64 0	45.1	20	48.7	42	28	61.1	3.1	**37.7**
37. Soules	Ba	W	45	60.5	34.0	19	49.2	18	23	57.8	2.9	**37.5**
38. Simcoe Red	Be	R	5	63.1	41.9	17	49.6	16	19	59.2	2.8	**37.5**
39. Treadwell	Be	W	35	62.5	41.9	19	49.1	15	16	60.1	2.6	**37.3**
40. Jones' Winter Fife	Ba	R	75	59 9	30.1	19	47.3	33	19	58.7	2.7	**37.0**
41. Currell	Ba	R	35	64.6	48.1	17	47.2	36	18	61.3	3 0	**37.0**
42. Turkish Red	Be	R	45	64.6	43.8	18	42.4	44	10	61.5	2.5	**36.8**
43. Penquit's Velvet Chaff	Be	R	20	64.8	37.4	18	47.0	17	29	61.7	2.7	**36.1**
44. Velvet Chaff	Be	R	45	63.1	32.7	17	44.8	14	22	62.5	2.4	**36.0**
45. Surprise	Ba	W	60	58 9	31.7	20	46.8	30	24	57.3	2.8	**35.6**
46. Early White Leader	Ba	W	75	58.4	32.4	22	46.7	21	26	56.1	2.4	**33.8**
47. Jones' Square Head	Ba	W	80	60.8	37.3	19	47.6	21	27	57.9	2.4	**33.2**
48. Bullard's Velvet Chaff	Ba	R	75	62.0	37.8	21	48.6	24	25	60.4	2.6	**31.9**

TABLE 3.—Characteristics and yields of forty-four new varieties of winter wheat grown in 1898.

VARIETIES. Arranged in order of their yield of grain per acre in 1898, as given in the last column of the table.	Heads bearded or bald.	Grain red or white.	Date of maturity.	Height of crop.	Percentage of		Weight per measured bushel.	Yield per acre.	
					Crop lodged.	Rust.		Straw.	Grain. (bu. 60 lb.)
			July.	ins.			lb.	tons.	bus.
49. Gold Coin	Ba	W	20	55	40	28	63.1	4.0	52.0
50. Silver Dollar	Be	W	18	60	8	13	63.2	3.5	51.2
51. White Golden Cross	Be	W	18	57	1	25	64.5	3.3	51.2
52. Pedigree Genesee Giant	Be	W	18	57	4	25	64.6	3.2	50.8
53. Oregon	Ba	W	18	55	12	15	62.3	3.3	50.4
54. Forty Fold	Ba	W	18	53	5	15	63.1	3.4	50.0
55. Zerena	Ba	W	18	56	1	15	62.9	2.1	49.9
56. Early Arcadian	Ba	W	16	53	2	25	62.2	3.1	49.7
57. Longberry No. 1	Be	W	20	60	15	25	63.9	3.6	49.6
58. Harvest King	Ba	R	15	53	15	10	64.3	3.4	49.6
59. Johnson	Be	W	20	59	18	30	61.3	3.5	48.9
60. Red Wonder	Ba	R	15	56	18	20	61.0	3.6	48.6
61. Red Cross	Ba	R	13	57	8	18	64.3	3.6	48.5
62. Mac. Garvin	Ba	R	15	53	12	15	64.5	2.9	48.1
63. Bearded Winter Fife	Be	W	18	53	23	15	63.1	3.1	47.8
64. Diamond Jubilee	Ba	W	18	56	5	20	63.8	3.0	47.6
65. Prize Taker	Ba	W	20	54	.....	25	63.6	2.8	47.3
66. Buda Pesth	Be	R	18	47	45	5	64.3	2.9	47.0
67. Nonpariel	Be	W	19	51	50	15	63.1	3.4	46.9
68. Ohio State	Ba	W	20	56	15	20	64.4	3.5	46.9
69. Queen Meg	Be	W	18	58	30	35	63.1	3.4	46.3
70. White Clawson	Ba	W	18	55	12	20	63.2	3.7	45.9
71. Michigan Amber	Ba	R	19	54	85	20	63.3	4.0	45.7
72. Eastman	Be	W	18	52	45	10	63.6	3.8	45.4
73. World's Fair	Ba	R	18	56	22	18	62.7	3.2	44.7
74. Bailey	Ba	W	18	55	8	20	61.5	2.8	44.6
75. Diamond Grit	Be	R	18	57	......	23	65.8	3.4	44.5
76. Wisconsin Triumph	Ba	R	18	55	30	15	63.0	3.5	44.5
77. Russian	Be	R	15	46	50	3	64.2	3.0	44.3
78. French Hero	Be	R	19	54	20	18	64.0	3.5	44.2
79. Canadian Hybrid	Ba	R	15	53	20	13	64.5	3.3	43.8
80. Hunter's Wheat	Be	R	19	52	60	23	63.3	3.4	43.4
81. White Bearded	Be	W	19	55	12	15	61.9	2.5	41.8
82. Mealy	Ba	R	15	52	40	13	63.7	3.0	41.0
83. Beattie's Victor	Be	W	20	57	10	25	62.8	3.0	40.5
84. Roberts	Be	R	11	57	50	20	63.3	3.4	40.5
85. Early Oatka Chief	Be	W	18	56	15	15	62.5	3.2	40.2
86. Long Amber	Ba	W	20	57	15	20	62.6	2.6	39.8
87. German Emperor	Ba	R	19	52	70	20	61.0	3.4	39.0
88. Silver Star	Ba	W	20	54	45	18	63.3	3.1	38.9
89. Pride of Illinois	Ba	R	15	53	80	35	62.2	3.2	38.8
90. Amherst Isle	Be	R	20	43	50	15	63.6	2.2	38.0
91. Murray's Hybrid	Be	W	15	52	35	25	62.4	2.9	37.7
92. Kalina	Be	R	15	56	60	40	62.1	3.3	36.9

Table 2 contains information of great value, as the results for 1898 are given and also the average results of each variety for a period of five years. Although Table 3 gives results for only one year, the contents are both interesting and valuable as presenting the records of so many new varieties. Some of these have been grown for two, three, and even four years, but for the sake of a proper comparison of the whole number upon a uniform basis, the results for only one year are here presented.

One of the principal advantages of giving the results of so many varieties as are given in Tables 1 and 2, is to enable any farmer to compare the varieties which are new to him with those he has been familiar with for several years. It also enables him to select varieties that will likely be adapted to the conditions of his own particular soil. For heavy rich soils which usually produce a large growth of crop which is apt to lodge badly, those varieties possessing short stiff straw should be selected ; while for light weak soils, those varieties with long heavy straw would likely give the best satisfaction. Generally speaking, the white wheats possess stiffer straw and yield more grain per acre than the red wheats, but the latter produce grain which weighs about one pound per measured bushel more than that produced by the white varieties. The hard, flinty, red wheats produce a strong flour which is comparatively dark in color, while the white wheats produce a beautiful white flour which is sometimes lacking in strength. Millers frequently mix the red wheat of Manitoba with the white wheat of Ontario in order to get a flour having a proper combination of both color and strength. The very hard wheats, such as are principally grown in the Canadian North-west and in the North-western States of the American Union, are nearly all red in color, while the softer wheats are represented by varieties of both the red and the white classes.

About twenty five acres of winter wheat are grown annually in the Farm Department of the Ontario Agricultural College. During the past three years the Dawson's Golden Chaff and the Early Genesee Giant varieties have been used for this purpose. The average yield produced from these two varieties when grown in the large fields for three years in succession has been about thirty-six bushels per acre.

Selection of Seed.

From a test made in our experimental grounds with two varieties of winter wheat in 1897 and again in 1898, we found that large plump seed produced a yield of 6 3·5 bushels per acre more than that produced from small plump seed, and 8¼ bushels per acre more than that produced from shrunken seed ; and also that seed grain which had been broken by the threshing machine gave a yield of only 1·5 as much as that grown from the large plump seed. In this experiment, the yield of straw and the weight per measured bushel of the grain produced was also greatly influenced by the different selections of seed which were sown.

Different Dates of Seeding.

For six years in sucession winter wheat has been sown on three or more different dates. This experiment has been conducted in duplicate each year and in one or two instances it was carried on in triplicate. The summary results of all these tests are here presented in tabulated form.

TABLE 4.—Results of sowing winter wheat on three different dates :

Dates.	Weight of grain per measured bushel.		Yield per Acre.			
			Straw.		Grain.	
	1898.	Average 6 yrs.	1898.	Average 5 yrs.	1898.	Average 6 yrs.
Sept. 2—3	63.4	58.3	3.6	3.1	44.8	39.5
Sept. 9—11	63.7	58.5	2.8	2.9	44.8	38.9
Sept. 17—20	63.9	57.1	3.0	2.4	46.4	33.5

Winter wheat was also sown on August 25th-26th in 1893, 1897 and 1898, and on September 26th, 27th in 1896, 1897 1898. The results of all these experiments go to show that we get best results from sowing winter wheat during the last week in August or the first week in September, and that it is not usually safe to sow later than about the 10th of September.

DIFFERENT QUANTITIES OF SEED PER ACRE.

An experiment which has been conducted for five years in succession, by sowing different quantities of seed of each of two varieties of winter wheat, shows that one and one-half bushels of seed per acre produced an average of two and three-fifth bushels of grain per acre more than when one bushel of seed was used. The results were quite similar from using either one and one-half or two bushels of seed per acre.

METHOD OF SEEDING.

In each of the past five years an experiment has been conducted in duplicate by sowing winter wheat broadcast and with a grain drill. The results from sowing the same quantities of seed by the two methods are very similar, there being only a difference of one five-hundredth part of a bushel per acre in the average yields. It should be understood that the land was in a good state of cultivation when the seeding took place in every case.

PREPARING SOIL FOR WINTER WHEAT.

In the spring of 1896 twelve plots, each one rod wide by six rods long were staked off for an experiment in different treatments of soil, preparatory to the growing of winter wheat. The experiment was conducted in duplicate, there being six plots in each set. The land had been plowed in the autumn of 1895 and received surface cultivation in the spring of 1896. Four plots in each were sown in the latter part of May with crops to be plowed under later in the season. These crops were peas, buckwheat, rape and crimson clover. The other two plots in each set were worked as a bare summer fallow throughout the season. About the first of August, each of the green crops were plowed under, and the land was then worked on the surface during the month of August. Farm yard manure at the rate of twenty tons per acre was applied to one of the summer fallow plots in each set. On the 25th of August winter wheat was sown on each of the twelve plots. This experiment was repeated in the following year by using twelve plots similar in size to those of the first set, but differently located. The winter wheat seeding in 1897 took place on the 29th of August.

TABLE 5. Results from preparing land in different ways for winter wheat:

Soil preparation 1896 and 1897.	Average results for two years (4 tests).				
	Height of crop.	Percentage of crop lodged.	Weight of grain per measured bushel.	Yield per acre.	
				Straw.	Grain (bu. 60 lbs.)
20 tons farm yard manure per acre on bare summer fallow	52.4	45.0	60.8	3.4	**40.4**
Peas plowed under..........	51.7	31.3	60.8	2.7	**37.0**
Bare summer fallow	52.3	40.0	60.7	2.6	**35.0**
Rape plowed under	50.7	30.8	60.4	2.4	**33.7**
Crimson clover plowed under..........	50.7	22.5	60.5	2.3	**31.2**
Buckwheat plowed under	50.5	17.5	60.4	2.0	**29.9**

The amounts of seed used for the green manure crops were as follows: Peas 2½ bushels per acre, rape 4 pounds, buckwheat 1 bushel, and crimson clover 12 pounds. Land which was treated as a bare fallow throughout the summer and afterwards received farm yard manure at the rate of twenty tons per acre, previous to the sowing of winter wheat, gave the largest yield of grain per acre in the experiment of each year. It should, however, be remembered that this was decidedly the most expensive of the six treatments. Where green crops were plowed under the labor was not great, but the seed required to produce these crops would of course add a little to the cost. The good results from using peas as a crop for green manuring are quite noticeable in this experiment.

The twelve plots used in this experiment in 1897 were cropped again in 1898, six with winter wheat and six with spring wheat, in order to ascertain the influence of the different soil preparations upon the crop of the second year. The average results show that the manured fallow gave the largest yield of grain, and that the land where the buckwheat had been plowed under gave the smallest yield in 1898. These experiments will likely be continued for several years in succession in order to get as full information as possible upon the subject.

Effect of Cutting at Different Stages of Maturity.

For this experiment, five plots each of two varieties of winter wheat were sown at the same time in the autumn of 1893. In the summer of 1894 one plot of each variety was cut at five different times. The period between each two cuttings was one week in length. The third cutting was made when the wheat was in that condition of ripeness in which it is usually cut throughout Ontario. It will therefore be understood that the wheat was quite green at the time of the first cutting, and that it was very ripe at the time of the last cutting. This experiment has been repeated in each of the years 1895, 1896, 1897, and 1898. The varieties used in each of the five years were the Dawson's Golden Chaff and the Early Genesee Giant. The average results of the ten tests, covering a period of five years, show that the largest yield of grain per acre was produced from the fourth cutting, the heaviest weighing grain per measured bushel from the third cutting, and that the best quality of straw and the heaviest yield of straw per acre were produced from the first cutting.

In order to find out the influence of cutting wheat at different stages of maturity upon the quality of the grain for seed purposes, samples were taken from the crop produced from each of the cuttings previously mentioned and these samples were carefully sown upon separate plots. In the average results of these tests made with two varieties in each of the past four years it is found that the heaviest weight of grain per measured bushel and the largest yields of grain and of straw per acre were produced from the last cutting.

Treatment for Stinking Smut.

On a good many Ontario farms the winter wheat is badly infested with what is known as the stinking smut which is also sometimes called hard smut, bunt, or smut balls. This disease produces a very unpleasant odor, and besides reducing the yield of wheat per acre, it frequently lessens the market value of the grain fully 25 per cent, and in some case renders it practitally useless for for the production of flour. This disease can be so easily and so effectually treated that there is no reason why any farmer cannot practically rid his wheat fields from this trouble in a very short time. An experiment in treating seed wheat for the prevention of smut has been conducted on our experimental grounds during each of three years with very gratifying results. Badly infested seed wheat not treated for smut, produced a crop containing an average of 170 smut balls per pound of grain ; while that treated with potassium sulphide produced an average of 12 balls of smut ; and that treated with either copper sulphate or hot water an average of less than 1 ball of smut per pound of grain. The treatment with copper sulphate was made by immersing the seed for five minutes in a solution of one pound of copper sulphate dissolved in one gallon of water. The hot water treatment consisted in immersing the seed for fifteen minutes in hot water at a temperature of 132 degrees F. For this treatment the water should not go below 130 and not above 135 degrees. Every farmer in smut-infested districts should treat sufficient seed to insure the harvesting of clean grain for seed next year.

Co-operative Experiments with Winter Wheat.

From among the varieties of winter wheat which have been tested in the Experimental Department of the College, nineteen of the most successful kinds have been selected and distributed over Ontario within the past six years. These have been sent out in sets of from three to five varieties in each set. Fourteen thousand four hundred and eighty-five packages of winter wheat have been distributed during the past six years, and comparative tests have been made upon fully thirty-eight hundred Ontario farms. This system of co-operative experimental work was established by the ex-students of the Agricultural College, but, through repeated requests from other farmers, an invitation is extended to all interested persons to join in the work. The results have, on the whole, been very gratifying, and the numerous experimenters have become much interested in the different experiments undertaken. For detailed results of these experiments, the reader is referred to the reports of the Ontario Agricultural and Experimental Union, which are published annually.

From among the conclusions given in the report of last year regarding these co-operative experiments with winter wheat for 1897, the three following are quoted as being of interest in connection with the results given in this bulletin :

1. " In average yield of winter wheat per acre, the Dawson's Golden Chaff stood highest among eleven varieties tested over Ontario in 1893, nine varieties in 1894, 1895 and 1896, and seven varieties in 1897."

2. " Three varieties of winter wheat have been tested over Ontario for four years in succession with the following yields of grain per acre : Dawson's Golden Chaff, thirty-two and a half bushels ; Early Red Clawson, twenty-nine and one-eighth bushels ; and Early Genesee Giant, twenty-nine and one-twentieth bushels."

3. " Dawson's Golden Chaff was the most popular variety with the experimenters in each of the past four years."

The Dawson's Golden Chaff is an Ontario variety, and it has certainly made a good record for itself at the Agricultural College and throughout Ontario. We sent some of this variety to a few of the agricultural colleges of the United States and have received reports this year already from two of these institutions. The assistant director at the Pennsylvania Agricultural College writes as follows : " By the enclosed report you will see that Dawson's Golden Chaff, the variety of wheat received from your station two years ago, has come out ahead this year." The " enclosed report " referred to gives the results of thirty-two varieties tested in 1898. From this report we also quote the following : " Dawson's Golden Chaff and Gold Coin are the only ones that promise to be better than the old and standard varieties." The results of the experiment with different varieties of winter wheat conducted at the Michigan Agricultural College are reported by the Agriculturist in the following language : We have just finished the threshing of some of our variety tests of winter wheat, the more promising of which resulted as follows : Dawson's Golden Chaff, 42 bushels per acre ; Russian, 31 ; Currell, 28 ; Rudy, 28 ; and Chaplin, 26.

CONCLUSIONS.

1. The average results of winter wheat growing on the experimental plots for nine years in succession are as follows: weight of grain per measured bushel, 60.2 pounds; yield of straw per acre, 2.7 tons; and yield of grain per acre, 39.5 bushels.

2. Dawson's Golden Chaff has given the largest average yield of grain per acre among seventy varieties of winter wheat grown at the Ontario Agricultural College for five years; also among eleven leading varieties tested over Ontario in 1893, nine varieties in 1894, in 1895, and in 1896, and seven varieties in 1897.

3. The Early Genesee Giant variety of winter wheat is a close rival of the Dawson's Golden Chaff variety in the small plots in the experimental department and in the large fields in the farm department of the Agricultural College, and also in the co-operative experiments conducted throughout Ontario.

4. Winter wheat which did not lodge until cut, produced a crop more than double the value of that which became lodged before it was ripe.

5. In five years' experiments with varieties of winter wheat, the American Bronze, Dawson's Golden Chaff, and Early Genesee Giant varieties possessed the stiffest straw of all the large yielders of grain.

6. Large plump kernels of winter wheat gave much better results than those which were small plump, shrunken, or broken.

7. In the average of six years' experiments in sowing winter wheat at different dates, it was found that when the wheat was sown later than September 9th, the crop was usually much poorer than when the seeding took place on or before that date.

8. As a crop, to use as a green manure to plow under in preparation for winter wheat, peas have given the best, and buckwheat has given the poorest results.

9. In an experiment in cutting winter wheat at different stages of maturity for several years in succession, it was found that the largest yield of grain and the best quality of seed were produced from the crop which was allowed to fully ripen before cutting.

10. Winter wheat, badly infested with "stinking smut" has been very effectually treated in three different years by the use of either copper sulphate or hot water as briefly described in this bulletin.

Distribution of Seed for Testing Purposes.

The following three sets of winter wheat varieties will be sent free, by mail in one-half pound lots of each variety, to farmers applying for them, who will carefully test the three kinds in the set which they choose, and will report the results after harvest next year. The seed will be sent out in the order in which the applications are received as long as the supply lasts :

Set 1.

Dawson's Golden Chaff.
Early Genesee Giant.
Early Red Clawson.

Set 2.

Dawson's Golden Chaff.
Imperial Amber.
Golden Drop.

Set 3.

Dawson's Golden Chaff.
Bearded Winter Fife.
Stewart's Champion.

Each person wishing one of these sets should apply as early as possible, mentioning which set he desires; and the grain, with instructions for testing, and the blank form on which to report, will be furnished free of cost to his address, until the supply of grain for distribution is exhausted.

All communications should be addressed to C. A. Zavitz, Agricultural College, Guelph, Ontario.

THE ONTARIO PROVINCIAL FAT STOCK AND DAIRY SHOW to be held in the CITY OF BRANTFORD, on Wednesday, Thursday and Friday, NOVEMBER 30, and DECEMBER 1 and 2, 1898. Over $4,000 in cash prizes are offered in the LIVE STOCK and DAIRY DEPARTMENTS. Prize lists and entry forms may be had by applying to F. W. HODSON, Sec.-Treas., Parliament Buildings, Toronto.

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Ontario Agricultural College and Experimental Farm

FARMYARD MANURE

BY

G. E. DAY, B. S. A., Agriculturist.

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BULLETIN 109.

FARMYARD MANURE.

By G. E. Day, B.S.A., Agriculturist.

I. CONSTITUENTS OF PLANTS.

To make a successful growth, plants require a number of substances. The chemical analysis of a plant shows it to contain the following elements: nitrogen, phosphorus, potassium, calcium, iron, magnesium, sulphur, carbon, oxygen, hydrogen, and a few other substances of less importance. All the elements named are essential to the growth of plants, and without them no plant can be produced. If only one of them is absent, the plant either will not grow at all or will make but an unsatisfactory growth, depending upon the importance of the element which is absent. Some of these elements are derived from the air and some from the soil; but it is only those which are derived from the soil which are under the farmer's control. Of the elements derived from the soil, those which are used in largest quantity and which are consequently in greatest danger of becoming exhausted, are nitrogen, phosphorus, potassium and calcium. These elements, however, do not exist in the soil as separate substances, but are found combined with other elements to form compounds; and, in speaking of most of them, it is customary to use the name of the compound instead of the single element. Thus, instead of speaking of "phosphorus" it is customary to say "phosphoric acid" or "phosphates," which are compounds of phosphorus and other elements; also, instead of saying "potassium" it is usual to speak of "potash," a compound of potassium and oxygen; and instead of "calcium" the term lime is used, since lime is the commonest compound of calcium found in the soil. Therefore the constituents of plant food in the soil which require most attention are nitrogen, phosphoric acid, potash, and lime. In many soils, however, there is abundance of lime, and, besides, lime is frequently found in combination with the other important substances and is thus applied to the soil along with them. The same may be said of iron, magnesium, and sulphur, which are the remaining elements derived directly from the soil by plants. Practically, therefore, the farmer may confine his attention to supplying the soil with nitrogen, phosphoric acid, and potash, unless in rather exceptional cases.

II. FARMYARD MANURE.

Farmyard manure is derived, either directly or indirectly, from plants, and consequently contains all the elements necessary for plant growth. It may be called, therefore, a *general manure*, that is to say, it supplies all the necessary elements of plant food. It does not follow, however, that because farmyard manure supplies all the elements of plant food, that it supplies them to all crops and soils in exactly the right proportion. For example, a certain soil is deficient in phosphoric acid and potash, but is rich in nitrogen. Now, if the deficiency in phosphoric acid and potash is made up by applying farmyard manure, there will also be added to the soil a considerable amount of nitrogen, and, according to the example quoted, there is already sufficient nitrogen in the soil in question, consequently the additional nitrogen is added at a loss. Arguments of this nature are frequently employed against farmyard manure as compared with special manures, or those which supply only one or two constituents of plant food, it being claimed that the use of special fertilizers admits of applying only those substances in which the soil is deficient and therefore constitutes economical manuring. It is also claimed that farmyard manure is bulky, heavy and expensive to handle, whereas most special fertilizers are much more concentrated. Still further, it is claimed that farmyard manure is comparatively slow in its action, because a great deal of the plant food which it contains is in such forms that plants cannot make use of it until the manure has fermented and decayed; whereas the plant food in many special fertilizers is in forms which plants can readily make use of, and consequently such manures give quick returns. These objections to farmyard manure are perfectly valid, and no doubt special fertilizers have an important place to fill under some systems of farming; but there are several things in connection with farmyard manure which must not be overlooked, and, in order to emphasise them, they will be dealt with separately.

1. Farmyard manure is a by-product. In many, if not in most cases, the profit from the animals fed leaves very little to be charged against the manure. As a result the farmer can afford to spend some extra labor upon it and to put up with its slower action. He may also afford to apply more of certain constituents than the crop requires; in fact, excessive application of plant food is liable to happen with any fertilizer, since no one is able to estimate exactly to what extent a soil is deficient in a given element of plant food. Further, in no case do plants take from the soil all the plant food applied in the fertilizer, frequently not more than half, so that in the case of expensive fertilizers the loss is a serious one.

2. Farmyard manure, as already stated, is slow in its action, the plant food which it contains being gradually made available for plants. But, though only a small portion of its plant food becomes available each year, the greater part of the unused plant food is not lost under judicious management, but is held in the soil for the use of succeeding crops. In the case of quick acting fertilizers, nearly all of their influence is confined to the year in which they are applied; and, though some have a more lasting influence than others, their effect upon succeeding crops is not nearly so marked as that of farmyard manure. The reason for this difference in effects upon succeeding crops is comparatively simple. Before plants can take up their food from the soil, it must be in such forms as will dissolve in the soil moisture or in the juices of the plant roots. When plant food is in such a condition it is said to be *soluble*, and it must be soluble before it can be available to the plant, so that the term *available* plant food means soluble plant food. Now, only a small portion of the nitrogen, phosphoric acid, potash, etc., in farmyard manure is in a soluble condition, and before the remainder of it can become soluble, the manure must undergo fermentation and decay. In the process of decay, the vegetable compounds of the manure are broken up, and the elements of plant food which they contain form simpler compounds which are soluble, and hence available to plants. It takes many years for the whole of the vegetable matter in an ordinary dressing of farmyard manure to decay, and since only soluble plant food can be washed out of the soil by rains, it follows that only a small portion of the plant food will be lost in this way, and that there will be a residue left over from year to year for a considerable length of time. On the other hand, special fertilizers which contain a large proportion of soluble plant food and are therefore quick in their action upon plant growth, are in danger of having any residue that may be left by the first crop washed out of the soil during the succeeding winter and spring, owing to the soluble

nature of the plant food they contain. This is especially true of soluble nitrogenous fertilizers, which leave practically no residue for succeeding crops. Phosphoric acid does not leach out of the soil in the drainage water so readily as nitrogen, because much of it is changed into insoluble compounds in the soil, after which it is but slowly made available for plants.

The lasting influence of farmyard manure is strikingly brought out in the Rothamsted experiments in England. At this noted experiment station, barley was grown for a great many years in succession on the same soil with different manures, and also without any manure. It will be sufficient for the present purpose to notice two of these plots. Plot 1 was continuously unmanured for forty years, and produced a crop of barley every year. Plot 2 received at the rate of fourteen tons of farmyard manure per acre every year for twenty years and was sown with barley each year. At the end of this period, plot 2 was divided into two parts. One part received farmyard manure at the same rate as before for twenty years more, while the other part received no manure of any kind during the next twenty years, and barley was sown every year on both parts. There are, therefore, two periods of twenty years each, and the results may be compared. The average yield of grain on the continuously unmanured plot for the first twenty years (1852 to 1871) was twenty bushels per acre. The average yield from the continuously manured plot during the same period of time was 48¼ bushels per acre. For the second twenty years (1872 to 1891), the average yield from the continuously unmanured plot was 13¼ bushels per acre; on the part of plot 2 which received no manure during the second twenty years, the average yield was 30¼ bushels per acre; while on the part of plot 2 which was continuously manured as before, the average yield was 49 bushels per acre. Thus, it will be seen that the influence of the first twenty years of manuring extends over the second twenty years, producing an average crop of 30¼ bushels, as compared with 13¼ bushels on the plot which received no manure during the whole forty years. Nor did the influence end there, for the experiment was continued longer, and during the next five years, 1892 to 1896 inclusive, the average yield from the continuously unmanured plot was 11½ bushels per acre; whereas on the part of plot 1 which had received farmyard manure from 1852 to 1871, but nothing after that date, the average yield during the same five years (1892 to 1896) was 24⅛ bushels per acre. Therefore, after twenty-five years without manure, plot 2 continues to show a marked advantage over the continuously unmanured plot, and no one can foretell how much longer the influence of that twenty years of manuring with farmyard manure will be traceable. To be sure, if the land had received but a single application of farmyard manure, the results would not have been so striking, but the example just given will serve to illustrate the lasting effect of farmyard manure, which is one of its remarkable and valuable characteristics.

3. Farmyard manure increases the humus (vegetable matter) of the soil. This action is extremely important, because humus, besides supplying plant food as was previously explained, also improves the water-holding power of soils, and makes clay soils more open in texture, more easily worked, and altogether more favorable for the development of plant roots. What were once barren sands have been brought to a high state of productiveness by simply supplying them with humus; and it is a well known fact that many clay soils which are now so difficult to manage, were much more easily worked and produced better crops when the land was new, the explanation of which is found in the fact that years of cultivation and cropping have reduced the supply of humus in the soil. A manure, therefore, which increases the supply of humus is worthy of much more care and attention than it frequently receives.

4. As the vegetable matter (humus) furnished by farmyard manure decays in the soil, substances are formed which have considerable influence upon the insoluble compounds of plant food contained by the soil, tending to make them soluble and fit for plant food. Humus makes clayey soils more open in texture, thus admitting air more freely ; and air also has an influence in making insoluble plant food available besides being, in itself, absolutely essential to the growth of plant roots.

5. It is believed by some very good authorities that farmyard manure also adds to the soil certain organisms (bacteria) which exert a very beneficial influence in making plant food available.

III. SOLID AND LIQUID EXCREMENTS.

Farmyard manure is composed of the solid and liquid excrements of animals, and usually contains in addition some substance which has been used for bedding, such as straw, sawdust, etc. When food enters an animal's stomach, a portion of it is digested and its constituents used to form bone, muscle, blood, fat, milk, horn, wool, hair, or other part or product of the animal body. In addition, a part of the digested portion of the food is used to renew those tissues of the animal body which are constantly wearing out, for the wearing out process is very rapid and necessitates a regular supply of food to furnish building material for new structures in place of the old. Therefore, in the animal body there are two classes of waste material which must be got rid of, namely, the undigested portion of the food, and the waste or refuse material from the worn out structures. The undigested food is excreted in the form of solid excrement, though the solid excrement also contains other waste products in addition. The waste matter from worn out structures is excreted in various ways, but most of those substances which are of value to the farmer are removed in the liquid excrement or urine.

Composition of liquid and solid excrements. Any figures relating to the composition of animal excrements can be only approximate, because so many influences affect the composition of excrements that it is impossible to give exact percentages. Since the solid excrement contains the undigested portion of the food, it follows that it will contain all the undigested nitrogen, phosphoric acid, potash, and other constituents of the food. The liquid excrement, on the other hand, contains a large part of the worn out material of the animal body ; and the main fertilizing constituents which it contains are nitrogen and potash with occasionally a little phosphoric acid. Now, the animal body is built up from the digested portion of the animal's food ; and, since the nitrogen and potash in the liquid excrement once formed a part of the animal body, it follows that the nitrogen and potash in the liquid excrement originally came from the digested portion of the food. Thus, the solid excrement contains (along with some other substances) the undigested portion of the food, while the liquid excrement contains part of the digested portion of the food. From these facts it will be seen that the more indigestible the food, the greater will be the proportion of its constituents which appear in the solid excrement ; and the more digestible the food the greater will be the proportion of its constituents which appear in the liquid excrement. There is, therefore, no definite or fixed relation between the composition of the liquid and solid excrements of any class of animals ; but while that is the case, the study of the results of a large number of analyses will be helpful in forming some general conclusions. The following figures are given by Beal, and represent averages of American analyses :

PERCENTAGE COMPOSITION OF SOLID AND LIQUID EXCREMENTS.

Name.	Nitrogen. Per cent.	Potash. Per cent.	Phosphoric acid. Per cent.
Cattle excrement, solid	.29	.10	.17
Cattle excrement, liquid	.58	.49	
Horse excrement, solid	.44	.35	.17
Horse excrement, liquid	1.55	1.50	
Sheep excrement, solid	.55	.15	.31
Sheep excrement, liquid	1.95	2.26	.01
Swine excrement, solid	.60	.13	.41
Swine excrement, liquid	.43	.83	.07

Though the figures given in the table are merely approximate, still they indicate that the liquid excrement of all the animals mentioned, except swine, is richer in nitrogen and potash than the solid excrement ; and since nitrogen is by far the most expensive of fertilizing constitutents, it follows that a ton of liquid excrement is worth much more than a ton of solid excrement.

The table, however, does not show what proportions of the fertilizing constitutents of the food are voided by animals in their solid and liquid excrements respectively. As the result of many years of investigation, Lawes and Gilbert, of the Rothamsted Experiment Station, have come to the following conclusions regarding the nitrogen of the food, which may be regarded as the most important fertilizing constitutent :

QUANTITIES OF NITROGEN VOIDED BY ANIMALS IN SOLID AND LIQUID EXCREMENTS.

—	Out of 100 lbs. nitrogen in the food there are :	
	Voided in solid excrement.	Voided in liquid excrement.
Fattening oxen	22.6 lbs.	73.5 lbs.
Fattening sheep	16.7 "	79 0 "
Fattening pigs	22.0 "	63.3 "
Milking cows	18.1 "	57.4 "

It will be noticed that all the nitrogen of the food is not accounted for in the table, but the remainder is used by the animal in increasing its weight or in producing milk. The figures in this table, as in the preceding one, are simply approximations ; but they illustrate very forcibly that by far the greater part of the nitrogen voided by animals is contained in the liquid excrement.

It has therefore been demonstrated that the liquid excrement of animals contains the greater part of the nitrogen and a large proportion of the potash consumed by the animal in its food ; and that liquid excrement (except that of swine) is worth more, pound per pound, than solid excrement.

IV. INFLUENCES WHICH AFFECT THE COMPOSITION OF MANURE.

Perhaps no substance with which the farmer has to deal is subject to such wide variation in composition as is farmyard manure. These variations in composition add to the difficulty of discussing the valuation, application, and other points in connection with the substance in question ; and, to assist in an intelligent study of farmyard manure, it will be well, before proceeding further, to devote some time to the consideration of those things which affect its value.

Different kinds of Animals. The manure from cattle and swine contains a high percentage of water, frequently over 80 per cent. So far as water content is concerned they are very similar, but the manure from swine is somewhat richer in nitrogen than cattle manure. Horse manure contains less water than that of cattle and swine ; fresh sheep manure contains rather more water than horse manure, but a higher percentage of fertilizing constitutents ; while poultry manure is similar to sheep manure in water content, and usually contains a higher percentage of nitrogen than any of the others.

Use and Individuality of Animals. A full grown animal which is receiving barely a maintenance ration, which is neither gaining nor losing in weight, and which is producing neither young, nor milk, nor wool, nor any other product, must, of necessity, return in its manure practically all the fertilizing constituents of the food it consumes. Fattening animals return in their excrements from 85 to 90 per cent., and cows in full milk only from 65 to 75 per cent. of the fertilizing elements of their food, the amounts varying with the rate and character of the gain or the quantity and quality of the milk. Young animals which are growing rapidly and producing a large amount of bone and muscle make relatively poor manure, the fertilizing value of their food being frequently reduced nearly 50 per cent. before it reaches the manure pile. Age is therefore an important factor in influencing the character of the manure from fattening animals. Animals which are producing and rearing young, return poorer manure than those of like species and under like conditions which are not producing young. To some it may seem strange that fattening animals can gain rapidly in weight and yet return in their manure such a large proportion of the fertilizing constitutents of their food ; but the main part of the increase in fattening animals is composed of fat, and pure fat contains no fertilizing constitutents.

Kind of Food. It is easy to understand the influence of food upon manure. The excrements of an animal are derived from the food which it consumes, and hence the composition of the food determines the composition of the excrements. Foods rich in nitrogen and mineral matter produce manure rich in the same constitutents, and foods poor in fertilizing elements produce manure of correspondingly poor quality. Thus, animals fed on straw and turnips make a very low grade of manure, while those whose ration contains grain, bran, oil meal, etc., make manure of very much higher value per ton.

Quantity and Quality of Bedding. The most common substances used for bedding are straw, sawdust, and shavings. These substances are poorer in fertilizing constituents than animal excrements ; hence their use in large quantities tends to decrease the value of the manure. But there is another important consideration. Bedding absorbs the liquid excrements, and if no bedding is used, it is more than probable that much of the liquid excrement will be lost ; therefore, the use of sufficient bedding to absorb this important liquid and prevent its waste, adds very materially to the value of the manure. Straw is of course the usual and, excepting peat, the most valuable absorbent. Sawdust and shavings are regarded unfavorably by some farmers. When applied in large quantity on light land, they appear to be injurious, probably by making the land too open and thus lessening its already limited water-holding power. There is need of further investigation in this connection ; but where sawdust and shavings are used in moderation in the stables and applied to the land judiciously, there is little danger of injurious results. Peat is used for bedding in some districts, and is an excellent substance for the purpose. It absorbs and holds a large amount of liquid ; it has considerable value as a fertilizer in itself ; and it improves the mechanical condition of the soil to which it is applied.

Treatment. No one needs to be told that the treatment manure receives affects its value very materially. Excessive fermentation, washing by rain, keeping in badly constructed yards, etc., all have their influence in reducing the value of manure. As this part of the subject is dealt with more fully in another place, no more need be said under this heading.

V. CARE OF FARMYARD MANURE.

Liquid Manure Tank and Absorbents. While it is true that some loss is sure to occur in the management of manure, still, by using a little forethought the most serious losses may be prevented. What has been said regarding liquid manure is sufficient to illustrate its importance, for it has been pointed out that the greater part of the nitrogen and a large proportion of the potash which an animal consumes in its food appear in the liquid excrement. The first step in saving this important liquid is to have perfectly water tight floors. In this respect, a cement floor excels all others. This loss being stopped, it is in order to consider how to prevent loss of liquid outside of the stable. In some cases, liquid manure tanks have been built at considerable cost, but the tank has its objectionable features. To begin with, there is the cost of construction, including a portable tank for carrying the liquid to the field. Then, in warm weather, liquid manure ferments very rapidly, and in fermenting it loses much of its nitrogen which escapes into the air in the form of a gas (ammonia). If the tank is emptied frequently, much of this loss is prevented, but the liquid in the tank is out of sight and too frequently out of mind when other work is pressing. There is also an objection to applying liquid manure to the land separately, for liquid manure is rich in soluble nitrogen and potash but contains very little phosphoric acid, while the solid manure contains most of the phosphoric acid but is comparatively poor in soluble nitrogen. As a result, the manuring is somewhat one-sided and less satisfactory than where the solid and liquid manure are incorporated and applied together. Moreover, in applying liquid manure alone, there is danger of applying more nitrogen than the crop can use, and soluble unused nitrogen is washed out of the soil before another crop can be grown. Sometimes the liquid manure is pumped from the tank and distributed over the manure heap ; but where there is sufficient absorbent material in the heap to retain the liquid thus applied, it is difficult to see what advantage this method possesses over carrying the liquid directly from the stable to the heap. On the average farm, straw is usually abundant, and where straw is plentiful there is little need of a liquid manure tank. Cut straw is more satisfactory than long straw, and a little cut straw in the bottom of the gutter behind the cattle will facilitate cleaning the stables. If straw is somewhat scarce, sawdust is a valuable adjunct. Where sawdust has to be used, it is better to use it in conjunction with straw than to use all the straw first and then use sawdust alone, since the mixture makes a more satisfactory bed and a more uniform quality of manure. Sawdust is excellent for the bottom of gutters, owing to its great absorbent power. Peat is an extremely valuable absorbent of liquid manure, but it is available in comparatively few districts. It is needless to say that for the system just described the stable gutters should have no outlet, and they are all the better if at least sixteen inches wide and from six to eight inches deep. Taking everything into consideration, therefore, the liquid manure tank seems unnecessary on the average farm; but for those cases where absorbents are extremely limited or entirely out of the question, the liquid manure tank is certainly better than nothing, and may be employed to advantage.

Open yards. After the manure is removed from the stable, the most serious losses are likely to occur. When manure is kept in open yards there is danger of losing a great deal of the soluble, and hence the most valuable part of it, unless much care is exercised. Many farmyards seem specially constructed for the purpose of wasting manure. It is no uncommon thing to see a large, sloping yard with the manure scattered thinly over it. As a result, the thin layer of manure is unable to hold all the rain-water which falls upon it, and the slope in the yard gives this excessive water a chance to drain away, carrying with it a large part of the soluble plant food from the manure. Frequently, too, the buildings about the yard have no eave-troughs. In such cases the manure receives an additional supply of water from the roofs, and the waste of plant food is proportionately greater. Where manure is kept outside, the opposite of the conditions just described should exist. The yard should be lower in the centre than at the sides so as to hinder drainage from the manure heap, and the buildings about the yard should be furnished with eavetroughs. It must also be remembered that twice as much rain will fall upon one hundred square yards as upon fifty square yards; consequently in order that the manure heap may receive as little rain as possible, it should be spread over as little ground as possible and kept in a compact pile. Manure which contains considerable straw may be made to absorb nearly all the rain which falls upon it, if it is kept in a compact heap so as to expose as little surface as possible to the rain. Many otherwise good yards are spoiled by having too large a space graded so as to be lower in the centre than the surrounding yard. The part of the yard thus hollowed out should be no larger than is absolutely necessary for the manure pile, while the remainder of the yard should fall away from the pile. When a large yard is made to slope towards the centre, it collects a great amount of water which floods the lower portion, causing much inconvenience as well as injuring the manure.

Manure Sheds. Owing to the dangers of loss from the open yard, even after more than average precautions have been taken, the covered manure shed is generally regarded as more satisfactory. The manure shed has several important advantages over the open yard. The manure is protected from rain and snow, and if the shed has a water-tight bottom, and a fair amount of absorbents have been used in the stable, there can be little loss of liquid manure. The shed may be so constructed that it will serve as an exercise ground for the stock, where they can take exercise in comfort even in the most stormy weather. The manure does not freeze as it does outside, and is therefore more easily drawn to the field in winter, if desired. The manure contains less water than that from outside yards, and consequently requires less labor in drawing. When manure sheds are built so as to allow animals to take exercise in them, loss of the droppings of the animals when out of the stable is prevented. The greatest danger of loss in the manure shed is from excessive fermentation of the manure. The manure, being kept drier than in the open yards, ferments much more readily, and if it is not properly attended to, loses much of its nitrogen. Fermentation is much more active when the manure is loosely piled, so that loss from fermentation is greatest in sheds when the stock do not trample the manure. If the shed is arranged so that the stock thoroughly trample and compact the manure, there is very little danger of loss; but when the shed does not admit of this, it must be cleaned out frequently.

Manure sheds are of numberless patterns, and their arrangement will depend entirely upon the construction of the stables and the requirements of the owner. Convenience, economy, and effectiveness must be considered. Sometimes the manure shed takes the form of a basement below the stables, the floor and walls being cemented. In some cases hogs are fed in this basement, to trample and compact the manure. Such an arrangement is certainly convenient and effective, but the cost of construction will probably prevent its general adoption. Generally speaking, the floor of a manure shed should be water-tight, and somewhat hollowed in the centre. A hard clay bottom covered with a layer of gravel will answer very well. The shed is all the better if set on a low stone foundation cemented on the inside, though one that will answer the purpose may be made by setting posts in the ground and boarding with rough lumber, care being taken to have the floor properly graded. It must be borne in mind, however, that the less care bestowed upon the construction of the manure shed the greater care will be necessary to prevent loss. If excessive heating is observed, or if liquid is seen escaping, it will be necessary to clean out the shed. When the manure is trampled and kept compact by the stock, there is not much danger of excessive heating, but trampling will not prevent the escape of liquid manure if the shed is not properly constructed. In sheds where trampling by stock is not practicable, sometimes the manure is kept from heating by frequent moistening with water. This plan can scarcely be commended. The effect of the water is only temporary, and heating soon commences again, calling for repeated applications. As a result, more water is added than the manure can retain, and the water which escapes from the heap carries with it much valuable plant food. Thus the object of the manure shed is defeated, and keeping the manure in an open yard would have saved, at any rate, the labor of carrying water.

Box Stalls. The practise of fattening cattle loose in box stalls is growing in favor. Whatever may be said of its value so far as the cattle are concerned, it is certainly conducive to the production of first-class manure, provided that the stalls are properly constructed and well bedded. The floor of the box stall or pen should be water-tight, cement being preferable. Sufficient straw should be used to absorb all the liquid, and the trampling of the manure by the animals prevents excessive fermenation. In such stalls practically no waste occurs, and they need not be cleaned out oftener than once in two weeks. If the manure can be taken directly from the stalls to the field, the danger of loss is comparatively slight.

Mixing Manure. When manure is stored in yards or sheds it is very important that, as far as practicable, the manure from different kinds of stock should be mixed. Horse and sheep manure is comparatively dry and, consequently, ferments very rapidly. The manure from cattle and swine is much more moist and ferments more slowly. Mixing different kinds of manure, therefore, tends to prevent excessive fermentation of the dry manure, while the dry manure absorbs some of the excessive moisture of the wet manure, and thus helps to prevent loss by leaching. Moreover, the mixing of manures gives a product of more uniform quality, and more satisfactory to apply.

Fermentation. The widest difference of opinion exists among both practical and scientific men as to whether farmyard manure should be applied to the soil in its fresh state, or whether it should first undergo fermentation, or decomposition, in the heap. The question is a very difficult one, and it is also very important. The changes which take place in a pile of fermenting manure are extremely varied and are not, as yet, fully understood. Anything like a full discussion of these changes would be out of place here, but the advisability of allowing farmyard manure to ferment gives rise to so much discussion that it seems as though some attempt should be made to explain a few of the more important changes which may occur before the subject can be intelligently considered.

Before taking up the question of changes in manure, it may be well to make a few preliminary explanations, the importance of which will appear later. To begin with, an attempt will be made to explain the terms *free oxygen* and *combined oxygen*, *free nitrogen* and *combined nitrogen.* Oxygen and hydrogen are both colorless gases. If they are mixed in a suitable vessel and allowed to stand for an indefinite time, no change will be observed. There is in the vessel simply a mixture of oxygen and hydrogen, the same as there might be a mixture of sand and clay. But if a match could be applied to the mixture, or an electric spark sent through it, there would be an explosion, and after the explosion (if the gases were mixed in proper proportions) not a trace of either gas would be found. Instead of the gases there would be merely a few small drops of water. Before the explosion the vessel contained two *gases*; after the explosion it contained a small quantity of *liquid* called water. Now, water is made up of oxygen and hydrogen, but it is very different from either of them, or from the mixture of the two before the heat was applied. Heat brought about a union of the two gases, resulting in what is called a chemical compound. Before the explosion the gases were *free*, that is, each had a separate existence; but after the explosion the gases were no longer *free*, each gas lost its identity and the two *combined* to form water. In other words, before the explosion the vessel contained *free* oxygen and hydrogen, but after the explosion it contained *combined* oxygen and hydrogen.

Take another example. The atmosphere is largely made up of the gases oxygen and nitrogen, but they are not combined, and though they are mixed, they still exist as two distinct gases. The atmosphere, therefore, is largely made up of *free* oxygen and nitrogen. Now, hydrogen might be mixed with oxygen and nitrogen, and under ordinary conditions, no change would occur, but there would simply be a mixture of three distinct gases, each possessing its own peculiar properties. But, under certain conditions, these three gases do combine and form the powerful acid known as nitric acid. Nitric acid is entirely different from any one of the gases or the mixture of gases before combination took place, yet it is composed of hydrogen, nitrogen, and oxygen, and nothing else. Nitric acid, therefore, is a chemical compound made up of *combined* hydrogen, nitrogen, and oxygen, and it is the *combining* of these substances that has changed their character and made them entirely different from the mixture of *free* hydrogen, nitrogen and oxygen.

When nitric acid comes in contact with certain other substances, another marked change takes place. For example, if it comes in contact with the element potassium, some of the potassium will take the place of the hydrogen of the acid, and the compound of hydrogen, nitrogen, and oxygen will be changed into a compound of potassium, nitrogen, and oxygen. The latter compound is known by the names *potassium nitrate*, *nitrate* of *potash*, and *saltpetre*, and possesses qualities entirely different from nitric acid. Similarly, had the nitric acid come in contact with the element sodium, the sodium would have taken the place of the hydrogen of the acid, and the resulting compound would then be composed of sodium, nitrogen and oxygen, and would be called *sodium nitrate* or *nitrate* of *soda*. In the same way calcium may take the place of hydrogen in the acid and form *calcium nitrate*, and ammonia will form *ammonium nitrate*. Potassium nitrate, sodium nitrate, calcium nitrate, and ammonium nitrate, are probably the most important nitrates from an agricultural standpoint.

Special attention has been given to the explanation of what nitrates are, on account of their great agricultural importance. The nitrogen contained in organic matter (vegetable or animal matter) exists in very complicated compounds, and cannot be used again by plants as food until these compounds have been changed into much simpler ones. The most common form, and in fact almost the only form in which plants can make use of nitrogen, is in the form of nitrates. Hence the nitrogen of farmyard manure is of no use to plants until it has been changed into nitrates. But the change of the vegetable compounds containing nitrogen into nitrates is not accomplished in a single step nor by a single agency. Manure contains many different kinds of minute organisms called *bacteria*, and each kind of bacteria has its own peculiar influence upon the manure. All the changes which occur in manure, whether in the heap or in the soil, are caused by bacteria, and it is now in order to consider a few of these changes.

Vegetable matter contains a large amount of carbon. Carbon is taken from the air by plants through their leaves, and hence it has no value as plant food when applied to the soil. Before the nitrogen of vegetable matter can be changed into nitrates, it is necessary to get rid of the carbon which exists in combination with the nitrogen. This first step is brought about by one kind of bacteria, and the process is called *fermentation*. Generally speaking, the bacteria which cause fermentation require the presence of free oxygen (air); and fermentation can be checked or hastened by regulating the supply of air. The carbon liberated by the bacteria, combines with the oxygen of the air and escapes in the form of a gas known as carbonic acid gas. The carbon being driven off, simpler compounds containing nitrogen are left, and other kinds of bacteria bring about further changes in these compounds. It would be out of place to attempt to follow these changes in detail, but ammonia and nitric acid are common products. Ammonia contains nitrogen, and as it very readily escapes into the air in the form of a gas when fermentation is rapid, the result may be a very serious loss of nitrogen. The smell of ammonia can be very plainly detected in the neighborhood of a rapidly fermenting manure heap. If fermentation goes on slowly, much of the ammonia is changed into nitric acid, or combines with nitric acid already formed, and if such substances as calcium, potassium, or sodium are present, they also combine with nitric acid to form the important nitrates, as previously explained. The process by which nitric acid is formed is called *nitrification*, and the bacteria which are instrumental in bringing about nitrification are called *nitrifying bacteria.* Nitrification requires the presence of free oxygen, and therefore cannot go on in the absence of air. Warmth and moisture are also necessary.

There is one more possible change which must not be overlooked. It has been stated that ordinarily the bacteria which cause fermentation require air. There are, however, some kinds of bacteria which can cause organic matter to ferment in the absence of free oxygen. Oxygen is necessary to fermentation, and in the absence of free oxygen, these bacteria obtain their supply by breaking up any nitrates that may be present, using the oxygen of the nitrate, and allowing the nitrogen of the nitrate to escape as a gas. These bacteria, therefore, are very injurious to manure, since they destroy the valuable nitrates and allow their nitrogen to escape. Their effect is directly opposite to nitrification, and hence it is called *denitrification.*

The conditions favoring denitrification, according to Prof. Warington, are : 1. The presence of denitrifying bacteria. 2. The presence of a nitrate and suitable organic matter. 3. Such a condition as to aeration that the supply of free oxygen shall be limited, 4. The usual essential conditions of bacterial growth, as plant food, moisture, and a suitable temperature. Of these conditions, Warington considers an abundant supply of organic matter as most important. On the other hand, nitrifying bacteria require organic matter containing nitrogen, an abundant supply of free oxygen, the presence of some element such as calcium, potassium, or sodium to combine with the nitric acid, together with a suitable temperature, degree of moisture, etc.

It will be seen therefore that fermentation may produce injurious as well as beneficial results. It must also be borne in mind that fermentation and nitrification must take place before the nitrogen of farmyard manure can be of any use to plants, and therefore the point to be considered is how to bring about fermentation with the least danger of loss.

A very common European practice which also has some advocates in this country, is to cause considerable fermentation of the manure while in the heap. In defence of this method, it is claimed that the fermented product contains more available plant food than unfermented manure. No doubt this claim is true, but it may be questioned whether the available plant food was not obtained at too great a cost. If air is freely admitted to the heap, fermentation is extremely rapid and a large quantity of ammonia is evolved, carrying away with it much of the valuable nitrogen. Manure that has fermented very rapidly, frequently presents a scorched appearance, and is said to be " fire-fanged." Such manure is practically worthless. If air is largely excluded by packing the manure so as to check fermentation, then conditions prevail which favor denitrification of some of the nitrates which may be formed. A careful study of the question leads to the conclusion that the conditions existing in the manure heap are rather more favorable to denitrification than to nitrification, and that attempts to bring about nitrification in the manure heap are almost certain to be accompanied by a great loss of nitrogen, principally in the form of ammonia.

It is true that fresh manure contains a large proportion of unavailable plant food, but if it has been properly cared for and contains all the liquid excrements of the animals, it will contain sufficient available plant food for the present requirements of the crop, while the remainder will gradually ferment in the soil and become available for succeeding crops. The conditions in the soil are entirely different from those in the manure heap. The manure is mixed with the soil, fermentation is gradual, air is freely admitted, and the mineral matter of the soil combines with the nitric acid as it forms. In a wet soil, however, where air is excluded by excessive water, or in cases where a very heavy dressing of manure has been applied, denitrification is very active, but the difficulty may be overcome by thorough drainage, or by light application of manure. In all soils there is always more or less loss of nitrates in the drainage water, but this loss will occur whether the manure has been fermented or not. As a result of investigations up to date the eminent authority, Prof. R. Warington, deduces the following conclusion: "The original voidings of the animal have a far greater manurial value than the final product of the manure heap which the farmer carries to his fields. In the whole progress from the stable to the field the loss of nitrogen is going on, this loss falling on the most valuable constituent of the manure, and resulting finally in a residue of comparatively inert matter." The subject of the preparation and preservation of farmyard manure is still under investigation, but up to the present time the bulk of evidence is in favor of applying manure in its fresh state so far as economy of plant food is concerned. Certain crops or conditions of soil may call for fermented manure, and sometimes the destruction of weed seeds may influence some farmers in their practice, but these are questions aside from the general issue.

Rotted or fermented manure is commonly believed to be more suitable for light, sandy or gravelly soils than fresh strawy manure. If the manure is very strawy no doubt some injury to the texture of such soils may result from its application, especially if applied and plowed under in the spring; but with manure of good quality applied judiciously, there is less need of rotting than is commonly believed, in fact, some excellent farmers prefer fresh manure for light soils. Just to what extent fermentation is effective in destroying weed seeds has never been clearly demonstrated. No doubt it has some influence, and may be justifiable under some conditions.

Fermentation of manure in the heap, therefore, is invariably accompanied by a loss of nitrogen, either as free nitrogen or as ammonia, but chiefly in the form of ammonia. Fermentation is accompanied by a rise in temperature, a high temperature indicating rapid fermentation, and the more rapid the fermentation the greater the loss of ammonia. If it is desired to ferment manure the temperature must be carefully watched, and some preservative should be used to retain the ammonia. Before deciding that fermented manure is necessary for any particular soil or crop, careful tests should be made with fresh manure applied in the most approved methods. But, in comparing the effects of rotted and fresh farmyard manure, great care is necessary. It will not do to apply equal weights of each to equal areas of land, and draw conclusions therefrom regarding their relative values. A ton of rotted manure represents a great deal more than a ton of fresh manure; consequently the rotted manure may have lost a large percentage of its original plant food and still contain more plant food per ton than the fresh manure. For example, at the Cornell Experiment Station 10,000 pounds of fresh cow manure, composed of 9,278 pounds of excrements mixed with 422 pounds of straw, were placed in a compact heap and exposed from April 25th to September 22nd. At the beginning of the experiment the manure contained forty-seven pounds of nitrogen, and at the end of the experiment it contained twenty-eight pounds of nitrogen, showing a loss of forty-one per cent. of the original nitrogen. But at the end of the experiment the manure weighed only 5,125 pounds. Therefore the 10,000 pounds of fresh manure contained forty-seven pounds of nitrogen, or 9.4 pounds per ton, while the resulting 5,125 pounds of rotted manure contained twenty-eight pounds of nitrogen, or 10.9 pounds per ton. Now, if the 5,125 pounds of rotted manure and 5,125 pounds of fresh manure were applied to equal areas of land, the results would naturally be in favor of the rotted manure. The unfairness of such a comparison may readily be seen. In order to get a fair comparison in this particular case 10,000 pounds of fresh manure should be used for every 5,125 pounds of rotted manure, when very different results may be expected. Since there are great variations in the shrinkage of manure during rotting, it is extremely difficult to obtain anything approaching fair comparisons of fresh and rotted manure when applied to the soil.

Preservatives. When it is necessary to store manure for a considerable length of time, especially if it is not well compacted, or when it is deemed advisable to ferment the manure, the question of preservatives becomes one of considerable importance. As already intimated, the greatest loss of nitrogen from the covered manure heap occurs in the form of ammonia, and considerable attention has been devoted to the prevention of this loss. Various substances have been tested, but the results so far have not been thoroughly satisfactory.

Gypsum, or land plaster as it is commonly called, is highly commended by some for use in the stables and on the manure heap, but, while it tends to preserve ammonia, its influence is comparatively slight.

Lime hastens ammonia fermentation, and therefore should never be applied to the manure heap.

Thomas slag, according to Holdefleiss, has the same effect as lime.

Sulphate of iron has some effect in preventing the escape of ammonia, but to be effective, would have to be applied in such large quantities as to injure the manure in other ways, not to mention the cost of the substance.

Kainit appears to have a little influence in preserving ammonia, but is of doubtful value. It has a tendency to prevent fermentation and is therefore recommended for use in stables.

Superphosphate is regarded by some German investigators as one of the most effective of the chemical nitrogen preservers. The phosphoric acid which it contains also adds to the value of the manure. Even with superphosphate it requires such large quantities of the substance to preserve all the ammonia that it can scarcely be called a success.

Dry earth containing a considerable amount of humus has given very fair results. Considering that it is to be had on practically every farm for the trouble of drawing, it is pretty safe to say that it is one of the best and safest preservatives that the farmer can use. The more humus it contains the better. Its free use both in the stables and on the manure heap will add to the value of the manure in no small degree.

VI. APPLICATION OF FARMYARD MANURE.

Rate of Application. A very common mistake in applying farmyard manure is to give a small part of the farm a very heavy coating and leave the remainder without any. There are several good reasons why such a practice should not be followed. If the manure has been properly cared for, there is no need of such heavy applications to supply sufficient plant food for the crops; and when heavy manuring is practised, a large part of the farm is neglected while a small part receives much more than it requires. The practice is similar to starving the greater number of a herd of cattle and giving the few remaining animals far more than they can eat. Very heavy manuring is wasteful. It is frequently claimed that if the first crop does not require the plant food applied, the next crop will be all the better off. It is true that the heavier the application, the greater the residue left over for succeeding crops; but it does not follow that there is no waste of plant food under heavy manuring. There are at least two important sources of loss of plant food in the soil under heavy manuring. In the first place, there is danger that some of the excessive plant food may be leached out of the soil and lost in the drainage water when the land is not under crop. In all fertile soils there is always a considerable loss of nitrates from the soil in the drainage water, and it is not difficult to understand that the greater the excess of soluble plant food in the soil, the greater the loss in the drainage water. Some loss is sure to occur, but an effort should be made to make the loss as small as possible; and moderation in applying manure is one step in this direction.

The other source of loss under heavy manuring is not so easy to understand, and may be best illustrated by reference to experiments conducted by Wagner and Maercker in Germany. After a long series of careful experiments in which farmyard manure was used with other fertilizers, notably with nitrate of soda, they were led to some remarkable conclusions, among which the following may be mentioned:

1. "The solid excrement of the horse and cow is practically without value as a manure for plants."

2. "When applied to the land, fresh horse or cow dung destroys the nitrates naturally contained in the soil, or added to it in the form of nitrate of sodium, and the crop which immediately follows is consequently less than if no dung had been applied."

The reason for these and other unfavorable conclusions is given in the second conclusion quoted above, viz., the farmyard manure brought about denitrification apparently of both the nitrates of the soil and the nitrate of sodium applied along with the farmyard manure; that is to say, it caused these valuable nitrates to be broken up, and the nitrogen which they contained to be liberated as free nitrogen which escaped into the atmosphere and was thus lost to the soil. Now, undoubtedly denitrification did occur in these experiments and very energetically too; and there is no room for doubt that in these experiments farmyard manure was a failure. But, as Warington points out, the experiments were conducted in zinc cylinders or pots from which there was probably no drainage. The amount of soil used in each pot was small, and the amount of manure used compared with the amount of soil was abnormally large, representing applications at the rate of from forty to one hundred tons per acre. In the field experiments at Rothamsted where moderate applications of manure were used along with nitrate of sodium, farmyard manure proved to be decidedly beneficial. In the discussion of fermentation of tarmyard manure, the conditions favoring denitrification were described, and it will be seen that the German conditions were particularly suitable for denitrification. From the German results a useful practical lesson is to be derived. They show that it is possible to apply farmyard manure in such a manner that its effect is positively injurious; and though it is extremely improbable that such conditions would exist in farm practice, it is more than probable that large losses of nitrogen through denitrification frequently occur when very heavy applications of farmyard manure are made. When the soil is not well drained, the danger of denitrification is increased.

It is a difficult matter to say what constitutes a light, moderate, or heavy application of farmyard manure. It has been shown that farmyard manure is subject to extreme variations in composition; consequently a given number of tons per acre might be a heavy dressing of manure in one case and a light dressing in another, depending on the quality of the manure. The rate of application will also be influenced by the natural fertility of the soil and the kind of crop to be grown, so that recommendations as to quantity can be made only in the most general terms, and a good deal must be left to the judgment of the person applying it. Generally speaking, about fifteen tons per acre of good manure from an outside yard may be counted a fairly heavy dressing for average soils. Well managed manure from a covered yard or shed contains less water than that from outside yards, and consequently a smaller quantity would be equivalent to fifteen tons of outside manure. Now, mixed farmyard manure of fairly good quality may contain .6 per cent. of nitrogen, .3 per cent. of phosphoric acid, and .45 per cent. of potash, though of course these percentages are merely approximations. The following table shows the amount of nitrogen, phosphoric acid, and potash supplied by fifteen tons of farmyard manure according to the percentages given above, together with the amount of these constituents removed per acre by a crop of wheat and turnips, as estimated by Van Slyke:

—	Nitrogen.	Phosphoric Acid.	Potash.
15 tons farmyard manure contain	180 lbs.	90 lbs.	135 lbs.
Wheat crop (15 to 30 bushels) contains	31 to 62 lbs.	10 to 20 lbs.	13 to 26 lbs.
Turnip crop (350 to 700 bushels) contains	40 to 80 lbs.	26 to 52 lbs.	90 to 180 lbs.

According to the estimates just quoted, fifteen tons of farmyard manure supplies an excess of all the fertilizing constituents, except phosphoric acid for the largest crop of turnips. All of the plant food contained in the manure is not available, but it is not known what percentage of the plant food can be made use of by the crop under ordinary field conditions, and probably never will be known owing to the complexity of the problem. In a fertile, well cultivated soil, however, some allowance must be made for available plant food already in the soil, either as a residue from previous manuring or as natural fertility, so that it is not necessary to supply in an available form the full amount of plant food required by the crop. It is quite probable, too, that average farmyard manure would not contain so much plant food as is assumed in the table, and further allowances must be made if the manure is of inferior quality. Practical results seem to indicate that about fifteeen tons per acre of fair quality of manure may be regarded as the maximum quantity necessary on average soil for the heaviest feeding crops, such as roots and corn. For wheat, the requirements are considerably smaller, as may be seen by referring to the table, where wheat is compared with turnips. Probably ten tons per acre, or even less, may be regarded as a heavy application for wheat. No fixed rule can be given regarding the quantity of manure to apply for different crops. Each farmer must be guided largely by circumstances, and by an understanding of some general principles underlying the operation. It is a pretty safe conclusion that moderate applications of manure to a large area will give better ultimate returns than heavy applications to a small area; and the smaller the supply of manure, the greater the necessity of restricting the amount applied per acre. The time has passed when it was thought necessary to apply from twenty to forty tons of manure per acre.

Depth of Covering. Farmyard manure should be kept as near the surface of the soil as possible. The rainwater as it percolates through the soil, has a tendency to carry the soluble plant food downward and out of the reach of plants; consequently an attempt should be made to delay the downward progress of plant food instead of assisting it by plowing the manure in deeply. Then again, nitrification is most active near the surface of the soil. Therefore manure kept near the surface is under more favorable conditions for having its plant food made available and consequently gives quicker returns. When a heavy application of manure has been plowed under deeply, it is no uncommon thing to see lumps of manure brought to the surface by subsequent plowing, showing that it had never become properly incorporated with the soil. It is quite probable, too, that this deeply buried manure has lost considerable nitrogen through denitrification. Economical manuring consists in obtaining quick returns over as large an area of the farm as possible, and this is accomplished by moderate applications incorporated with the surface soil. Shallow covering of manure also increases the humus of the surface soil. As a result, the soil does not bake and crack in dry weather; it absorbs and retains water much more satisfactorily, and works up into a fine tilth more easily.

Time of Application. Farmyard manure gives better results with spring sown crops if applied and incorporated with the soil during the preceding fall. This is the case especially with crops sown in the early spring, such as mangels or a grain crop. The reason is obvious, since mixing the manure with the soil in the fall gives more time for the preparation of the plant food which it contains. The quantity of manure available for fall application is usually limited, for keeping manure in the yard throughout the summer is open to some very grave objections. Extended experiments at various American experiment stations show that very serious losses may occur in the manure pile during the summer. Sheldon, of the Kansas Experiment Station, concludes that manure should be hauled to the field in the spring, otherwise the loss in six months may amount to nearly forty per cent. of the nitrogen it contains. Experiments at the Cornell Experiment Station tend to confirm this conclusion; but in one case, where the manure was very firmly packed, the loss in value was less than ten per cent. When manure is carelessly scattered over badly constructed yards during the summer, the loss in value is extremely great. When kept in manure sheds during the summer there is danger of excessive fermentation. To say the least, it is an extremely difficult matter to keep manure over from spring until fall without incurring considerable loss.

To avoid this loss and to relieve the pressure of work in the spring, the practice of drawing manure as it is made and spreading it on the land during the winter is becoming popular in many districts. No doubt some loss occurs when this method is followed, but just how great the loss is it is impossible to ascertain. Steep hillsides or those parts of a field that are subject to the wash of surface water in the spring are entirely unsuitable for the winter application of manure; but on comparatively level land, where little washing occurs, it is probable that the loss of plant food is no greater than in the average yard or shed. At any rate the practice seems to be giving good results on many farms, and, so far as present knowledge goes, it seems to have many commendable features when judiciously followed, though no doubt it is frequently abused. Land which is inclined to be wet in the spring, or which is intended for early sown crops, should not be manured during the winter, because the manure tends to retard the thawing and drying of the soil.

The method practised on the College farm has given excellent results. In the regular course of rotation, roots, corn, and peas are sown on land that has been two years under clover and grass, either as meadow or pasture. The sod is plowed as early as possible the preceding fall and thoroughly cultivated, so as to have the sod fairly well rotted before the weather turns cold. In the fall all the manure that can be obtained about the place is drawn on the land intended for roots and corn and spread upon the surface. Then the land is ribbed or ridged up with the double mouldboard plow, as is commonly practised for roots, making the ribs or ridges about twenty-one inches apart. By this means the manure is incorporated with the soil in the ridges. In the spring these ridges are cultivated down and the land is in excellent condition for a root crop, or any other crop. This method not only ensures a thorough mixing of soil and manure, but it also tends to prevent loss of plant food in the drainage water, especially on rolling land. All the manure which accumulates during the summer, together with that which is made during the fall until the plow is stopped by frost, is treated in this way, the hilly or rolling ground receiving the first attention, so as to lessen the danger of waste. There is never enough manure to cover all the corn and root ground in the fall, so manure is applied to the remaining ground during the winter and early spring, and incorporated with the surface soil by means of the gang plow and cultivator after the early sown crops are in. It will be seen that by this method no manure is available for the fall wheat ground in the fall, but in the rotation fall wheat follows the peas, and before the peas are sown the land is given a coating of manure which is incorporated with the surface soil. The object is not to manure the pea crop, but to prepare a store of available plant food for the wheat which follows the peas. On fairly rich soil a very light application of manure is sufficient for this purpose. On soils which tend to produce too great a yield of straw, applying manure before sowing peas would be open to objection, since it would probably aggravate the evil. Where the plan is practicable it possesses several important advantages. It admits of the application of manure for roots in perhaps the most effective manner. It allows of applying fresh or coarse manure in the spring with a crop that has little need of it, consequently during the summer its plant food is being rendered available for the fall wheat which is to follow. It obviates the danger of having to apply manure for fall wheat at the time when the ground is very dry, the evil effects of which will be noted presently. It also admits of the application of coarse manure when the soil is moist, consequently the manure ferments readily and increases the humus of the soil, and when the pea crop is removed the ground is mellow, moist, and in good condition for wheat.

When manure is applied during the summer, it should be mixed with the soil as soon as possible to prevent drying. It is not likely that simply drying the manure would result in any very serious loss of plant food, but when dry manure is mixed with a comparatively dry soil, the necessary fermentation cannot take place, since, as was previously explained, moisture is necessary for the development of nitrifying bacteria. As a result, the manure is apt to form masses of dry, inert material in the soil, which never seem to become properly mixed with the soil afterwards. For the same reasons, plowing under manure during dry weather may injure the water-holding power of the soil, since there is not sufficient moisture to ferment the manure and change it into humus, and the soil is rendered too open in texture. The fault is not in the manure, but lies in the time and method of applying it.

VII. VALUATION OF FERTILIZING CONSTITUENTS IN MANURE.

Few subjects present more real difficulties than the valuation of the fertilizing constituents of farmyard manure. Farmyard manure varies so in composition that it is impossible to estimate with any degree of accuracy how much plant food a given sample contains without first subjecting it to a chemical analysis. Even if the composition is known the difficulty is by no means overcome, for the next point to decide is what money value to attach to the different elements of plant food in the manure, a problem more difficult to solve than the first. A common method is to value each constituent at the price per pound which would have to be paid for it if purchased in the form of a commercial fertilizer. It is argued that were it not for farmyard manure the farmer would be forced to use commercial fertilizers; consequently the manure is worth whatever it saves him in expenditure for its equivalent in commercial fertilizers. From this point of view the argument is perfectly sound; but there is another way of looking at the question, and it may well be asked whether commercial fertilizers are always *worth* what they *cost*. For example, a pound of nitrogen in a good commercial fertilizer usually costs about fifteen cents in the United States, and this value is frequently employed in valuing the nitrogen in farmyard manure and in fodders. In valuing fodders in England, Lawes and Gilbert value nitrogen in the form of ammonia at four pence per pound, which is equivalent to about 9.8 cents per pound for nitrogen, or say ten cents per pound. Now, because nitrogen costs fifteen cents per pound in the United States and ten cents per pound in England, does it follow that nitrogen is worth more to the American farmer than to the English farmer? There is a difference between what a thing is worth and what it costs, as everyone knows, and therefore there are two ways of valuing the constituents of plant food in any manure or fertilizer. It is possible to ascertain, approximately, the value of a manure pile or of certain fodders in terms of commercial fertilizers; but if it is required to find just how much the manure and fodders are worth, so far as increased productivity of the soil or increased value of the land is concerned, probably a very different scale of values may be necessary. It is a comparatively simple matter to show, according to the first method, that plant food to the value of \$50 or \$100 per acre has been added to a certain farm, and to reason therefrom that the farmer's capital has been increased by that amount ; but when it is attempted to show that the farmer's profits have been increased in like proportion, or that the selling price of his farm has been increased to the extent of $50 or $100 per acre, the real difficulties of the problem are fully appreciated. Soils, seasons, cultivation, and markets, all combine to complicate matters, so that it is impossible to say just what cash returns may be expected from the application of a given quantity of plant food. But plant food must be added to the soil ; there is no option in the matter ; and therefore all that is left for the farmer to do is to study how he can obtain sufficient plant food at the lowest possible cost. The importance of making the best possible use of animal excrements has already been pointed out. If animals can be so managed that their products pay for purchased fodders, certainly no cheaper fertilizer is available than the manure resulting from the use of these fodders. It will not do, however, to spend money recklessly in animals and feeding stuffs, believing that the loss sustained on the animals will be more than made up by increased fertility of the soil. It may be possible to justify this course of action by attaching money values to the plant food contained in the purchased fodders, but the bank account may tell a very different story. It is not intended to discredit the practice of valuing the manurial constituents of feeding stuffs—far from it. The practice is a very commendable one, and manurial value should always be considered in purchasing food for animals. It is intended, however, to sound a note of warning against the abuse of the practice, and to show that it is possible to attach values to fertilizing constituents which can never be realized when put to a practical test.

The composition of farmyard manure is so greatly influenced by the foods which animals consume, that it becomes of importance to know something of the relative values of feeding stuffs for furnishing plant food. Since the fertilizing constituents of fodders exist in insoluble forms and must undergo many changes before they become available for plants, it is customary to attach somewhat lower values to them than the market values of the same constituents in soluble commercial fertilizers. A common plan is to value the nitrogen of feeding stuffs at twelve cents per pound, phosphoric acid at four and a half cents per pound, and potash at four and a half cents per pound. Below is given a table, the first column of which shows the result of applying the values mentioned to the fertilizing constituents of some representative feeding stuffs, the composition of the fodders being obtained from American analyses. The second column shows the result of applying the same values to the fertilizing constituents contained in the fodders according to English analyses. The third column shows the same values applied to the remaining fertilizing constituents of the fodders after being fed to cows producing ten quarts of milk per head per day, data regarding the fertilizing constituents in the manure being obtained from the estimates of Lawes and Gilbert American analyses are more satisfactory for this country than English analyses, as the difference in climate likely influences the composition of the fodders. The only reason for inserting the second column is to furnish a basis of comparison for the third column. The second and third columns are computed from English analyses ; consequently, to obtain an idea of the probable shrinkage in manurial value of fodders as the result of being fed to cows, it will be necessary to compare the third column with the second.

TABLE I. Showing value of fertilizing constituents in one ton of various fodders according to American and English analyses; also value of fertilizing constituents returned in manure per ton of food consumed by cows producing ten quarts of milk per head per day; estimating nitrogen worth twelve cents, phosphoric acid, four and a half cents, and potash four and a half cents per pound ·

Fodder.	Total value of fertilizing constituents per ton of different fodders.		Value of fertilizing constituents returned in manure per ton of food consumed by cows producing ten qrts. of milk per head per day.
	Computed from American analyses.	Computed from English analyses.	
Cotton seed meal	$19 70	$22 88	$19 96
Oil cake	16 77	16 19	13 04
Wheat bran	10 46	11 81	9 71
Peas	9 02	11 50	8 80
Wheat middlings	7 73	10 98	8 46
Oats	6 24	6 48	3 96
Wheat	6 65	6 22	3 60
Barley	4 77	5 74	3 11
Corn (maize)	5 36	5 54	2 91
Clover hay	7 29	8 53	7 18
Meadow hay (mixed)	5 02	6 04	4 78
Wheat straw	1 98	2 25	1 35
Potatoes	1 22	1 37	1 06
Mangels	87	1 06	86

The method of valuation shown in the first column is very commonly adopted in estimating the manurial value of fodders, but no allowance is made for what the animals remove from the food. A comparison of the second and third columns shows that the reduction in value when fed to cows giving a fair average flow of milk, amounts to a considerable percentage of the original value. Allowance must also be made for losses which are almost certain to occur before the manure reaches the field. Then, too, there are losses in the drainage water, and under some conditions there may be losses due to denitrification. Therefore, even if it be granted that the values attached to the different fertilizing constituents are not too high, it is quite apparent that considerable deductions must be made from the figures given in the table before they represent the actual worth of the fodders as fertilizers. It is also apparent that valuations of the fertilizing constituents of fodders are sometimes very misleading. The table is not without value, however, for if it does not show the actual manurial values of the fodders, it gives an intelligent idea of their approximate relative values, a very important consideration in buying fodders.

It has been already intimated that Lawes and Gilbert employ lower values than those commonly used in America in estimating the manurial value of fodders. In their most recent publications they value nitrogen as ammonia at 4 d., phosphoric acid at 2 d., and potash at $1\frac{1}{2}$ d. per pound. The following table shows the effect of applying these values to the fertilizing constituents of the fodders under consideration, estimating £1=$4 86 :

TABLE II. Showing manurial value per ton of food consumed, after deducting the fertilizing constituents in fattening increase and in milk. Adapted from estimates of Lawes and Gilbert. Nitrogen (as ammonia), 4 d.; phosphoric acid, 2 d.; and potash $1\frac{1}{2}$ d. per lb.

Fodder.	Manurial value per ton of food consumed, deducting the constituents in fattening increase and in milk.	
	For the production of fattening increase.	For the production of milk, supposing the yield per head per day to be 10 quarts.
Cotton seed meal........	$18 16	$16 36
Oil cake	12 62	10 65
Wheat bran..	9 35	8 04
Peas	8 85	7 17
Wheat middlings... . ..	8 54	6 97
Oats	4 79	3 24
Wheat	4 60	2 93
Barley	4 17	2 55
Corn (maize)	4 03	2 41
Clover hay	6 56	5 73
Meadow hay (mixed)	4 51	3 75
Wheat straw	1 58	1 01
Potatoes	99	79
Mangels	77	67

Table II. is of interest as a means of comparing the relative influence of fattening and milk production upon the manurial value of feeding stuffs. As in the preceding table, no allowance is made for other losses which may occur. The third column of Table I. is obtained from exactly the same data as the second column of Table II., except that different values are applied to the manurial constituents. It is interesting, therefore, to compare these two columns, because they show the difference between American and English valuations of fertilizing constituents, and afford another illustration of the need of care in applying money values to manure.

The whole subject of valuing fertilizing constituents in any form, is full of difficulty. An attempt has been made to show the importance of distinguishing between market value and actual value as shown by increased productivity, and to show that it is impossible to affix money values to fertilizing constituents, which would represent their true worth in increasing the profits of the farmer. The whole question is largely a matter of judgment. But understanding is necessary to sound judgment, and therefore an attempt has been made to assist in understanding this complex subject.

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ONTARIO AGRICULTURAL COLLEGE
AND EXPERIMENTAL FARM.

EXPERIMENTS
IN
THE FEEDING OF LIVE STOCK.

BY G. E. DAY, PROFESSOR OF AGRICULTURE.

I—HEAVY, MEDIUM, AND LIGHT MEAL RATIONS FOR FATTENING STEERS.
II—MANGELS VS. SUGAR BEETS FOR MILK PRODUCTION.
III—ALFALFA AND RED CLOVER HAY FOR LAMBS.
IV—CORN AND PEAS FOR FATTENING LAMBS.
V—PARTIAL PARALYSIS AND CRIPPLING OF SWINE.

I. HEAVY, MEDIUM AND LIGHT MEAL RATIONS FOR FATTENING STEERS.

Owing to the narrow margin between the price per pound of lean and fat cattle, it becomes of great importance to study economy in methods of feeding; and every feeder is anxious to know what is the best method to adopt. Since meal is the most expensive portion of a steer's ration, it attracts special attention in the study of economical feeding; and the wide difference of opinion among feeders regarding the relative economy of heavy and light meal rations, has led to the experiments here reported. Up to the present, three experiments have been completed with heavy, medium, and light meal rations for steers, and the results are so suggestive that it has been deemed advisable to collect and arrange them for publication.

The plan followed was practically the same in the three experiments. In each experiment nine steers were divided into three groups, making three steers in each group. With the heavy ration group, an effort was made to feed one pound of meal per day per hundred pounds live weight of the animals. It was found impossible, however, to keep all the steers up to this limit, so they were kept as near it as was deemed safe. With the medium ration group, the aim was to feed about two-thirds of a pound of meal per day per hundred pounds live weight of the animals. The steers in the light ration group were started on about one-third of a pound of meal per day per hundred pounds live weight, and this quantity was increased as deemed advisable. The following table shows, approximately, how the meal rations were increased during the third experiment, and will serve to illustrate the plan followed in the three experiments, the differences being comparatively slight:

Period.	Heavy ration.	Medium ration.	Light ration.
	Meal per steer per day.	Meal per steer per day.	Meal per steer per day.
	lbs.	lbs.	lbs.
December 6th to January 3rd	10	8	4
January 3rd to February 1st	11	8	5
February 1st to March 1st	12	9	6
March 1st to April 1st	12.5	9	8
April 1st to May 23rd	12.5	9	9

The average live weights of the steers at the beginning and at the close of this experiment were as follows:

Heavy ration group:	1,120 lbs. at the beginning;		1,418 lbs. at the close.	
Medium "	1,155	"	1,448	"
Light "	1,145	"	1,417	"

The meal rations as given in the table are merely approximations. The meal actually consumed by the heavy ration group amounted to nearly nine-tenths of a pound of meal per day for every hundred pounds of the average live weight of the animals throughout the feeding period. The medium ration group averaged two-thirds, and the light ration group slightly over one-half of a pound of meal per day per hundred pounds of the average live weight of the animals during the feeding period. To be strictly accurate, the meal consumed per day per hundred pounds live weight was: heavy ration, .89 lb.; medium ration, .66 lb.; light ration, .53 lb.

In the first two experiments the meal consisted of equal parts by weight of peas, barley and oats, and in the third experiment it was composed of equal parts by weight of corn and oats.

The rest of the ration consisted of clover and timothy hay, straw, and a limited quantity of roots. The amount of roots fed per steer per day seldom exceeded twenty-five pounds. Sometimes the hay and roots were fed separately, and sometimes the hay was cut and mixed with pulped roots a day in advance of feeding, in the proportion twenty pounds of roots to fifteen pounds of hay. All the groups, however, were fed exactly alike, with the exception of the quantity of meal, and all foods were carefully weighed. No ensilage was fed, except for a short time near the close of the first experiment. The object was to use only such foods as are available on practically every farm.

In each experiment the steers were given a preliminary period of feeding, during which all the groups were fed exactly alike. In the first experiment, the preliminary period covered twenty-one days; and in each of the other experiments, thirty days. The first experiment extended over 216 days, the second, 179 days, and the third, 168 days.

In each of the first two experiments, one steer in the medium ration group and one in the light ration group were discarded as unsuitable for experiment, so that these experiments were completed with two steers in each of these two groups. In the third experiment, however, all the steers were retained.

The following table shows the weights and gains of the different groups in the three experiments :

Group.	Total weight, beginning of experiment.			Total weight, close of experiment.			Total gain per steer.			Average gain per steer per day.		
	1st experiment.	2nd experiment.	3rd experiment.	1st experiment.	2nd experiment.	3rd experiment.	1st experiment. 216 days.	2nd experiment. 179 days.	3rd experiment. 168 days.	1st experiment.	2nd experiment.	3rd experiment.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Heavy ration..	2,700	3,235	3,361	3,870	4,140	4,255	390	301.66	298	1.80	1.68	1.77
Medium ration.	*1,999	*2,245	3,467	*2,765	*2,815	4,345	383	285	292·66	1.77	1.59	1.74
Light ration...	*1,979	*2,241	3,436	*2,650	*2,835	4,252	337.5	297	272	1.56	1.65	1.62

* *Two steers.*

Perhaps the first thing which will be noticed in connection with the table is the fact that none of the gains are large. This is due, in a large measure, to the use of a very inferior quality of hay.

It will be noted, further, that the heavy ration group made the largest gain in each experiment. In the first and third experiments the medium ration groups come second in rate of gain, but in the second experiment the medium ration group made the smallest gain. This exception is no doubt due to the individuality of the animals used.

But while it is desirable to have animals make a rapid gain, it is by no means the most important consideration. The cost of producing a pound of gain is an important factor in determining the profit or loss in feeding, and in these experiments, as will be shown, the most rapid gains did not prove to be the most economical.

In arriving at the cost of a pound of gain, it is necessary to attach values to the foods used. Valuing foods is an extremely difficult matter, for reasons which need not be dealt with here. In the first experiment, the foods were valued as follows :—Meal, $13 ; hay, $6 ; straw, $3 ; roots, $2, and ensilage (of which little was used in the first experiment), $2 per ton. These were counted fair average values at the time, though the hay, considering the quality, was certainly valued rather high, and perhaps the same may be said of the straw also. During the next two experiments, however, coarse grains had advanced considerably in price, but, for the sake of uniformity, the original valuations have been used in all the experiments. However, as the sole object of these experiments is to study the *relative* economy of the different methods of feeding, the method of valuing the fodders is not a matter of great importance.

The following table shows the cost of producing a pound of gain, under the different systems, in the three experiments, together with the average cost of a pound of gain in the three experiments :—

Group.	Cost of producing one pound of gain.			
	First experiment.	Second experiment.	Third experiment.	Average of the three experiments.
	c.	c.		c.
Heavy ration	6.37	7.70	7.68	7.25
Medium ration	5.59	7.26	7.22	6.69
Light ration	5.91	6.46	7.21	6.53

It has already been pointed out that in each experiment the heavy ration group made the greatest gain; but, from the table just given, it will be seen that in every case this gain was the most expensive. In the case of the medium and light rations the results are not so conclusive, though on the whole the light ration has some advantage.

Summary and Suggestions.

1. In each of three trials, covering periods of 216, 179 and 168 days respectively, a comparatively heavy meal ration gave larger but more expensive gains than those obtained with lighter meal rations.

2. In the average of three trials the most economical gains were obtained by commencing with about one-third of a pound of meal per day per hundred pounds live weight of the animals, and gradually increasing as circumstances demanded.

3. In two of the trials the groups which made the most economical gains received, on an average, very little more than half a pound of meal per day per hundred pounds of their average live weight during the feeding period.

4. Other experimenters have shown that the cost of producing a pound of gain increases as the animals become fatter; therefore a finished steer is fed at a loss. From this it would seem that, to feed economically, an effort must be made not to have the steers finished for any considerable time before they can be disposed of. No doubt the light ration obtained some of its advantages through more nearly meeting the conditions favoring economical feeding, as given above.

5. No fixed rules can be given regarding the rate of increase in the meal ration. Each feeder must be guided by his judgment and what has been said regarding the methods employed in these experiments can be taken only as a general guide.

6. The more attention given to making the coarse fodders palatable, the better the results obtained from a given quantity of meal.

7. The experiments described deal only with somewhat protracted feeding periods. Shorter feeding periods would no doubt call for a considerable modification of methods and a more rapid increase in the meal ration.

II. MANGELS VS. SUGAR BEETS FOR MILK PRODUCTION.

Chemical analyses show that sugar beets contain a lower percentage of water and a higher percentage of nutritive material than mangels. The main difference in nutritive material, however, is in connection with the fat and heat producing substances, sugar beets containing more of such substances than mangels. In order to test the comparative value of these two kinds of roots for milk production, two experiments, each with different cows, have been completed, and the results of the two experiments correspond so closely that they are of interest.

In each experiment four cows were used. They were selected from the herd in the dairy department, care being taken to select cows as nearly as possible in the same stage of lacatation. After a week's preparatory feeding, during which all the cows were fed the same ration, the rations were changed. Two of the cows were fed sixty pounds of sugar beets per cow per day for two weeks, then they were fed sixty pounds of mangels per cow per day for two weeks. The other two cows were ted sixty pounds of mangels per cow per day during the first two weeks, and then changed to sixty pounds of sugar beets per cow per day during the next two weeks. Thus each experiment lasted four weeks, and each cow was fed two weeks on mangels and two weeks on sugar beets. In addition to the roots, the cows received a meal ration and what clover hay they would eat, each cow receiving like quantities of hay and meal. In the first experiment, the meal ration consisted of equal parts by weight of peas, barley, and oats, and each cow was fed seven pounds of this mixture per day. During the second experiment, each cow was fed six pounds of bran and two pounds of pea meal per day.

It might have been a better test of the relative nutritive value of these two foods, had no meal been fed; but the object of these experiments was to test the influence of these foods upon the milk flow when fed as they most likely would be in ordinary practice, namely, in conjunction with a meal ration. This seems to be the main practical point at issue, and the question in which practical men are most interested.

The following condensed table shows the amount of milk produced by each cow on sugar beets and on mangels in each experiment :—

	Milk produced on sugar beets.	Milk produced on mangels.
First Experiment.	lbs.	lbs.
Cow No. 1	306.75	277.50
" 2	393.75	406.75
" 3	262.00	272.50
" 4	305.50	318.75
Total	1,268.00	1,275.50
Second Experiment.		
Cow No. 1	319.00	330.00
" 2	318.75	326.50
" 3	273.25	265.25
" 4	319.25	316.75
Total	1,230.25	1,238 50

Comments.

1. In each experiment there is a slight difference in the total milk yied in

favor of the mangels, amounting to 7.50 lbs in one case and 8.25 lbs. in the other, in the milk produced by four cows in two weeks.

2. In each experiment, cows 1 and 2 started on sugar beets and finished on mangels, while cows 3 and 4 started on mangels and finished on sugar beets. With this in mind, a study of the table shows that in the first trial cow No. 1 decreased in milk flow, and cow No. 2 increased in milk flow after being changed from sugar beets to mangels; and that both cows 3 and 4 decreased in milk flow after being changed from mangels to sugar beets. In the second trial, however, all the cows gave more milk during the second two weeks than during the first two, but the cows which were changed from sugar beets to mangels made a greater increase, on the whole, than those which were changed from mangels to sugar beets.

3. Everything considered, these experiments indicate that there is very little, if any, difference between mangels and sugar beets as foods for stimulating the flow of milk. It must be remembered, however, that these trials have no bearing upon the relative values of these foods for maintaining life or producing fat.

4. On the College farm mangels have given much larger yields per acre than sugar beets.

III. ALFALFA AND RED CLOVER HAY FOR LAMBS.

Alfalfa is attracting considerable attention at the present time, both as a green fodder and as hay. The large yields of fodder per acre as compared with red clover have tended to increase its popularity, but the fact that alfalfa hay contains a larger amount of indigestible fibre than red clover hay, has caused some to regard it with disfavor. The two experiments reported here are therefore not without interest, although conducted on a somewhat small scale.

In the first experiment, red clover hay, first cutting of alfalfa, and third cutting of alfalfa were fed to three groups of lambs, two of which groups contained four lambs each, and the third group, five lambs. In addition to the hay, the lambs received a meal ration which consisted of equal parts by weight of oats and peas.

The second experiment was a repetition of the first, except that a second cutting of alfalfa was used instead of the third cutting, and no meal was fed, the the lambs receiving nothing but the hay.

Unfortunately, in both experiments, neither the red clover hay nor the first cutting of alfalfa could be called first class.

The first experiment continued for 74 days, and the second for 42 days.

In studying the table given below, it must be remembered that in the first experiment the lambs were fed meal in addition to the hay, while in the second experiment they were fed nothing but hay. Since no meal was fed in the second experiment, the gains are much lower, and the amount of hay fed per pound of gain is correspondingly greater.

In each experiment more or less hay was wasted, especially in the case of the first cutting of alfalfa. If the hay actually eaten were alone taken into account, the amount of hay per pound of gain would be considerably less than that shown in the table. But, from a practical standpoint, the amount of hay which it was necessary to feed to the lambs to produce a pound of gain, is of more importance in comparing the value of the different kinds of hay, than the hay actually consumed in making a pound of gain.

The following table shows the average weekly gains per lamb in each group in the two trials, together with the amount of hay fed per pound of gain :—

Group.	Average weekly gain per lamb.	Average hay fed per pound of gain.
	lbs.	lbs.
First Experiment.		
Red clover	2.10	9.03
First cutting alfalfa	2.15	8.48
Third cutting alfalfa	2.31	8.20
Second Experiment.		
Red clover	1.15	20.52
First cutting alfalfa	1.35	17.81
Second cutting alfalfa	1.33	18.18

Comments.

1. In each experiment the alfalfa hay gave slightly better results than the red clover hay.

2. In the first experiment the third cutting of alfalfa gave somewhat better results than the first cutting, but in the second experiment the first and second cuttings of alfalfa were practically equal.

3. In the second experiment, one lamb in the red clover groups made an extremely low gain, while the other lambs in the same group made an average gain equal to that of the alfalfa groups. This would indicate that the lower average gain on red clover was due to the individuality of this one lamb, and therefore the average gain for the group is probably misleading.

4. Everything considered, it cannot be said that any one of the fodders used showed marked superiority over the others.

5. The experiments indicate that the feeding values of red clover and alfalfa hay are very similar.

6. All animals continued in perfect health from the beginning to the end of each experiment, indicating that alfalfa hay is a safe fodder for sheep.

IV. CORN vs. PEAS FOR FATTENING LAMBS.

Numerous inquiries have been received regarding the fattening value of corn as compared with peas. Two experiments have been made with lambs for the purpose of comparing these two foods, and though the results are somewhat contradictory, they are given here for what they are worth, and another report will be made when further tests have been completed.

In the first experiment, eight lambs were divided into two groups, making four lambs in each group. One group was fed equal parts by weight of corn and oats, and the other group was fed equal parts by weight of peas and oats, the grain being ground in each case. The average meal ration was slightly over one and one-half pounds of meal per lamb per day. In addition to the meal ration, both groups were fed equal quantities of red clover hay.

In the second experiment, a change was made. Twelve lambs were divided into three groups of four lambs each. One group was fed ground corn, another group, ground peas; and the remaining group, equal parts by weight of ground corn and peas. At first, the lambs were fed one pound of meal per lamb per day, which quantity was eventually increased to a pound and a half per lamb per day, On the average, the lambs received 1.37 lbs. of meal per lamb per day. In addition to the meal, all groups were fed equal quantities of red clover hay.

The first experiment continued for 74 days, and the second experiment, 104 days.

The following table shows the average weekly gains per lamb, and the amount of meal consumed per pound of gain in the two experiments:

Group	Average weekly gain per lamb.	Average meal consumed per pound of gain.
	lbs.	lbs.
First Experiment.		
Corn and oats	2.29	4.72
Peas and oats	2.10	5.14
Second Experiment.		
Corn	2.52	3.80
Peas	2.91	3.30
orn and peas	2.60	3.68

Comments.

1. In the first trial, corn and oats gave a larger gain than peas and oats.
2. In the second trial, peas alone gave the largest gain, followed by the mixture, corn and peas.
3. The second trial is more satisfactory than the first, because it covered a longer period of time, and because, from the method of feeding, a more direct comparison of corn and peas was obtained. It is a suggestive fact, also, that the gain made by the group on corn and peas is intermediate between the gains made by the other two groups, as it affords additional evidence regarding the superiorty of peas over corn.
4. During the second trial, ground corn could be bought for $17 per ton, while peas cost from 60c. to 66c. per bushel. As a result, though the peas gave the largest gain, the corn gave the cheapest gain.
5. According to the results of the second trial, if pea meal is valued at $20 per ton, ground corn would be worth $17.35 per ton.
6. Further experiments are neccessary to verify results and make it possible to draw conclusions.

V. PARTIAL PARALYSIS AND CRIPPLING OF SWINE.

By J. Hugo Reed, V.S., and G. E. Day, B.S.A.

During the winter and early spring months, many pigs become affected vith a partial paralysis, and others, while apparently not paralyzed become lame rom a rheumatic inflammation of the joints.

Symptoms of Paralysis. Paralysis, while sometimes showing itself suddenly, usually developes gradually. The pigs show a disinclination and partial inability to come to the trough at feeding time. The appetite is capricious, sometimes they eat fairly well, and at others take very little. The hind limbs are especially affected. Motion apparently causes more or less pain, expressed by squealing, though it is probable that the squealing is not so much indicative of pain as of the inability of the muscular system to obey the will. The symptoms gradually increase in intensity until in many cases complete paralysis and loss of appetite occur, and death soon follows. In some cases, the symptoms do not undergo marked change for a considerable length of time, and in others a spontaneous cure is effected. Occasionally spontaneous diarrhœa occurs, which is usually followed by recovery.

Symptoms of Rheumatic Affections. The symptoms of rheumatic affections are much the same as those of paralysis, but are often accompanied by a swelling and evident tenderness of the joints affected. Movement causes considerable pain, and constipation is usually present.

Causes of Paralysis. Experience indicates that paralysis occurs as a sequel to digestive trouble, and is usually associated with constipation. It commonly occurs among well-fed hogs that are confined in small premises, and hence do not take much exercise. Inaction and liberal feeding cause indigestion, affecting both stomach and intestines; constipation of the bowels follows; and this, through its influence upon the nerves, causes partial paralysis.

Causes of Rheumatic Affections. The great cause of rheumatism is dampness of the premises. Damp sleeping places or damp walls are extremely injurious to hogs.

Curative Treatment for Partial Paralysis. The treatment is to produce purgation, reduce the supply of food, and give food that is easily digested. Purgation can be caused by giving in solution from two eight ounces of epsom salts, according to the size of the animal. It is also good practice to give in addition ten to twenty grains nux vomica three times daily to overcome the paralysis of the muscular coats of the stomach and intestines. The latter may be given in the food if the animals will eat. The fluid must be carefully given, because the animal is likely to squeal during its administration, and if a considerable quantity of fluid be introduced into the mouth while the animal is squealing, some of it will pass down the wind pipe into the lungs, either causing death at once, or complicating the existing disease with mechanical bronchitis, which will probably prove fatal.

If the disease is noticed in its first stages, it frequently can be overcome by giving the affected animals a complete fast of about twenty four hours, and then giving them a drink of skim-milk which contains a liberal dose of epsom salts. Unless they are very thirsty, the animals will likely refuse to take the salts in this way; but when practicable, the method is much preferable to forcible administration, as it involves no risk.

Curative Treatment for Rheumatic Affections. About all that can be done for rheumatism is to remove the animal to dry, comfortable quarters, administer a purgative, and feed lightly. Treatment of the diseased limbs does not appear to be necessary. Removing the cause and acting upon the digestive organs will usually effect a cure except in well advanced cases.

Hyphosulphite of soda, a teaspoonful to each animal in its food, is recommended by some, but has not been tested at this institution.

Prevention of Paralysis and Rheumatism. When animals become sick, it is important to know what to do; but it is infinitely more important to know how to prevent disease. Paralysis and rheumatism may almost invariably be traced to mistakes in feeding, or to unsuitable surroundings. Of course, it is impracticably to describe all the possible ways of successfully feeding and managing swine, and all that can be attempted is to give a few suggestions.

Exercise. Constipation is practically unknown among hogs that have plenty of excercise. The influence of exercise upon the action of the bowels is so well known that it need not be dwelt upon; and when the bowels move regularly, there is little to be feared from paralysis. As far as practicable, therefore, hogs should be encouraged to take exercise; but, unfortunately, exercise is frequently out of the question during the cold winter months.

Feeding. Where exercise is limited, the skill of the feeder is taxed to the utmost. There is probably no *best* meal ration for the hog,—at any rate it is not known. Generally speaking, the greater the variety of foods, the better. But if an exclusive meal ration is fed, the danger point is always near, for digestive troubles are liable to occur. Dairy by-products are excellent, and lessen the danger to a considerable extent, but they are not always available. Roots, however, are available on nearly every farm during the winter, and they form an excellent regulator. It is a well-known fact that where hogs have access to pasture they are remarkably free from the evils under discussion, and roots have an action somewhat similiar to grass. In our experimental feeding, our most thrifty and vigorous hogs have been those which received roots. Our method of feeding roots is very simple. The roots are pulped and mixed with the dry meal ration, and then the whole mass is moistened with water, milk, or whey as the case may be. Sugar beets, mangels, or turnips may be fed in this manner, but potatoes are probably better cooked. Of course, the other roots may be cooked if desired, but we have not found it necessary to do so. For growing pigs three to five months old, we have allowed the roots to constitute as high as fifty per cent. of the weight of the total ration; that is to say, we have fed a pound of roots for every pound of meal. This may be regarded as extreme root feeding, and the pigs fed in this way were rather thin and did not make rapid gains; but they were remarkably healthy and gained rapidly when the meal ration was increased at a later period. Twenty-five to thirty per cent. of the weight of the total ration may be regarded as a fair proportion of roots. If the animals leave some of the roots, it is not necessary to decrease the proportion of roots in the mixture. The difficulty can be overcome by feeding a smaller quantity of the mixture, giving them only what they will eat up clean. In this way the danger of overfeeding is avoided. Roots may be used for all classes of hogs, and the quantity must be regulated by the feeder, who must be guided by the condition of the animals. Some prefer feeding the roots whole, as this gives the pigs more exercise.

For feeding sows, or even for younger animals, variety may be given the ration by running some good clover hay through the cutting box, steaming it, and mixing it with the meal ration. An occasional feed of this mixture is much relished, and has a decidedly beneficial effect.

Generally speaking, an effort must be made to avoid overloading the animal's stomach with concentrated food. When hogs run at large during the summer, there is little danger of doing this; but, in winter feeding, or in feeding hogs shut in pens, great care is necessary. When hogs are confined in pens during the summer, green foods, such as grass, clover, peas, rape, etc, can be used to advantage.

Correctives. Under the name "correctives" are included those substances which are not foods, but which have a beneficial action upon the digestive organs. Earth is one of the simplest, though perhaps not the best of these. It is certain, however, that hogs greatly relish a little fresh earth during confinement. Ashes are also good, mixed with a little salt and kept in boxes where the hogs can get them at will, they are certainly beneficial. Charcoal is excellent, and has a tendency to prevent indigestion. The charcoal may be fed alone or in conjunction with other substances. The following mixture is recommended by the veteran swine breeder, Theodore Louis: "Take three bushels of common charcoal, eight pounds of salt, two quarts of air slacked lime, one bushel of wood ashes. Break the charcoal well down, with shovel or other implement, and thoroughly mix. Then take one and one-quarter pounds of copperas and dissolve in hot water, and with an ordinary watering pot sprinkle over the whole mass and again mix thoroughly. Put this mixture into self-feeding boxes, and place them where hogs of all ages can eat of their contents at pleasure." If the droppings of the hogs are of a constipated nature, the following mixture works well: Equal parts by weight of epsom salts, sulphur, and powdered charcoal. Feed the hogs some of this once daily in their food. The quantity to be given will depend upon the size of the animals, say from a teaspoonful to a dessert-spoonful for each animal, increasing or decreasing the dose according to the condition of the droppings.

The Piggery. The building is of great importance. Without a suitable piggery, no amount of skill can make a success of swine feeding. To those who contemplate building, a few suggestions may be useful. In the first place, the building *must be dry*—dry walls, dry beds, and, as far as practicable, dry floors. Dampness is one of the great causes of unthrifty and rheumatic pigs, though injudicious feeding will aggravate the evil. Then the pens should be reasonably warm and well ventilated; and, lastly, they should admit the sun freely. The central feed passage with pens on each side is open to grave objections, because the pens on one side of the passage, at least, will receive little or no sun. A building facing the south with all the pens on the south side and the feed passage on the north, is preferable. No windows need be put in the north side, but a double supply should be put in the south side. If the windows are placed a good distance from the floor, they will amply light the feed passage. With this arrangement, the cold side of the building is tightly sealed against the wind, and every pen receives its share of life-giving sunlight.

Opinions differ widely as to the best material for the walls of a piggery, and it is, perhaps, possible to be too positive in this matter. It seems only fair, however, that the public should be made acquainted with some experience we have had in the experimental feeding department of the College. We have one piggery with concrete walls, one foot thick, a cement floor, and plank sleeping places for the pigs. We used this pen during two winters, and the results were disastrous. During each winter more than half the pigs became more or less crippled, some of them died, and others were practically worthless. As a summer pen, it has proved quite satisfactory; but for winter feeding, it is a failure It seems impossible to ventilate this pen without making it too cold. The concrete is a much better conductor of heat than is wood and it seems to carry away the heat of the pen, condensing moisture upon the walls, and leaving a damp, chilly atmosphere. If artificial heat were used, probably the difficulty could be overcome. It is intended to line the walls with lumber, leaving an air space between the boards and the wall.

Reports are to hand of piggeries with concrete and stone walls which are giving satisfaction, but from what has been stated it will be seen that a concrete piggery may be quite the reverse of satisfactory.

During the past winter, which was exceptionally severe and seems to have occasioned more than ordinary difficulty with regard to crippling, we kept our hogs in a frame building with cement floor and plank sleeping places. The outside of this building is single boarded with battens over the cracks. On the inside, the walls are double boarded with tar paper between the two layers. The floors and beds are almost identical with those of the other building. In this pen, we had not a single case of crippling. Our experience, therefore, leads us to prefer wooden walls.

The floors present another serious problem. A cement floor possesses the great advantage of durability; and where wooden platforms are provided for sleeping places, they seem to be very satisfactory. For breeding pens, no doubt wooden floors are safer. If a wooden floor is used, its durability can be increased by laying it on joists about eighteen inches above the ground, and having the space below the floor well ventilated. A single thickness of two-inch plank laid with water-tight joints, is preferable to a double floor. With a double floor there is more or less danger of moisture collecting between the two layers, in which case drying is slow, and decay rapid. One great objection to wooden floors is the danger of trouble from rats, which may perhaps be lessened by having the space beneath the floor well lighted and ventilated.

There are numerous methods of ventilating piggeries. A plan which we have used with fairly good results, is to run straight ventilating shafts from the ceiling to a cupola on the roof. The shafts are made of rough lumber and should be, at least, two feet square. In the bottom of the shaft (at the ceiling) is a trap door which opens into the shaft. A small rope attached to the top of the trap door runs through the side of the shaft and then down through the ceiling, so that by pulling the rope the door can be raised to any degree required. On some days it is much more difficult to secure ventilation than on others, and the large shafts with trap doors permit of regulating ventilation according to circumstances. Two such ventilating shafts should be sufficient for a pen fifty feet long.

Conclusion.

The suggestions which are here offered for consideration are based upon observation and experience. No man is infallible, and no doubt there may be room for difference of opinion on some of the points dealt with; and it is not unlikely that some effective means for preventing and curing paralysis and rheumatism have been omitted. Notwishstanding all this, however, we hope that the thoughts which have been presented may be of assistance to some who have encountered difficulties.

ONTARIO DEPARTMENT OF AGRICULTURE.

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AGRICULTURAL COLLEGE AND EXPERIMENTAL FARM.

LUCERNE OR ALFALFA: COMPOSITION AND DIGESTIBILITY.

By R. Harcourt, B. S. A., Assistant Chemist.

INTRODUCTION.

In many parts of the Province of Ontario a great deal of interest is taken in the growing of lucerne. This is, at least partly to be accounted for by the fact that the plant grows and produces large crops even in our dryest weather. During the past extremely dry season, when most grasses were brown and parched, the lucerne was a rich green color, making a luxuriant growth. In the past, in many places, it has been grown only in small plots near farm buildings, to be used as a supplementary food for farm stock, especially for working horses. Now, on many hundred-acre farms, ten, fifteen, and even twenty acres of lucerne may be found, and many tons of hay are made from it every year. The idea seems to prevail that though this plant produces an immense amount of rich food when cut and used green, yet when cut and cured as hay, it forms a harsh, stalky, indigestible fodder. So, to ascertain what ground there is for this idea, and to learn, if possible, at what

Fig. 1. Single plant of lucerne, showing the large number of stems from one strong tap-root; also, an elongated underground stem bearing branch-producing stalks.

stage in its growth the plant should be cut to get the maximum amount of digestible constituents, the work of this bulletin was undertaken. While all the work has been done with scientific accuracy, the treatment of the subject in the bulletin is of a practical, rather than a scientific, character.

History of Plant.

Lucerne, or Alfalfa (*Medicago sativa*), is a plant of the large and valu-e botanical family called Leguminosae. The clovers all belong to this family and form a peculiar but interesting series of plants botanically and practically, as well as chemically. Lucerne, though not a true clover, resembles the clover very much ; it belongs to the genus *Medicago*, while the clovers are of the genus *Trifolium*. Lucerne is one of the most ancient of forage plants, having been cultivated by the Greeks, Romans, and Egyptians before the Christian era, and at a later date especially within the ninteenth century, by many of the nations of Europe. The Spaniards introduced it into South America, where it has been grown for a long time, especially in the arid and semi-arid regions along the west shore From this region it was introduced into Mexico and California ; and from there it has spread across the western states and the territories of the United States, where it still retains the Spanish name of Alfalfa. The same plant coming to us from countries of Europe, other than Spain usually goes by the the name of Lucerne, from the valley of Lucerne in Switzerland, where it is grown in very large quantities.

Description of Plant.

Lucerne is rather a slender growing, branching perennial plant, with leaves much smaller than those of the common red or mammoth red clover. It is of a peculiar dark, rich green color which is easily distinguished in a dry season, even at a considerable distance. The lucerne blossoms differ markedly from those of the clovers, the latter having blossoms aggregated or clustered in a somewhat rounded head or bunch, while the former has its beautiful small, hooded, or pea-like, purple blossoms scattered along the stem loosely, in what the botanist calls a raceme. Again, the seed pods are single and coiled spirally, while in the red and white clovers they are straight and crowded into a head. The brownish yellow seeds resemble those of the red clover somewhat, but are larger, longer and more kidney-shaped.

The plant usually has a single long and strong tap root, which throws off numerous small branches or rootlets as it passes downwards. Various influences may cause an apparent breaking up of this tap root into a number of smaller roots, which, however, penetrate the soil almost as deeply as the main root. In an open, porous subsoil the tap-roots have been traced to a depth of twelve and fifteen feet. In such a soil the length of the root seems to be limited only by the distance to the water table, even if that be twenty or thirty feet below the surface. Good strong roots have been found at a depth of eight feet in very heavy clay soil. These roots on decaying leave little tube-like openings leading down into the ground in all directions, and must be of considerable value as a means of underdraining and aerating the soil. Again, these roots running so deeply into the soil are of great value in bringing back to the surface plant food which has been washed down beyond the reach of other plants, and also in bringing the plant into contact with water that is largely unavailable for the growth of other crops.

In addition to this lucerne, like the clovers, has the power of assimilating the free nitrogen of the atmosphere. All members of the leguminosæ family, which includes peas, vetches, lupines, clovers and lucerne, are found to have small nodules or tubercles on their roots. These tubercles, knots, or nodules contain millions upon millions of extremely small vegetable organisms called bacteria, which live on the juices of the root and in the process of develop-

Fig. 2. Single stem of lucerne taken from plant shown in Fig. 1.

Fig. 3. Plants three months from date of seeding, showing the long tap-root and the small development of top as compared with the root.

ment supply the plant with an available form of nitrogen which they by some means, not as yet thoroughly understood, transform from the free nitrogen of the atmosphere. Thus, through the agency of these minute organisms, leguminous plants have at their disposal a practically unlimited supply of nitrogen, which, so far as is known, is unavailable to other farm crops. For this reason all the legumes are valuable as improvers of soil fertility. Lucerne is especially valuable, owing to its extraordinary length of root which brings it into contact with nitrates and ash constituents that are out of the reach of other plants ; and these must of necessity be carried up to the growing parts of the plant and thus become available for food or manure. This conclusion is fully borne out by the results of chemical analysis ; for upon reference to tables of analysis, it will be seen that as a food for young and growing stock it is the equal of any of our fodders ; and that in nitrogen, potash and phosphoric acid, it is richer than the grasses and fully as rich as the clovers.

Cultivation.

One drawback to the growing of lucerne is the fact that it cannot be used in a short rotation of crops. On account of the length of time it requires to become established in the soil, and on account of the size and toughness of the roots, the land seeded with lucerne should be selected with the view of allowing it to remain for a number of years. Just how long it may be profitably left before breaking up depends very much upon how clean the land was at the time of seeding ; but the time varies between six and twelve years, although in some cases it has been found profitable to leave it even longer. A crop that is expected to hold the ground for so long a period, should have a faultless seed-bed. It will amply repay careful cleaning of the land previous to seeding. This is especially true on rather poor land, where the first year's crop will likely be small and consequently in danger of being overcome with weeds. The land may be prepared by means of a late summer fallow, or better, the seeding may follow a hoed crop ; but, whatever the preparation of the land, it must be clean and, as the seeds are small, it is essential that it be in a very fine condition mechanically.

The soil best suited for the growth of lucerne seems to be a deep loam, rather dry, containing a fair proportion of lime, with *good deep natural drainage.* It will, however, do well upon almost any soil that is well drained, provided it once becomes well rooted. Heavy clay and light sandy soils both produce excellent crops of lucerne, but on the latter it naturally requires generous manuring. It should never be sown on land in which the water table stands near the surface, or on land likely to be covered with water at any season of the year. This will exclude most low-lying ground where grasses naturally do well.

The amount of seed sown varies considerably, some sowing about 15 lbs. of seed per acre, while others use as much as 40 lbs., or even more. Under ordinary conditions 15 to 20 lbs. per acre are sufficient. The covering may be done with a light harrow and roller. If sown with oats, barley, or the like, not more than about one half the ordinary amount of grain should be sown per acre, even then the young plants are apt to be killed by exposure to the sun when the " nurse " crop is removed, especially if hot dry weather follows the cutting of the grain crop. Better results are usually obtained by sowing the seed alone. The best time to sow is as soon as the ground can be got into good condition in the spring and danger of heavy frosts is passed. In some cases, difficulty is experienced in getting a good stand on clay soils. An excellent " catch " has been obtained over bare, heavy clay knolls by giving them a top dressing with barnyard manure at the time of seeding.

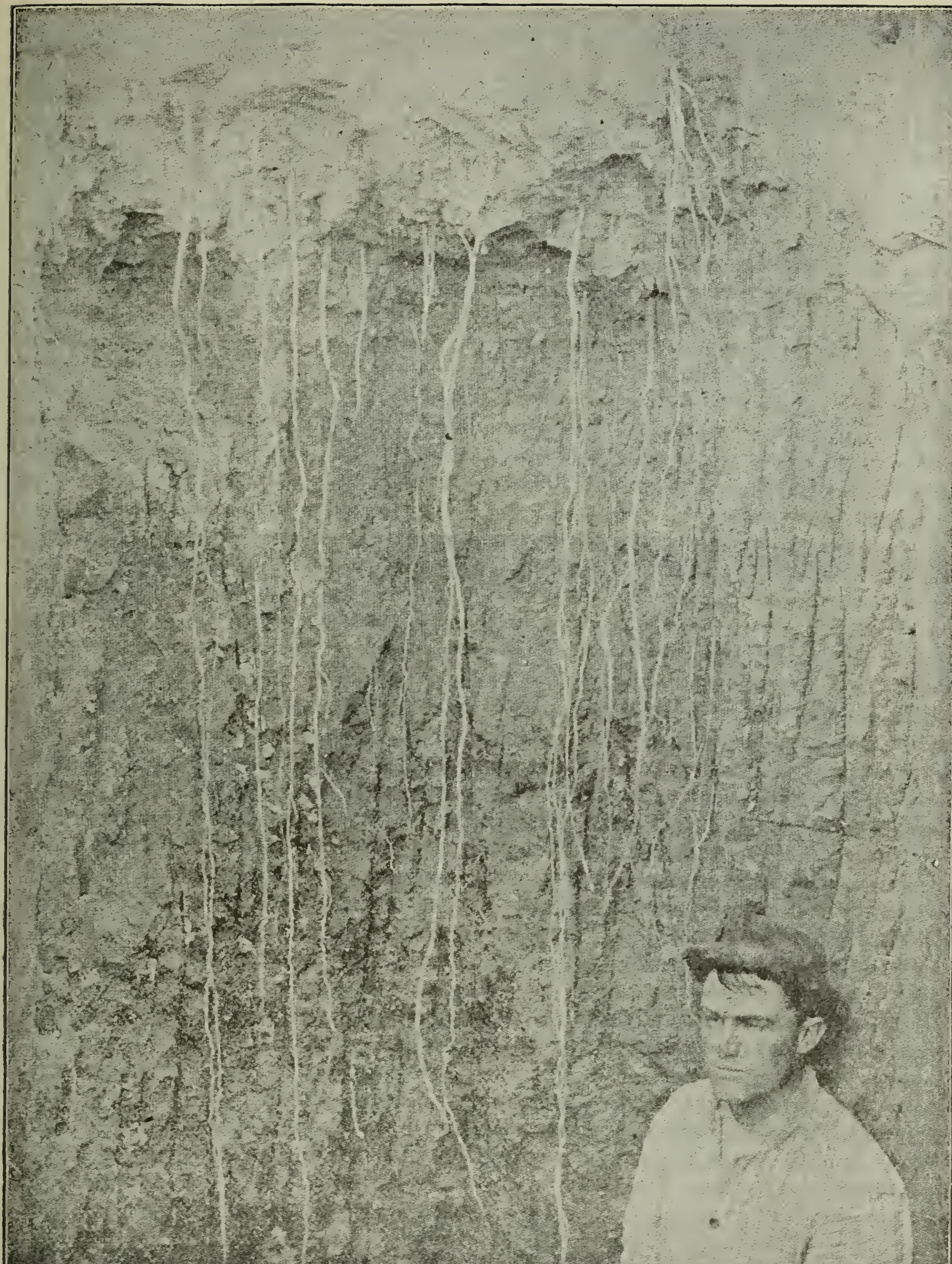


Fig 4. This photograph represents the face of an opening made to the depth of rather more than 13 feet in an alfalfa field on the Experiment Station Farm, at Rocky Ford, Otero County, Colorado. The soil is a fine alluvium. The roots penetrated to a depth of 12 feet 6 inches, and the simplicity of the root system is well shown, the roots being shown in their natural position. The upper margin of the photograph represents the surface of the ground, which lacks sufficient sharpness to show the crowns and stubble in the picture.

This alfalfa was four years old and cut from four to five tons of hay a year. The diameter of these roots, just below the crown, averaged a little less than ½ inch.

Vitality of Seed.

A great deal has been written concerning the poor vitality of lucerne seed. North Carolina Bulletin No. 60 has the following : "The vitality of lucerne seed is so low that seed over one year old is scarcely worth sowing." Loudon says : "Great care should be had to procure it (lucerne seed) plump and perfectly new, as two years old seed does not come up freely. Colorado Bulletin No. 35 records a germinating experiment in which a very high percentage of seed, two, three and six years old, sprouted. The United States Experiment Station Record, Vol. vi, No. 5, gives in tabular form the result of an eleven years' test of the duration of the vitality of some agricultural seeds made by S. Samck* from which the following is taken. Well matured seed was selected, a portion of which was examined each year from 1883 to 1894. The unused portions were kept in paper bags in a dry airy room and seeds taken from them each succeeding year for the test

Results of Eleven Years' Seed Testing.

Kinds of seed.	Percentage of vitality.										
	1 year	2 yrs.	3 yrs.	4 yrs.	5 yrs.	6 yrs.	7 yrs.	8 yrs.	9 yrs.	10 yrs.	11 yrs.
Lucerne	94	91	87	75	72	71	68	66	63	59	54
Red clover	90	90	88	84	74	68	44	16	10	3	2
Alsike	73	64	51	37	15	7	6	5	3	3	3
White clover	74	72	63	52	50	50	35	31	26	23	22
Timothy	95	90	90	88	86	79	66	39	15	1	0
Orchard grass	46	47	44	44	38	29	21	12	8	5	

It will be seen that in the first year of the experiment, out of 100 seeds of lucerne planted, 94 germinated ; of the same number of red clover, 90 germinated ; of alsike, 73 ; of white clover, 74 ; of timothy, 95 ; of orchard grass, 46 ; while in the eleventh year but 54 out of the 100 seeds of lucerne grew, 2 of red clover, 3 of alsike, 22 of white clover, and none of either timothy or orchard grass. According to these figures, age does not affect the vitality of lucerne seed so much as it does the other seeds used in the experiment. No observations, however, were made by the experimenter regarding the strength of the plants from the old seed as compared with those from the new seed.

Care of Crop.

The first year is the most critical period in the growth of lucerne ; and, unless on very rich ground, no crop need be expected the first season. During that time the roots are pushing down deep into the soil, so that the plants may be in a position to grow a good top the second year. If there be considerable growth, the crop may be lightly pastured, but not late in the season.

* Tirol. landu, Blatter, 13 (1894), No. 18, pp. 161, 162, 1883 to 1894.

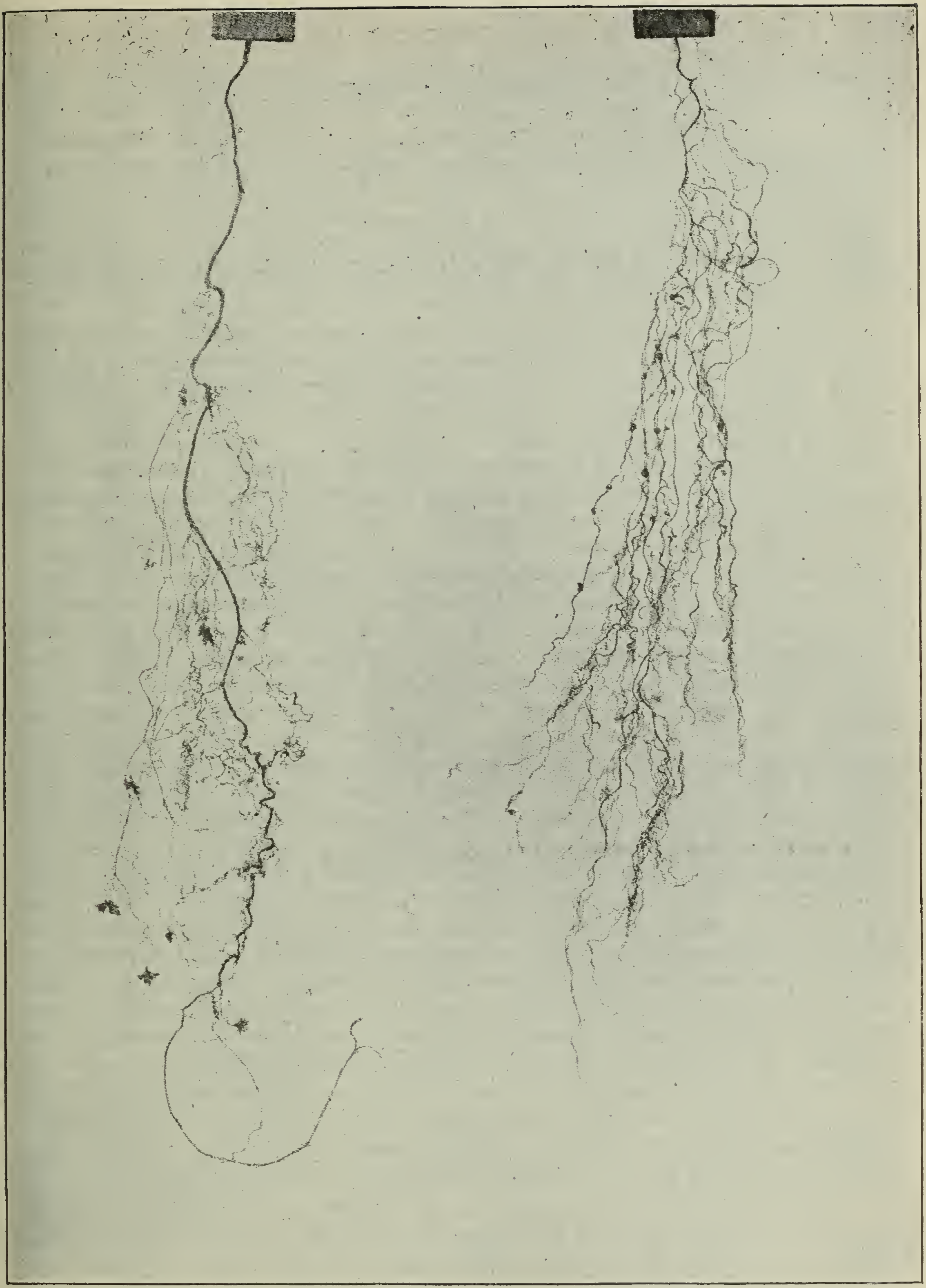


Fig. 5. It was not possible to get the details of the small roots in photographs of plants whose roots were from 7 to $11\frac{1}{2}$ feet long. We present in this plate the terminal portions of two roots, $7\frac{1}{2}$ feet from the surface, each showing nodules, which appear as round or irregular black spots on the roots. The extremities of the tap roots, I regret, were broken off.

A better plan is to go over the ground with the mower, having the finger-bar set high to avoid injuring the young plants. This will cut off any weeds that may be growing and form a mulch around the growing plants. The second year, although not at its best, if the season is at all favorable, two or three crops may be cut; and this may be continued for a number of years. During a particularly favorable season, even four crops may be secured. When it is cut for hay, an average soil will produce from fifteen to twenty tons of green crop per acre. The lucerne grown on the college experimental grounds yielded as an average of three years 20.33 tons of green crop per acre.

In some sections the first cutting for the season, which is always the largest, is cured as hay, and the second is cut for seed, after which it is pastured. By other farmers it is used almost entirely for pasture, but owing to some peculiarities of its growth it is not so well suited for pasturing as for use as a soiling crop. If lucerne is to be pastured, enough stock must be kept on the field to eat off all the growth before the plant passes the early blossoming stage, or else the field must be mown as often as the plants reach that stage of maturity. A more nutritious pasture will be obtained in this way. If the field be too closely pastured, the crop may be injured. Farmer's Bulletin No. 31 offers the following explanation on this point, "The young plant consists of a number of low branches springing up from a simple basal stalk at the crown of the root. The branches ascend directly above the ground and form a compact tuft. On the old plant, however, certain of the more robust stems elongate underground and become new branch-producing stalks. In this way the simple stalk, or rhizome, becomes two or many headed. When the stems are cut or grazed off, the stalk dies down to the very base and new buds spring up on the upper part or crown of the new root and grow, forming new stems. This method of growth explains why many farmers have reported that alfalfa is injured or destroyed by continuous close grazing. The stems of many other forage plants, when cut or broken, branch out above ground, forming lateral shoots that immediately grow up and take the place of the old stems. If alfalfa is closely grazed, and if every young stem is eaten off as rapidly as it appears, the vitality of the root will be impaired and the plant may die, because the new growth comes directly from the root itself, and not from the bases of the old stems. There is more danger of killing out the alfalfa fields when sheep are pastured on them than by the pasturing of cattle, horses or hogs, as the latter do not graze the plants as closely as do sheep, except at times when there is insufficient forage."

On some soils, the stand of lucerne may deteriorate very rapidly after the fourth or fifth year, unless it receives proper attention. It is naturally a strong grower and will hold its own if it has a fair chance. Where, for any reason, plants have been killed, seed should be sown as soon as possible.

Lucerne should never be grown in an orchard, for the roots go deeper than those of the fruit trees, and seriously retard, if they do not altogether destroy, the growth of the trees. The trees, however, may be planted on ground which has grown lucerne, for, through the action of the deep roots of the plant, mineral fertilizers are brought near the surface, the subsoil is made porous, and the dead and decaying roots furnish organic food in the best form for rapid absorption by the roots of the trees.

Lucerne as a Fodder.

When cut before it becomes too woody, there are few plants that are equal to lucerne in nutritive value. It makes an excellent hog pasture, but the plants must not be allowed to stand until they become hard and woody. The most nutritious fodder will be obtained by cutting off the plants every time they reach the blossoming stage. Sheep do well on it and produce a fine quality of wool. Dairymen who have used lucerne speak very highly of it as a cheap food for milk production. Bulletin No. 80 of the Geneva Experiment Station, New York, gives results of some feeding experiments in which lucerne and other forage plants were used in the feeding of milch cows. It was found in a great number of cases that where lucerne was substituted for some other food, or the amount of lucerne in the ration was increased, there followed a decrease in the cost of the milk. According to English* authorities, the feeding of lucerne to milch cows produced "milk that was not only rich in solids, but contained a large proportion of butter fat—the butter being of a brilliant yellow color, of exceedingly firm texture, even during the hot weather, and containing a most aromatic flavor."

It must not be forgotten, however, that lucerne, as a food for stock, deteriorates very rapidly after a certain stage of maturity has been reached. If allowed to stand until the blossom has fallen, a great many of the leaves will have dropped off, leaving the stalks comparatively bare. The woody part will have increased rapidly and the protein or flesh producing will have decreased; consequently the digestibility will have decreased, and possibly to such an extent that it will be unsafe to feed it in large quantities to any animal. During our digestion experiments, we fed three sheep for four weeks entirely on lucerne hay that was made after the plants had reached full blossom; and, at the end of the fourth week one of the animals was taken sick with impaction of the third stomach, caused, no doubt, by the indigestible nature of the food eaten. With proper treatment, it quickly recovered and, with the other two sheep, fed for four weeks longer on earlier cuttings of lucerne, without any further trouble. Some ripened lucerne has been fed by the farm department with serious results. In one case a valuable cow died of stoppage of the bowels; a post mortem examination showed that all passage had been stopped by a ball of indigestible fibre, which was supposed to have formed from the lucerne eaten. Although we have not had sufficient experimental evidence to prove it conclusively, it would seem as though there was great danger in feeding in large quantities lucerne hay that has been made from the plant in advanced stages of maturity. For this reason some have objected to its use altogether; but this is an extreme position to take; for, when cut in the earlier stages of its growth, lucerne has been found to be as digestible as either red clover or timothy.

Soiling Crop.

As a soiling crop, it is unsurpassed; it is one of the earliest crops, if not the earliest, in the spring, and by judicious arrangement may be used throughout the whole season. For soiling purposes, it may be cut before

* Royal Agricultural Society Report. Vol. 23, 1887.

blossoming ; and as the sooner it is cut, the sooner another crop will follow, it is better not to wait for the full growth of the plant before commencing to use it. By beginning early and cutting about one thirty-fifth of the plot each day, so as to go over it every five weeks, a lucerne field will afford a constant cut from the latter part of May until October, since by the end of each five weeks the portion first cut will be ready with another crop. This is one of the best uses that can be made of lucerne ; and, where at all possible, it will be found very profitable to have at least a small plot of it near the farm buildings for supplementary feeding, as all kinds of stock are fond of it. While all fodders deteriorate towards maturity, this is especially true of lucerne. This was clearly brought out by W. L. Summerby, one of the '98 graduating class of this college, who worked out an interesting thesis on "The Nitrogen of Lucerne." For analysis a cutting was made each week from the time the plant was six inches high until the blossom had fallen. The following is an extract from one of Mr. Summerby's tables :

PROTEIDS OF LUCERNE.

Time of Cutting.		Per cent. of Crude Protein.
1st Cutting ;	6 inches high................	25.33
2nd "	buds forming	23.24
3rd "	first flowers	18.80
4th "	full bloom	15.65
5th "	blossom falling	14.23

The above shows clearly that as the plant matures, the amount of crude protein decreases, and, therefore, the nutritive value of the plant decreases. The earlier the plant is cut, the richer the food it makes. When we want the maximum amount of digestible matter per acre, other points have to be considered in determining at what stage of maturity the plant should be cut. This point will be discussed later.

AS A HAY CROP.

Owing to the large amount of water in green lucerne and to the thickness of the stem, it is somewhat difficult to cure as hay. This is especially true of the first crop, which, besides containing a higher percentage of water than the succeeding ones, is usually ready for cutting while the ground is still damp from the spring rains, and before good hay weather has set in. As is the case with clovers, the leaves of lucerne break off very readily when dry ; and, as these are the most nutritious part of the plant, there is likely to be considerable loss. The curing should, therefore, be done in the cock as much as possible ; and, so far as practicable, the raking and handling should be done while the hay is a little "tough." The loss of the leaves will thus be reduced to a minimum. It would be impossible to give detailed directions for the curing of the hay, because conditions and weather vary so much in different parts of the province and different seasons. Much care and time are necessary to make good hay, and experience and good judgment are required.

Composition of Lucerne as Affected by the Stage of Maturity.

(a) *Plan of Experiment.*—A great diversity of opinion prevails among growers as to the stage of maturity at which lucerne should be cut to obtain the largest amount of digestible matter. To solve this question, we undertook a study of the composition and digestibility of the plant as affected by maturity. For this purpose, last year we cut the second crop of lucerne for the season at three different degrees of ripeness. The first cutting was made when the buds were well formed; the second, nearly two weeks later, when the blossoms were about one-third out; and the third, nearly another two weeks later, when the plant had passed the full blooming stage. This year we have cut both the first and second crops as nearly as possible at the same three stages of maturity. The crop, immediately after being cut, was weighed, then spread back on the ground, and cured in the usual way. The cured hay was again weighed and a sample taken for chemical analysis, the rest being used for the digestion experimental work. The three cuttings of each crop of this year were made from the same plot, which was one-tenth of an acre in size. Each cutting, therefore, was made from one-thirtieth of an acre. Lucerne from the same plot was used for the work done last year; but the cuttings were from a smaller area. The plot was situated on a hill-side, the soil of which was a gravelly loam with a clay sub-soil, and was seeded on the twelfth of May, 1894.

(b) *Result of Experiment.*—The following table gives the weight of the various cuttings calculated to the yield yer acre:

Yield per acre in Green State and as Hay, and figured to Dry Matter.

———	Green State.	As Hay.	Dry Matter.
Second crop, 1897.	lbs.	lbs.	lbs.
1st cutting; buds formed	17,100	3,761	3,197
2nd " blossom one-third out	15,400	4,493	3,819
3rd " a little past full bloom	11,500	3,902	3,317
First crop, 1898.			
1st cutting; buds formed	18,000	3,582	3,045
2nd " blossom one-third out	19,050	5,001	4,251
3rd " a little past full bloom	17,550	4,581	3,894
Second crop, 1898.			
1st cutting; buds formed	7,125	2,234	1,899
2nd " blossom one-third out	9,090	2,947	2,505
3rd " a little past full bloom	8,040	2,604	2,214

Very little rain fell during the growing period of the second crop of 1898, which will, no doubt, account for the much smaller yield than that obtained from the second crop of 1897. In every case but one, the largest yield in green state, as hay, and as dry matter, was obtained from the second cutting, which, it will be noticed, was made when the plants were about one-third in blossom. It is quite possible that the weight of the crop would have increased for a few days longer; but it is evident that by the time the plant reaches full bloom or a little beyond, there is a marked decrease, which can be at least partially accounted for by the large number of leaves which had fallen off previous to the third cutting. Not only was the yield less in the third cutting, but the percentages of the most valuable food constituents had also decreased. This is shown in the following table:

PERCENTAGE COMPOSITION OF LUCERNE HARVESTED AT DIFFERENT DATES.

Calculated to water-free substances.*

—	Ash.	Crude Protein.	Crude Fibre.	Nitrogen-free Extract.	Crude Fat.	Amides.
Second crop, 1897.						
1st cutting; buds formed	8.54	20.12	28.47	37.88	4.99	3.73
2nd " blossom one-third out	7.09	15.54	31.57	42.90	2.89	4.52
3rd " a little past full bloom	6.23	13.79	40.46	37.54	1.99	2.88
First crop, 1898.						
1st cutting; buds formed	9.73	20.45	29.98	35.90	3.93	4.94
2nd " blossom one-third out	6.92	14.72	31.16	40.84	4.36	3.59
3rd " a little past full bloom	7.12	13.59	36.75	39.44	3.15	3.53
Second crop, 1898.						
1st cutting; buds formed	7.52	16.77	26.10	45.84	3.77	4.39
2nd " blossom one-third out	7.73	16.32	31.46	41.21	3.28	4.62
3rd " a little past full bloom	7.68	14.30	35.81	39.52	2.69	3.56
Averages of above.						
1st cutting	8.59	19.11	28.18	38.89	4.23	4.35
2nd cutting	7.24	15.52	32.06	41.67	3.51	4.24
3rd cutting	7.01	13.89	37.67	38.82	2.61	3.32
Averages of some American analysis of 1st and 2nd crops cut at similar stages of maturity.						
Buds formed	11.63	18.46	27.56	39.36	3.06	4.09
Medium bloom	9.60	15.44	33.58	39.08	2.40	2.23
Full bloom	8.35	13.12	37.64	39.36	1.94	1.86

* Fuller table of analysis will be found in the Chemical Department of the Ontario Agricultural College Report for 1898.

(c) *Explanation of terms.*—*Ash* is the part of the fodder which remains unconsumed by burning to whiteness at the lowest possible red heat. It is essential to the formation of bone. *Crude protein* is the muscle formers collectively, which includes both the albuminoids and amides. As protein is the most expensive part of a cattle food, a large amount of it in a fodder it desirable. *Amides* appear to be an imature form of albuminoids and are not, capable of performing all the functions of the latter. As a plant matures, they are converted into albuminoids. *Crude Fat* is that part which is soluble in ether, and consists of a mixture of oils, wax, coloring matters, etc. Linseed oil is a common example. *Crude Fibre* is the woody portion of a fodder. It is the part that is most indigestible and therefore of the least value. *Nitrogen Free-Extract* is a mixture of substances commonly called carbohydrates. Starch and sugar are good examples.

Need of Determining the Digestibility.

It will be noticed that there is a marked similarity in the composition of the various cuttings of the different crops. The average composition of these cuttings will be found in the table; also, the averages of some American analysis of first and second crops which had been cut at different stages of maturity very similar to our own. It is interesting to note the similarity in composition of these two sets of averages. The table shows clearly that the per cent. of crude protein decreases, and that the crude fibre increases very rapidly. Since the other constituents are fairly constant in composition, the decrease and increase of the protein and fibre respectively affect to a very large extent the value of a fodder. As a plant matures, then, its most valuable constituent (protein) is decreasing in percentage while the most worthless part (crude fibre) is increasing very rapidly. This naturally leads to the conclusion that the earlier a crop is cut, the better it is for use as a fodder. It must not be forgotten, however, that up to a certain stage in the growth of a plant it increases in weight and consequently, while the percentage of crude protein decreases, the absolute amount may increase; also, that, as maturity advances, the protein becomes more valuable, as the amount of amides decreases. At the same time, crude fibre is increasing both relatively and absolutely. This is shown very clearly in the following table:

Table Showing the Increase or Decrease in the Amounts of Crude Protein and Crude Fibre.

Second crop 1897	Pounds of dry matter per acre.	Per cent. of crude protein.	Absolute amount of crude protein.	Per cent. of crude. fibre.	Absolute amount of crude fibre.
First cutting	3,197	20.12	643.2	28.47	910.2
Second cutting	3,819	15.54	593.5	31.57	1,205.6
Third cutting	3,317	13.79	457.4	40.46	1,342.1
First crop 1898					
First cutting	3,045	20.45	622.7	29 98	912.9
Second cutting	4,251	14.72	625.7	33.16	1,409.6
Third cutting	3,894	13.59	529.2	36.75	1,431.4
Second crop 1898					
First cutting	1,899	16.77	318.5	26.10	495.6
Second cutting	2,505	16.32	409.5	31.46	788.1
Third cutting	2,214	14.30	236.6	35.81	792.8

It will be noticed that in two cases the absolute amount of crude protein increases with the second cutting and that in one case it decreases slightly, but that in every instance there is a decrease with the third cutting. The absolute amount of crude fibre increases with each successive cutting, although the total dry matter shows a marked decrease in the third cutting. It is evident from the above figures that the second cutting of each crop yielded the largest amount of dry matter and that here too, in two cases out of three, we obtained the largest amount of *crude protein.* But the crude fibre has increased so rapidly that in order to decide whether the crop has actually increased in food value or not, it is necessary to determine the digestibility of the constituents of the various cuttings ; for it is only the part of the food which is digested that has any nutritive value.

Digestibility of Lucerne as Affected by the Stage of Maturity.

While the determination of the digestibility of the constituents of a fodder by an animal may seem to be comparatively simple, it is surrounded by many difficulties, which make the work tedious and tend to make the results somewhat uncertain. Consequently the work requires to be done a number of times before anything like reliable results can be obtained. We have now made in all seven tests with each of the three different cuttings.

Differences in age, breed and species of ruminants make comparatively slight differences in the proportions they digest from any given material. The seventh annual report of the Storr's Agricultural Experiment Station, Connecticut, has the following : "The results of digestion experiments in Germany warrant the following general conclusions upon the influence of species, breed, etc., upon digestibility of feeding stuffs.

a. Influence of kind of Animal.—All ruminants, such as cows, oxen, sheep and goats, seem to digest practically the same amount of protein, fat, nitrogen-free extract and fibre from the same kind of food. In general, horses digest less of the food constituents than do ruminants. This is especially true of the fibre and fat in the hays and grasses.

b. Influence of Breed.—The influence of breed upon digestibility has been studied with sheep, but no difference due to breed have been found. In general, it is probably true that different breeds of animals of the same species digest practically the same amounts of nutrients of the same foods.

c. Influence of Individual.—Individual differences have always been observed. The variation is quite wide ; and, on this account, the results from the influences of kinds and breeds of animals are somewhat obscured, variations in the amounts digested by different individual animals of the same species and breed being wider than most variations in different species.

d. Influence of Age.—The few experiments conducted (principally with sheep) indicate very little difference, if any, due to age.

From the above it will be seen that the digestibility of a fodder by a sheep can be taken as a tolerably correct measure of its digestibility by a cow or steer. In our work, sheep have been used, because they are much more easily experimented with than larger animals.

Last year but one sheep was fed on each of the cuttings of lucerne ; this year the experiment was made in triplicate, with three shearling wethers that followed through in succession the three different cuttings of each crop. The

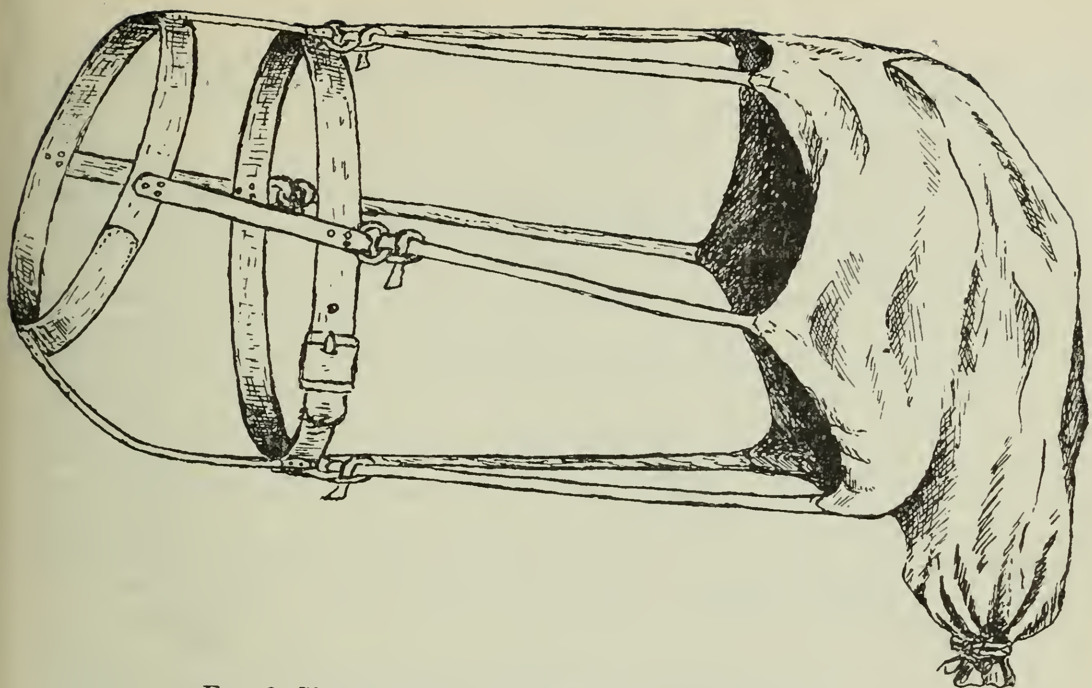


Fig. 6. Showing harness and bag used in collecting fæces.

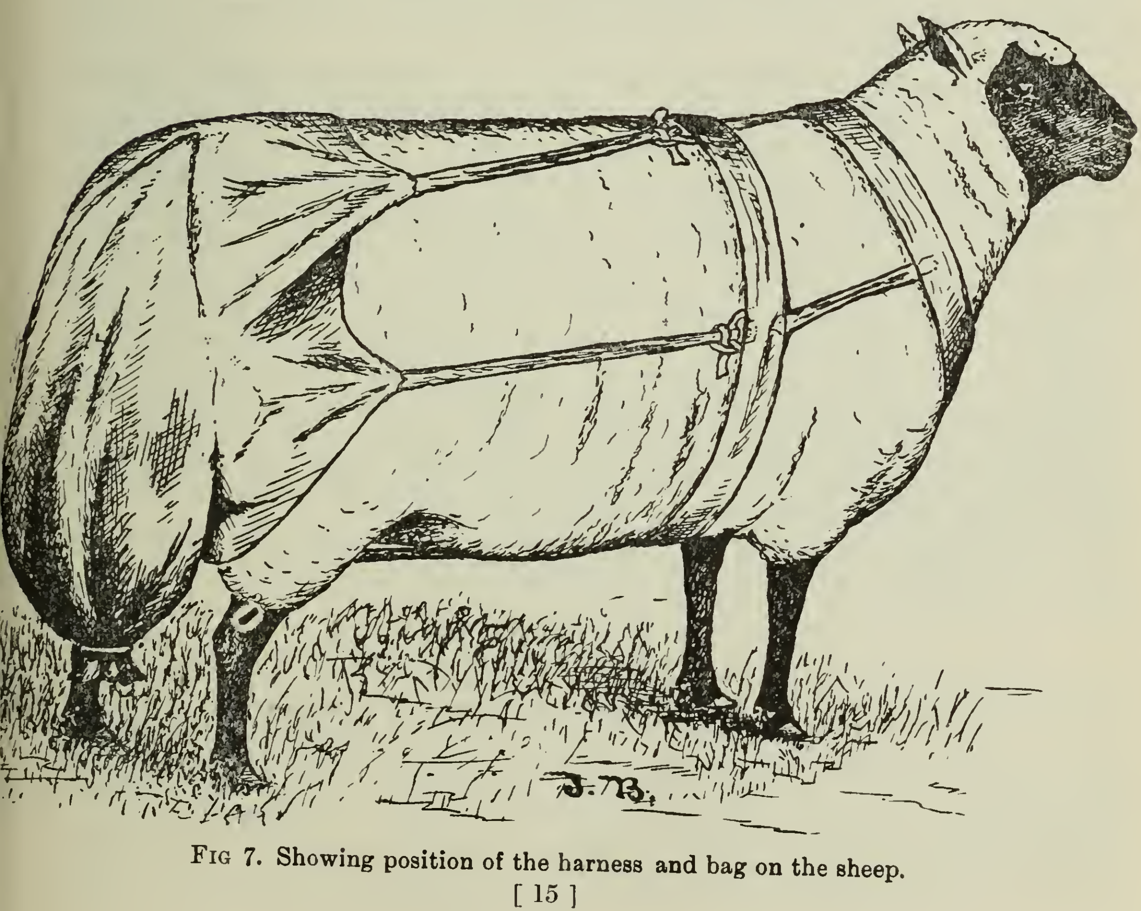


Fig 7. Showing position of the harness and bag on the sheep.

last cuttings of the two crops were purposely fed one after the other to see what effect they would have upon the digestive system of the animals, with the result that was previously mentioned.

e. Plan of Experiments.—A digestion experiment is usually conducted as follows: Healthy animals in the prime of life are fed a weighed amount of food of known composition, and in such a way as to prevent any possible waste. The undigested residues, which forms the solid excrement of the animal, is received directly into an appropriate bag attached to the animal. The excrement is dried, weighed and a representative sample ground and analysed. From the weight of the fodder fed and its percentage composition the weight of each constituent fed can be calculated. In like manner, from the weight of the dried excrement and its percentage composition, the weight of each constituent in the excrement can be determined. The difference between these two gives the amount of each nutrient which has been digested and resorbed during the passage of the food through the alimentary canal. The urine, containing solid bodies representing the waste of the animal organism, does not require to be analysed for the simple control of the digestive activities outlined above.

In this year's work each animal was placed in a pen which was about four feet square. The manger was arranged on the outside of the pen, with stanchions on the inside in which the animal's head was placed while feeding, thus effectually preventing any loss of food by scattering. No more of the fodder was fed than the animal would eat up without a particle of waste. A rubber-lined bag for collecting the fæces was attached to the animal by means of a suitable harness.

Each experiment lasted thirteen days and was divided into two parts. The first seven days were given to preliminary feeding, so that all traces of previous food might be removed from the system; the next six days formed the experiment proper, during which the solid excrement was carefully collected, being removed from the bags twice a day and placed on the drying pan. The results of this work will be found in the following table, which gives the number of pounds of each constituent digested, for every 100 pounds fed. For example: From 100 lbs. of protein fed 73.4 lbs. were digested in the first cutting, 72.8 in the second, and 64.4 in the third. These figures are what are known as digestion co-efficients, or the percentage digestibility of the constituents of the fodder. Each of the results in the table represents the average of seven digestion experiments; one of which was conducted with the second crop of lucerne in 1897, three with the first crop of lucerne in 1898, and three with the second crop of 1898.

f. Results of Experiment.—Digestion co-efficients, or the number of pounds digested out of every 100 lbs. of each constituent fed.

AVERAGE OF THE SEVERAL CUTTINGS.

——	Dry Matter.	Crude Protein.	Crude Fat.	Nitrogen free Extract.	Crude Fibre.
First cutting	58.6	73.4	48.8	71.8	30.1
Second cutting	56.2	72.8	50.4	70.1	37.7
Third cutting	51.3	64.4	44.1	64.0	37.1

From the above figures, it will be noticed that there is a gradual decrease in the digestibility of the hay as the growth advances. The deterioration appears to be more rapid during the period between the second and third cutting than during that between the first and second; or, in other words, there is a more rapid decrease in digestibility after the early blossoming stage than previous to that. Apparently the younger the plant, the richer it is in valuable constituents and the more digestible are these constituents. But, as has been pointed out, as the plant matures the absolute amount of these constituents increases. Therefore, when a crop is cut for hay, the object should be to cut at such a stage of maturity that the largest possible amount of the valuable constituents can be got without too great a decrease in digestibility. It has been shown that in every case the largest yield per acre of dry matter was obtained at the time of second cutting, or when the plants were about one-third in blossom. It has also been shown that after this period there is a more rapid decrease in digestibility. Hence it would appear that this is about the time when there is the largest amount of digestible nutrients present. This is borne out by the table given below.

Table showing the amount of digestible matter, calculated to the yield per acre, of the several cuttings of the different crops :

——	Dry Matter. Lbs.	Digestion Co-efficient.	Digestible Matter. Lbs.
Second crop, 1897 :			
First cutting, buds formed..........	3,197	58.6	1,873
Second cutting, blossom one-third out...	3,819	56.2	2,146
Third cutting, a little past full bloom....	3,317	51.3	1,701
First crop, 1898 :			
First cutting, buds formed	3,045	58.6	1,784
Second cutting, blossom one-third out....	4,2[illegible]1	56 2	2,389
Third cutting, a little past full bloom....	3,894	51.3	1,997
Second crop, 1898 :			
First cutting, buds formed..............	1,899	58.6	1,112
Second cutting, blossom one-third out.. .	2,505	56.2	1,407
Third cutting, a little past full bloom....	2,214	51.3	1,135

The above figures show clearly that in our work the largest amount of digestible matter was obtained at the time of the second cutting, or when the growing crop was about one-third in blossom. As the different cuttings were made two weeks apart, it is possible that a larger amount of digestible matter would have been obtained a little earlier or a little later than the period mentioned. All that we can say is that according to the results of our work the crop should be cut when *about* one-third in blossom.

There is a marked decrease in the digestible matter in the two weeks between the second and third cuttings. Taking an average of the three different crops, we find that this decrease amounts to 18.8 per cent, or very nearly one-fifth, of the digestible matter of the second cutting. Because of this rapid decrease in food value, also because of the rapidity with which the new crop comes on when the old one is removed, and because of the danger in allowing stock to eat the fodder when the plant becomes hard and woody, lucerne, whether in the pasture field or in the hay field, should not be allowed to stand later than the early blossoming stage.

Comparison of the Feeding Value of Lucerne, Red Clover, and Timothy.

It is interesting to compare the composition of lucerne hay with that of red clover and timothy, each crop being cut at the time when it apparently yields the maximum amount of digestible matter. The following table gives the percentage composition of the hays all figured to the same per cent of water, and the calculated amounts of the several constituents digested per ton of the hay fed.

Percentage Composition of Lucerne, Red Clover and Timothy Hay.

——	Water	Dry Matter	Protein	Fat	Nitrogen free Extract	Fibre	Ash
Lucerne	15.00	85.00	13.20	2.98	35.42	27 25	6.15
Red Clover	15.00	85.00	11.47	2.04	41.31	23.63	6.55
Timothy	15.00	85 00	6.03	1.70	45 22	28 31	3.72
Amounts digested per ton of hay fed.							
Lucerne	....	955.40	192.19	30 04	496.58	205.46	....
Red Clover	....	974.95	141 03	29.38	587.42	209.36	....
Timothy	....	920 21	48.67	16.15	528.44	306.88	....

According to the above figures, the clover hay contains the most digestible matter; but one ton of lucerne hay will contain about one-third more digestible protein than the same weight of clover hay, and nearly four times as much as a ton of timothy hay. In digestible nitrogen-free-extract and crude fibre it is lower than either of the other two.

R. Warrington, F. R S., in his book on "The Chemistry of the Farm." has the following on the comparative nutritive value of different foods: "The only basis on which the nutritive value of foods of different composition can be compared is in respect to their capacity for producing heat. The production of heat and mechanical work is the principal result which food accomplishes in the animal body; the capacity for producing heat is also intimately related to the capacity for producing fat. On the other hand, the amount of heat which any food is capable of producing stands in no relation to its power of increasing or renewing the nitrogenous tissues of the body. We may, however, safely assert that the amount of heat generated by the combustion of the digestible constituents of any food will be a fair guide to its nutritive value, when the diet of which it forms a part supplies a sufficient amount of digestible albunimoids, and this will be the case whenever foods are skillfully employed." If, then, these three fodders be compared upon the basis of their ability to produce heat or energy, they will bear the following relationship to one another:—Red Clover 100, Lucerne 91, and Timothy 86. If, however, allowance be made for the large amount of protein or flesh-producing material, in the lucerne, it will easily rank first as a food for young and growing stock. As has been stated, lucerne usually gives larger returns per acre than either red clover or timothy; and when this is considered along with the above facts regarding its nutritive value, it will be obvious that lucerne will be a valuable addition to our list of fodder crops.

Conclusions

The foregoing results lead us to the following conclusions:

I. That the composition of lucerne is very similar to that of the clovers, both in food and in ash constituents.

II. That it is quite as digestible as red clover or timothy, when cut at the proper stage of maturity.

III. That, in our experiments, a much larger amount of digestible matter was obtained by cutting when the plants were about one-third in blossom than by cutting either two weeks earlier or two weeks later.

IV. That after the early blossoming stage the deterioration, both in percentage composition and in digestibility, is very rapid.

V. That, cut when about one third in blossom, lucerne yields more digestible protein than either red clover or timothy.

VI. That there appears to be danger in feeding lucerne hay that has been made from the plant in advanced stages of maturity.

VII. That, notwithstanding the rapidity with which lucerne deteriorates after passing the early blossoming stage, the fact that, when properly saved, it yields a large amount of nutritious food, makes it a most desirable addition to our list of fodders.

APPENDIX.

At the time this bulletin was completed, the attention of the department was drawn to the fact that one farmer had just lost two valuable cows while pasturing on lucerne. Therefore, before allowing the bulletin to go to press, it was thought advisable to ascertain whether many other farmers had had similar experience. Accordingly a circular letter was prepared and sent to a number of farmers of our own province who have grown lucerne for sometime, and to the Directors of a large number of American Experiment Stations, asking them what had been their experiences with lucerne as a pasture crop, as a soiling crop, and a hay crop While every one who had used lucerne as a soiling crop reported very much in its favor, comparatively few had used it for hay or pasture, and, consequently could not report definitely under either of these heads. However, those who had had experience with lucerne as hay or pasture liked it very much, and reported no more trouble from pasturing it than from pasturing rank growing clover, provided the same precautions were taken.

Acknowledgements.

I desire gratefully to acknowledge the assistance received from the Experimental Department in the work of this bulletin. I also wish to state that, with the kind permission of Dr. W. P. Headden, A.M., Ph. D., chief chemist of the Colorado Agricultural Experiment Station, Figures 4 and 5 have been reproduced from bulletin No. 35 of that station.

ONTARIO DEPARTMENT OF AGRICULTURE.

BULLETIN 112. Toronto, December, 1900.

AGRICULTURAL COLLEGE AND EXPERIMENTAL FARM.

FOUL BROOD OF BEES.

By F. C. Harrison, Professor of Bacteriology.

Historical Resumé.

In all probability the first definite reference to foul brood is by Aristotle (1), who mentions an inertness which seizes the bees, and causes a bad smell in the hive. He also suggests that bees are liable to become diseased when the flowers on which they work are attacked by blight. Bee dysentery causes a bad odor as well as foul brood; but in the former disease the spotting and consequent smell are usually outside the hive.

Columella (2) mentions a bee pestilence and an annual distemper which seizes the bees in spring. Pliny (3) writes of a disease of bees, but as he uses the same term as Aristotle he has probably copied it from the latter author.

Schirach (4) in 1769 was the first writer to name the disease "Foul Brood." He says that "it is dangerous and a most destructive disorder to the bees, a genuine plague when the complaint has reached a certain stage. The cause can be attributed to two sources—1. The putrid (or tainted) food with which the bees feed the larvæ for lack of having better. 2. By the mistake of the queen bee, in misplacing the larvæ in their cells, head upside down. In this position the young bee, unable to get out of its prison, dies and rots away." Further, Schirach clearly distinguishes between foul brood and chilled brood, and mentions the fact, that putrefaction follows the death of the brood from frost, but in this case "it is only an accident and not a disease."

The remedy Schirach recommended was to remove all diseased combs from the infected hives and to keep the bees fasting for two days, after which they are furnished with other cakes of wax, and a suitable remedy given, "as a little hot water mixed with honey, nutmeg and saffron, or a syrup composed of equal parts of sugar and wine, seasoned with nutmeg." Thus, as Cowan (5) remarks "we had given us nearly 130 years ago, a method of cure almost identical with what is by some claimed as new to-day."

Tessier (6) about the same time as Schirach, says, that when the larvæ die in their cells it causes an infection in the hive which makes the bees sick. It is then necessary to drive away or sometimes move the bees from the hive, and to take care to fumigate the infected hive if it is going to be used again. It is necessary, in order to avoid the same inconvenience, to take out the parts of the comb that may be moulded by reason of the dampness. Duchet (7), who wrote on bees in 1771, does not mention any disease that can be certified as foul brood, but he describes bee dysentery.

Della Rocca (8), Vicaire-General of Syra, an island in the Levant, relates with much detail the history of an epidemic of foul brood, which caused great destruction in the island during the years 1777 to 1780. Della Rocca describes very minutely the symptoms, destruction and mistakes that were made in attempting to combat the disease. "The disease," he says, "manifests its presence by defects in the combs filled with brood, and which only contain a putrid mass ; instead of the bee pupæ there is only rottenness in the cells, which, however, being capped always preserve a healthy appearance. If these cells are broken open, a blackish liquid flows out, which spreads the infection through the hive. This disease only manifests itself in cells which contain a nearly mature larva or a capped one. The bees themselves remain in good health, and work with the same activity, but their numbers decrease daily. This disease, however, was not so general in a hive but that a small portion escaped ; some new bees emerged, but in too small numbers to supply the daily losses Thus a hive attacked by this scourge will perish from scarcity of population. At first it was not noticed that this disease was epidemic, and the hives emptied by death of the bees, were filled with fresh swarms, and these contracted the same disease and perished. Yet another mistake was made. The remains of the hives that were lost were taken into the streets of the town to expose them to the sun, in order to extract all the wax, and the bees from the neighborhood sucked up the honey, caught the disease, and communicated it to other hives, and all, without exception perished in a short time. The epidemic, having reached the island, spread everywhere and the mortality among the bees was general, either from eating infected honey, or from stopping up the infected combs, or from the bees nourishing their brood on infected honey." Della Rocca criticizes Schirach's statement regarding the misplacement of the larvæ by the queen as a cause of the disease, because "everybody knows that the queen has nothing else to do but deposit eggs. These are then cared for and nourished by the bees, and when the larva is nearly ready to change into the pupa, the bees close the cell, and every position which is given the larva depends on their good pleasure and not on the queen's." Della Rocca himself thinks that "some pestilential blight had without doubt corrupted the quality of the honey and the dust from the authers," and recommends "burning everything without pity, as there is no other resource when the disease is well established, as the pest is without doubt the most terrible in the natural history of bees."

Neither Wildman (9), Keys (10), Woolridge, Needham (11), Rhein, Reaumur (12), or other authors about the same time (latter end of the 18th century) mention this disease.

Bevan (13) names the disease "Pestilence," and also quotes Schirach's name "Foul Brood," and says regarding it, that the "Pestilence has been attributed to the residence of dead larvæ in the cells, from a careless deposition of ova by the queen . . . it has also been attributed to cold and bad nursing, that is, feeding with unwholesome food."

Nothing further of note appears in bee literature till the year 1860, when Dr. Leuckhart (14) writes that he was formerly of the opinion that foul brood was caused by the same fungus (*Panhistophyton ovatum*) which is noticed in a disease of the silk worm, but now after observation and experiment, is quite certain that the disease is caused by neither vegetable nor animal parasite. He also notes that the term "foul brood" is applied to a number of diseases affecting bees.

Molitor Mühlfeld (15) recognizes two forms, one contagious and the other not contagious, and thinks that the only cause of contagious foul brood is a fly (*Ichneumon apium mellificarium*) which lays its eggs on the young larvae of the bee.

A discovery of note was Preuss's (16) in 1868. He contradicts Mühlfeld's statement about the fly, and states that foul brood cells can be detected by the sunken cap. With a microscope magnifying 600 diameters, he found small dust like bodies with a diameter of $\frac{1}{500}$ m. m. belonging to the genus *Cryptococcus* (Kutzig) and called the specific form *alvearis*, likened it to the fermentation fungus (*Cryptococcus fermentum*) and thought that the last germ gained access to the young bee and changed to *Cryptococcus alvearis.* He notices that many experts lay the cause of the disease to fermenting food but the larvae are easily contaminated by the fermentation fungus which is always present in the air. He also mentions the enormous rapidity with which the fungus multiplies and gives an elaborate calculation of the number that might be found in a cell containing a deceased larva

As might have been expected, Preuss's statement aroused considerable discussion at the meeting of German bee-keepers, a short while after the publication of his paper.

Vogel (17) expressed doubt as to whether *C. alvearis* was the real cause of foul brood or only a consequence of the disease, but on the whole agreed with Preuss.

Wiegand (17) agreed with Preuss's theory, and in giving his experi ence said that the disease was introduced into his apiary through honey brought from a distance.

Pollman (17) believed that the disease was introduced by feeding honey from Havanna, where, when extracting the honey, both brood and honeycomb were mashed up and the honey pressed out.

Dr. Leuckhart (17) agreed with those who thought the disease due to a fungus, but discredited the supposition that it was the same as the fermentation fungus mentioned by Preuss, and rather thought it was related to the silk worm fungus and that most of the brood diseases ending in death were called "foul brood" while they were really something else. He believed that the fungus was present in the eggs of the queen when laid.

Geilen (17) believed that the disease came from the putrefying remains of animal bodies, upon which the bees alighted.

Mühlfeld (18) again in 1869, presented his former views, and also those of Preuss's and gave directions for maintaining the health of bees. He recommended the boiling of the honey, and a use of carbolic acid in the strength of 1:100 or permanganate of potash 1:300 as disinfectants.

Lambrecht (19) thought that foul brood was caused by the fermentation of the bee bread.

Hallier (19) considered it no specific disease, but thought it was probably produced by different fungi.

Cornallia (20) proved contrary to the above and found a fungus, which he thought developed foul brood. He called it *Cryptococcus alveaxis* and used carbolic acid, potassium permag , and lime water as disinfectants.

Fisher (21) advanced a new foul brood theory in 1871, which somewhat follows the view of Liebeg regarding the silk worm disease and plant diseases. According to this theory, the predisposing cause was insufficient nourishment, especially short stores for winter and spring. Shortage of pollen supply was the next cause. Fisher tried to prove his views by the practical experience of bee keepers and explained that the first result of repeated and continued feeding was an increase in the production of bees ; and a consequent disproportion between brood and brood feeders arose, which should be looked upon as another cause of foul brood. The disease, he said, might be lessened or exterminated by applying means to reduce the production of brood, as the removing of the queen and the area which the brood occupied. Foul brood is probably the cause of a quantitative dearth of nourishment and a consequent degeneration of the bees. The appearance of fungous growths was only a secondary matter.

Schonfeld (22) infected several hives with foul brood and when it had fully developed he took a comb of the rotten brood to the Physiological Institute at Breslau, and had it submitted to a microscopical examination by Drs. Cohn and Eidam (22). This examination showed that in every dead larva, and in each foul broody cell, whether the contents were yet white and fluid or brown, tenacious and ropy, there were to be found long oval bodies, which Preuss called "micro-cocci." "Close to and among them, Cohn was the first "to find, with the most powerful of the five microscopes that were used, a "countless number of slender pale rods, joined together, and which he at once "identified as bacteria of the genus *bacillus*. The length of a single rod was "about 6 micromillimetres, but many of them were two and three jointed, so "that these foul brood bacteria microscopically resembled the anthrax bacteria, "though of course they were different physiologically and in the manner in "which they acted as ferments"

It is not surprising when we remember the state of bacteriological knowledge in 1870, that Preuss should have mistaken micrococci for the spores of a bacillus. In 1885, Cheshire & W. Cheyne (23) confirmed Cohn's conclusions and demonstrated that the disease, foul brood, was caused by a bacillus to which they gave the name of *Bacillus alvei*; and they worked out the following requirements of the causal relation of this bacillus to the disease, usually spoken of as Koch's rules:

1. Constant association of this germ (*B. alvei*) with the disease in the larvae of bees.
2. Isolation of the germ from the diseased larvae, and study of the same in pure cultures on various media
3. Production of the characteristic symptoms of the disease by inoculation of pure cultures.
4. Discovery of the same germ in the re infected larvae. Re-isolation and growth on various media, comparable to that previously isolated.

The infection brought about by Cheshire was accomplished by spraying a particular part of the comb with a culture of *B. alvei* in milk. This part and no other became affected with foul brood. Adult bees were also infected by feeding them with these cultivated bacilli. The experiments of Cheshire and Cheyne convinced everyone, and since that date *B. alvei* has been generally regarded as the causal agent in the production of this disease.

Dickel (24) wrote in 1888 that several species of bacilli were able to produce foul brood. There was one form of the disease which affected the unsealed brood, and another which affected the sealed brood; and even a third, a mixed form, which seemed to be most malignant.

Klamann (25) supported Dickel's researches, but stated that it was not necessary to count more than two kinds of the disease, as there were certainly several other microbes which contributed to the ruin of the hive. Klamann stated that he found seven and was persuaded that he would be able to isolate an even greater number of bacteria from the diseased larvae. It seemed to him certain that *B. alvei* was the most virulent, and that this germ alone was to be considered the cause of foul brood.

Symptoms of the Disease.

The disease principally affects the larvae. In a healthy comb the young larvae lie at the bottom of the cells, curled up in the shape of the letter C and in color are of a pure pearly whiteness, plump in appearance, with full skin. If examined when the disease is just developing, the affected larvae are usually found to have changed their position. They are no longer curled up, but lie extended in the cell, or move about unnaturally. The bees themselves may at this time or subsequently show symptoms of the disease by a kind of inertness or inactivity which seizes them. As the disease progresses, the young larvae lose their plump appearance, become flabby and die. Then a process of decomposition begins, which is shown by their yellowish appearance. This yellow color turns brown, and if touched with a pin or needle at this time or later, a portion of the putrid mass may be pulled out in a long, ropy, tenacious string, due "to the chitinous aerating sacs and tracheae which do not undergo decomposition at all; and these remaining cause the peculiarity referred to" (26). This ropy mass gradually dries down to the bottom of the cell, leaving nothing but a brown scale which adheres to the wax.

As a rule, the bees do not remove larvae dead from this disease. Instead they become quite inactive, lose their desire to fly, are often seen fanning at the entrance of the hive, which in many cases emits a bad smell. A phase of the disease, which some authors have described as being a different form, is that in which the larvae die after the cells have been capped over. These cappings become darker in colour than those of the healthy brood; then become indented or sunken, and lastly become perforated with irregular holes. By putting a needle into any of these cells the same ropy mass, before described, may be drawn out. If an examination is made from the juice of the larvae at different stages of the disease, the bacillus may be detected; but spores do not form till after death has occurred. The ropy mass contains large numbers of spores, as does also the dry scale.

According to Cheshire (26), the bees themselves become diseased. In a number of cases he obtained the bacillus from the blood of bees from infected hives. Hilbert's examination in 1875 led him to declare that the mature bees in infected hives were liable to be affected. Some writers contradict the statement that the bees themselves are affected by the disease; but they lose sight of the fact that the bees do not die in the hive, but leave it sometime before death occurs.

The queen may become infected. Cheshire (26) demonstrated the presence of bacilli in the ovary of a queen; but he did not make cultures therefrom. W. G. Smith (27) reported that a queen sent to Cheshire and examined by him contained *B. alvei* in both of her ovaries. McKenzie (28) examined five queens from infected hives and succeeded in obtaining bacilli from the ovaries of three. He thinks that their presence there is accidental, as in the case of a queen from a badly diseased hive he was unable to find the bacillus, whilst in a six weeks old queen from a hive in which there were only a few diseased cells, he succeeded in finding it. A queen sent by T. A. Govan (29) to Cowan, the editor of the British Bee Journal, was examined, and *B. alvei* was found in the ovaries. F. F. Ward (30) removed a queen from a diseased hive and placed her in a strong, healthy stock, "which speedily became a mass of corruption." This operation was subsequently repeated with a like result.

I have also myself examined seven queens from diseased hives, and in three cases have had no difficulty in finding the bacillus, and have obtained typical cultures therefrom. The method of examination employed has been the same as that used by McKenzie. The upper surface of the bee is sterilized and cut longtitudinally, and all the internal organs except the ovaries are removed. The surface of the ovaries is then sterilized and a hot needle plunged into the centre and allowed to stay there until it is cold, when it is withdrawn and used to inoculate agar cultures. According to Cheshire (26) the bacilli are found in the eggs. In one examination he says he counted nine bacilli from a half-developed egg taken from the ovary of a queen. McKenzie (28) thinks that this statement requires confirmation, as he was not able to find any infected eggs.

I have myself examined a very large number of eggs at various times. In these examinations three different methods were employed: 1.—The eggs were taken from the cells in which they were laid with sterilized forceps and washed in corrosive sublimate, 1 : 500 crushed and placed on agar plates. In many cases typical growths of *B alvei* developed from eggs thus treated; but as it might be maintained that the eggs were laid in cells previously infected with *B. alvei*, and that the momentary immersion in corrosive sublimate failed to kill all the spores that were upon the exterior, the next lot of eggs 2.—Were crushed between cover-glasses, a small portion transferred into agar, and the remainder on the cover-glass stained by Gram's method. In several instances the bacillus was found in the crushed egg, and in every case the cultural test confirmed the microscopical examination. Again, as this method also might be criticized for the reasons above stated—(3) eggs were imbedded in parraffin and serial sections made and stained by Gram's method No cultural tests were made; but in a few eggs of several hundreds sectioned a bacillus corresponding in its morphological characteristics to *B. alvei* was found. All the eggs examined were taken from hives more or less affected with the disease.

In view of these facts, I am of the opinion that the eggs of bees from diseased hives may in some instances be infected.

Chilled Brood.

Chilled brood is sometimes mistaken for foul brood; but the appearance of the former is very different from that of the latter. In the case of chilled brood the larvae turn grey; afterwards the colour darkens, and in the final stages of decomposition it becomes black. No ropiness develops.

A number of writers in various bee periodicals have mistaken chilled brood for foul brood, or they have stated that chilled brood turns to foul brood; but Schirach, as long ago as 1769, clearly distinguished between the two, and McKenzie (28) also performed several experiments in refutation of the statement that if chilled brood is allowed to putrify foul brood may arise *de novo*. He endeavoured to isolate *B. alvei* from chilled brood, but without success. Again, he killed perfectly healthy brood by chilling, and infected some of the cells from a pure culture of *B. alvei*. The chilled brood were allowed to putrify in a moist chamber for several months and examined with the same results, viz: that in the cells in which *B. alvei* was placed it was to be found, but not in any others I have also performed similar experiments and they fully confirm McKenzie's contention. So far *B. alvei* has not been isolated from chilled brood in any stage of decomposition. Canestrini (31) described a case which was in all probability chilled brood and not an infectious malady; but his inoculation experiments failed to establish the pathogenicity of the bacillus, which morphologically resembled *B. megatherium*.

Geographical Distribution.

It has been thought that the disease varies in different countries, that foul brood as it occurs in England is different from foul brood in America; but as no bacteriological evidence has been produced in support of the contention, it is not necessary to argue the question. I have examined diseased larvæ from Canada, from Europe (France, Switzerland, Austria, Germany, Italy and England), Cuba, and 13 States of the Union, ranging from New York to California and from Michigan to Florida, and have succeeded in isolating *B. alvei* from all of them. It is true that some of the cultures show certain differences, but they have not been sufficiently pronounced to constitute even a well marked variety of the species. The pathogenicity of the bacillus no doubt varies in different countries; of that we have abundant evidence, and the possible explanation is given by Bertrand, who thinks that where bees have been kept for many years the disease has existed for a long time and remains in an endemic state; but there has been produced in these countries a race of bees which have acquired a relative immunity, which considerably diminishes the effects of the disease, and enables apiculturists to treat it more easily. In new countries into which the disease has been introduced it rages with great virulence, and remedies giving good results in the older countries are worthless in the new. As an example of this statement, we have the different methods of treatment used in Canada and in Europe.

Bertrand (32) reports the disease as being present in every country in Europe. Benton (33) says that he has never met with the disease during the six years he has kept bees in the Orient. Della Rocca (7) described a terrible epidemic in the Levant in 1780. Bovill (34) says that he has never seen it in Cyprus. In Africa, Feuillebois (35) reports it in Algeria, and Bochatey (81) in Tunis. In Australia it is present in all the colonies, and especially so in New South Wales (36) and South Australia (37). Brickwell (38) reports that New Zealand is full of the disease.

The Organism

Bacillus Alvei, Cheshire and W. Cheyne, 1885, from the larvæ of bees suffering from the disease known as foul brood, la loque (Fr.) and faul brut (Ger.).

Morphological Characteristics.—In form the organism is a slender bacillus, with ends slightly pointed and rounded. "In the larval juices it is about $\frac{1}{7,000}$ of an inch in length and $\frac{1}{20,500}$ in breadth. On agar the bacilli vary considerably in size, averaging $\frac{1}{7,260}$ inch, some as small as $\frac{1}{10,000}$ inch, and others as large as $\frac{1}{5,000}$ inch. When they have attained the latter size, division of the rod seems to begin. They are always somewhat pointed at their ends. Their average breadth is $\frac{1}{30,000}$ inch, ranging from $\frac{1}{35,000}$ to $\frac{1}{25,000}$ inch (23). Klamann (25) states that a clear space often appears in bacilli with pointed ends. From agar cultures 24 hours old, at 37° C., the bacilli average 4 μ in length and 1.0 μ in breadth. On gelatine cultures, grown at 22° C., they are somewhat shorter. They grow singly, but occasionally form chains of various length.

Stains.—With the ordinary aniline stains the bacilli colour rather badly—Eisenberg (39) and Klamann (25). The best stains are methelene blue and methyl violet. The bacilli accept Gram's stain, but the spores are not colored by it. I find the most satisfactory stain is methyl violet.

Capsule.—No capsule has been demonstrated by Welch's method.

Flagella.—The bacilli are actively motile and possess a single flagellum at one pole. The motility of the bacillus is quite pronounced in fresh cultures obtained from bouillon, agar and gelatine. The flagella stain by Pitfield's, Loefflers's and Van Ermegen's method.

Spore Formation.—Spores are formed by the bacillus, and are large oval bodies averaging in length $\frac{1}{12,000}$ inch, and in breadth $\frac{1}{23,700}$ of an inch. On agar the spores are arranged in long rows, side by side, and are greater in diameter than the cells from which they are derived. The earliest appearance of spore formation takes place in 41 hours, at 36° C. (Cheyne), but in some cases it is even sooner. The spores are formed in the centre of the rod, and the formation occurs as follows: The rod begins to swell and become spindle-shaped. Occasionally the swelling is more marked at one end than in the centre. The spindle-shape increases in size, and the centre of the swelling gradually ceases to take the stain. The capsule of the spore is apparently formed within the rod and is not merely the outer part of the rod. In three or four hours the rod is seen to have almost or completely disappeared, although parts of the faint outline of the ordinary bacillus may be noticed.

Germination of Spores.—Under favourable conditions the beginning of the germination of the spores takes place in about three hours. The spore loses its oval shape, becomes elongated, and is soon seen to burst through the spore capsule. It then presents the appearance of a short rod, with a pale envelope embracing one end. The rod gradually leaves the spore capsule, and then goes on multiplying as a full grown bacillus. According to Eisenberg (39), the spores are decolorized by the tubercle bacilli stain, but preparations may be obtained by using the Ziehl-Neilsen stain and alcohol for decolorization. The spores also stain by the method of Neisser.

Polymorphism.—Variations in size and shape may be brought about by growth in acid media, or in media containing different sugars. These variations occur also in the same culture, subjected to exactly similar conditions of growth.

Involution Forms.—Abnormal forms are especially abundant when the bacillus is grown on blood serum; peculiar Y-like forms and clubbed shapes are of common occurrence, and relatively few spores are found.

Biological Characters.

Bouillon.—"In meat infusion at the temperature of the body, they grow rapidly, causing muddiness and, after a few days, a slight but not tenacious scum" (23). In bouillon, with a reaction of +.08 (57), at 37° C., there is a slight turbidity in 14 hours, especially noticeable when the tube is shaken. In 24 hours, the liquid is uniformly turbid, with a very fine sediment. In 48 hours, the turbidity increases and a pellicle commences to form. Reaction of the culture at this time, +.07. After 96 hours the broth is clear, with a pellicle, white, rather massive, and somewhat tenacious. There is also much sediment. Reaction, after 10 days' growth,—neutral.

Glycerine Bouillon.—Media with original reaction of +.08. At 37° C., the bouillon becomes slightly turbid in 12 hours, and quite turbid in 24, with a fine, whitish pellicle on surface, which does not extend to the sides of the tube. If the culture is shaken, the pellicle deposits in flaky masses. The reaction is +1.2. In 36 hours, the turbidity clears, leaving the media bright, with a smooth, thin, tenacious, and white pellicle on the surface. In many cases the pellicle becomes very wrinkled and greasy-looking. At the end of 8 days, the reaction is +2.2, and the bouillon is several shades darker in colour, but quite clear. The reaction after 14 day's growth is +4.2. At 22° C. the same changes occur but growth is slower. The bacilli are relatively less numerous than in bouillon and are slightly shorter and thicker.

Glucose Bouillon.—With a reaction of +2.0, at 37° C., the broth is more turbid than plain bouillon after 14 hours' growth; and in 24 hours, the sediment is heavy, and turbidity very marked, but no pellicle. In 48 hours. the media is opaque and cloudy, and the pellicle is beginning to form. In 96 hours the broth is less cloudy, but the sediment is heavier, and a white, thick pellicle is formed. It is often wrinkled, but not quite so much so as that on the glycerine broth. Reaction of broth after 10 days' growth, +4.6. The bacilli are occasionally clubbed and y-like forms may occur. They average 5 μ in length and may be slightly curved.

Lactose Bouillon.—With a reaction of +1.06, at 37° C., the growth resembles that of plain bouillon for the first 24 hours; but at the end of 48 hours, it is more turbid. In 96 hours, a tenacious pellicle forms, less massive than that on Glucose broth. Reaction after 10 days' growth, +2.4. The bacilli average 3.5 μ in length.

Saccharose Bouillon.—With a reaction of +1.0, at 37° C., the turbidity and sediment are heavier than any of the other bouillons. In 48 hours the broth is quite opaque and whitish looking. A heavy sediment is then present and pellicle formation is just beginning. In 96 hours, the cloudiness is about the same, but there is an increase of sediment and the pellicle is thin and membranous. Reaction of media after 10 days' growth, + 4.04. The bacilli average 5 μ in length.

Gelatine Plates.—At 22° C. in 24-36 hours, the colonies are small, round, oval, or lozenge-shaped, with peculiar projections or shoots from one end of the colony, giving it a pear-shaped, or tadpole-like appearance, according to the amount of development of the projection. In many cases, several of these outgrowths occur from different portions of the colony. By placing a cover glass on the surface of the gelatine and using objective 7, the bacilli may be seen moving around and around the colony and to and fro along the projections. At the end of 48 hours, the colonies are larger. Fine processes or projections are shooting out into the gelatine in all directions, forming peculiar figures in circles or club-line forms. "It is impossible," says Cheyne, "to give a proper idea of the appearance of the growth. The forms assumed are the most beautifully shaped I have ever seen; but they are very numerous, always retaining the tendency to form curves and circles." After a time the gelatine is liquefied and the beautiful appearance of the colony is destroyed by the liquefaction of the gelatine.

These peculiar shaped colonies are most typical when the germ is taken from the diseased larvæ. After prolonged cultivation on various kinds of media, there is a tendency for the colonies to become round, and the peculiar branching forms are not seen in such numbers. The composition of the gelatine also seems to make a difference in the appearance of the colonies. In gelatine containing 12 per cent. gelatine the processes are not so long. The same effect may be brought about by using more peptone in the composition of the media.

Gelatine Tubes.—In stick cultures at 20° C. growth occurs all along the line of puncture. On the surface, delicate branching or ramifying growth occurs in three days. These outgrowths soon run together and the gelatine is liquefied, first around the line of puncture, and in 5 days extends over the whole surface. The growth in the depth of the gelatine occurs as a whitish streak all along the needle track; and from this, numerous shoots and growths branch out into the gelatine in all directions, giving a haziness to the appearance of the gelatine, which then begins to liquefy. If the inoculation is a heavy one, the shoots are coarse and may have club-shaped extremities, and from these swollen ends fresh shoots may start. Cheyne obtained the most characteristic growth in gelatine containing 3 per cent. of peptone, as well as 10 per cent. gelatine. The whole tube is liquefied in from 2-4 weeks' growth. The liquid becomes yellowish in color and gives off a peculiar odor. Klamaunn states that in gelatine acidified with lactic acid the growth is slow and long threads are formed.

Gelatine Streak Cultures.—In gelatine streak cultures the appearance is very similar to what one sees in stick cultures. The bacilli first grow along the line of inoculation; and then throw out shoots into the surrounding gelatine, producing the appearance noted in the stick culture. The bacilli move to and fro along the channels of liquefied gelatine.

Agar plates.—On agar plates at 37° C., the colonies at the end of eight hours are small and burr-like, with spines protruding in all directions, giving the colony the appearance of a sea-urchin. In some cases the projections are from one side or end. At the end of 12 hours, the colonies have well-defined projections, visible to the naked eye. The colonies in the depths of the agar are more spiny, the processes being much shorter. On agar plates streaked with a light inoculation, most beautiful forms occur. The growth of the bacilli spreads over the surface and branches repeatedly, giving the appearance of seaweed. This appearance is distinctively characteristic; and as the growth is very rapid, this method commends itself for making a quick diagnosis of the presence of the bacillus in larvæ supposed to be diseased.

Potato cultures.—On potatoes the growth differs considerably, according to the reaction and age of the potato. Sometimes a brownish wrinkled growth forms, which gives off a peculiar odor; at other times a dryish yellow layer appears. "The bacilli grow very slowly indeed at 20° C." (Cheyne 23.) Even at 37° C. they grow slowly.

Milk.—In milk at 37° C., coagulation of the casein occurs in three days. The milk becomes yellowish and gives off a characteristic odor. After several week's growth, the curd is digested and a whey-like fluid remains.

Blood serum.—On blood serum at 37° C, the growth is rather slow and polymorphic forms are common. "Very long filaments are formed" (23). These long forms may be from 5 to 10 times as long as the average bacillus growing on gelatine, and consist of single cells. The filaments are often wavy or twisted and of unequal thickness. The extremities of the long, bent rods are often clubbed; and y-forms are numerous. Spores are formed very sparingly, and the blood serum is liquefied.

Synthetic media (Uschinsky).—In Uschinsky's medium no growth occurs; but if the medium is neutralized, good growth ensues. The bacilli occur in threads and a pellicle is formed.

Dunham's Solution. The bacilli are small when grown in this solution; No threads form; but there is a slight indol reaction after nine days' growth.

Relation to Free Oxygen. Cheyne states that the germs grow most rapidly on the surface of agar and arrange themselves side by side; and they produce spores in this position after a few days' growth. Eisenberg (39) says nothing under the head of aerobiosis. Howard (40) writes that, "It grows best under anaerobic conditions; is a facultative aerobe; grows under the mica plate; and in the presence of oxygen the growth is slight and slow." Howard also states that under anaerobic conditions it emits a foul odour resembling that of foul brood. It will be thus seen that Cheyne and Howard do not agree on this point. The former author also says that the characteristic odour is given off under aerobic conditions, whilst Howard states that this smell is emitted under anaerobic conditions. Further, Cheyne states that the bacilli grow with great rapidity on the surface of agar, whereas

Howard obtains his best growth under the mica plate, which does not give complete anaerobiosis. Howard's conclusions are thus at variance with Cheyne's, and my own results fully corroborate those of the latter author.

Howard states that the vitality of the spores of *B. alvei* is destroyed when exposed to atmospheric air from 24 to 36 hours. In making his experiments he took sterilized road dust and mixed it with the dry foul brood masses from several cells which were previously dissolved is distilled water. The mixture was worked dry, and spread on sheets of paper, and trial cultures were made immediately and at intervals of every twelve hours for three days; and according to his results no growth occurred after 36 hours In giving these results, Howard does not state whether he exposed the spores to sunlight or diffused light; nor does he mention the age of the dry foul brood masses, which he used from several cells. These are points of considerable importance, for as everyone knows the disinfecting power of direct sunlight is much greater than diffused light, and the vitality of the spores from foul brood masses of different ages varies considerably. This, I may add, has been clearly shown by some of my experiments, subsequently described. In my experiments, the spores obtained from a pure culture on the surface of agar, were spread on cover glasses and placed in a glass chamber, so arranged that a current of air was constantly circulating over them. This chamber was exposed to the ordinary light of a room with six large windows, and a cover glass was taken out every 24 hours and tested, to see if the spores would grow. This experiment was continued for one month and at the end of that time the spores still germinated rapidly. In another experiment, spores spread on cover glasses were exposed to a very diffused light, simulating as far as possible the amount of light which would enter a hive. Cover glasses were taken out from time to time and transferred to agar, in order to ascertain if the spores were alive or not. The experiment was begun two years and four months ago and from the last cover glass taken and placed upon the surface of an agar plate a copious and typical growth of *B. alvei* was obtained. Further, thin strips of filter paper, plunged into a bouillon culture and allowed to dry, were threaded on a wire suspended in a wire basket and so exposed that the air could freely circulate around them in the ordinary light of a room. Trial cultures were made at intervals, and at the expiration of 6 months the spores from the paper germinated when the strips were placed on the surface of agar.

Again, a drop of bouillon containing spores was placed in a sterile tube and allowed to dry; and at the expiration of 124 hours (36 of which were in sunlight at a temperature varying from 30° 37° C) sterile bouillon was added. The tubes were then placed in the incubator, and in less than 24 hours a good growth of the germs had taken place.

From these experiments it will be seen that the results are directly at variance with Howard's statement, as they go to show that the vitality of the spores of *B. alvei* is not destroyed by exposure to atmospheric air, with or without sunlight, for even a much longer time than 24-36 hours.

With regard to the aerobiosis of this bacillus, good growth has been obtained in an atmosphere of hydrogen by Novy's method. Buchner's method also gave good results. The growths in the various media are very similar to those produced under aerobic conditions, but with this difference, that the surface growths are, as a rule, whiter in the hydrogen atmosphere. In illuminating gas (water gas) no growth occured; but the spores were not destroyed by the action of the gas; for when the gas was let out of the Novy jar, good growth ensued on all cultures. In acetylene gas, a restricted growth occurred. In fermentation tubes, growth occurred both in the open and in the closed arm of the tubes. No gas was formed, the bouillon in the closed arm was uniformly turbid. Thus *B. alvei* is a facultative anaerobe.

Production of Alkali In ordinary bouillon a slight amount of ammonia is formed. Control bouillon did not give the Nessler test. In glycerine and the sugar bouillons, there is no trace of ammonia. Cheyne's cultures are faintly alkaline, both before and after inoculation in meat infusion. Klamann states that ammonia is produced.

Acids formed A varying amount of acid is formed. All the sugar bouillons give an acid reacton.

Formation of Pigment. On potatoes, a yellowish growth is produced; on all other media, the surface growth is white.

Development of odours Cheyne states that gelatine cultures give off an odour of stale, but not ammoniacal urine, or what may be better described as a shrimpy smell; and this peculiar odour has been formed by Cheshire to be distinctive of diseased larvae. Klamann and Howard both state that a peculiar odour resembling that of the diseased larvae may be noticed in artificial cultures.

The Effects of Desiccation I have already noticed, under the head of "Relation to Free Oxygen," that the spores of *B. alvei* have considerable vitality in withstanding desiccation. My experiments prove conclusively that the spores are extremely hard to kill by desiccation and in this respect resemble those of authrax, which are known to resist thorough desiccation for a number of years. One experiment which shewed this characteristic was as follows: An agar plate completely covered with a typical growth of *B. alvei* was allowed to dry out completely, and was left exposed to the ordinary light of the room for 7 months, and at the end of that time, a portion of the film was scraped off with a knife, placed on suitable medium and incubated, with the result that a typical growth immediately ensued.

Spores on cover glasses were exposed to September sunlight (Latitude 43) for varying periods of time, and growth occurred after 4, 6 and 7 hour's exposure. The age of the spores varied from 5 days to 18 months; and spores 3 months old were not killed by 7 hours' exposure.

Thermal Relations.

Maximum for Growth. The maximum for growth is about 47°C. At 44°C., good growth occurs; but at 50°C., growth ceases. Experiments on maximum for growth were performed on germs isolated from a number of different places, and little or no difference was noticed in their behaviour when incubated at the temperatures mentioned.

Optimum for Growth. The optimum for growth is about 37.5°C. for all media except gelatine. This has been determined by Cheyne & Eisenberg (39). On gelatine the best results are, of course, obtained from higher temperatures; but as 10% gelatine melts at about 24°C., 22°C cannot be exceeded.

Minimum for Growth. Cheyne says that the bacilli do not grow below 16°C. I have, however, occasionally obtained growth at 14°C. on the surface of agar; but it has been extremely slow. The spores will not germinate at this temperature. No difference, under this head, is apparent in germs obtained from different countries.

Thermal Death Point. This is a very important matter, because in the heating of wax and honey from colonies suffering with foul brood, it is necessary to know the temperature that will destroy spores and thus prevent the infection of other bees; and unfortunately a considerable discrepancy exists in the results of experiments to determine the thermal death point of the bacillus, accounted for in part by the different methods used by different investigators.

McKenzie (28) found the thermal death point by suspending silk threads saturated in a beef broth culture of *B. alvei* containing spores. The threads were allowed to dry, and introduced into melted wax, and left therein for a definite time, at a fixed temperature. At the end of that time, the thread was introduced into melted agar and thoroughly shaken so as to separate the wax from the threads. The cultures thus made were rapidly cooled, and the tubes placed in the incubator at 37°C. The following are his results :

At 100°C.	for	$\frac{1}{4}$	of an hour,	growth.
“	“	$\frac{1}{2}$	“ “	growth.
“	“	1	hour,	growth.
“	“	$1\frac{1}{2}$	hours,	growth.
“	“	2	“	growth.
“	“	$3\frac{1}{2}$	“	no growth.

At 90°C.	for	$\frac{1}{2}$	hour,	growth.
“	“	1	“	growth.
“	“	2	hours,	growth.
“	“	3	“	no growth.
“	“	4	“	no growth.

A temperature of 50°C. did not destroy the spores in 24 hours. These experiments were repeated with the same results, which results were criticised by Corneil (28), who claimed that the heat to which the bacteria were exposed in melted wax was not moist but dry heat, and consequently that the wax had to be heated to a high temperature and for a long time in order to destroy the spores. According to the testimony of two prominent foundation makers, the wax during the refining and purifying process reaches a temperature of quite or nearly 100°C. for a short time. During the sheeting, however, it does not reach a temperature much above the melting point, say 79°C. Two other foundation makers, Dadant & Hunt (41), state that, in refining, the wax is heated for some time to 100°C., and is kept liquid for 24 hours ; so McKenzie thinks that if these temperatures are reached in the making, there is little danger of foul brood from comb foundation, as the specific gravity of bacteria in the melted wax is so great that throughout the process of manufacture the bacteria tend to fall to the bottom. Sternberg (42) states that the spores require for their destruction a temperature of 100°C. for four minutes (determined in 1887) ; but there is no statement as to the age of the spores. In Howard's experiments (40) tubes of liquid gelatine containing spores of *B. alvei* were placed in an open vessel of boiling water and allowed to remain therein for a definite time—“ in all probability the water did not reach boiling point ”—and trial cultures were made at stated intervals, with the following results :

After	15	minutes—	growth.
“	30	“	“
“	45	“	“
“	50	“	no growth.
“	60	“	“

His trial cultures were on potato and gelatine ; but no statement is made regarding the age of the spores, where they were from, or the temperature at which they were incubated. It is, however, evident that they were not given the most favourable conditions for growth.

I have myself performed the following experiments on the thermal death point of the spores :

Method. Test tubes containing bouillon were placed in boiling water. Three loopfuls of culture were introduced into each of the tubes ; and tubes, withdrawn from the boiling water at stated intervals, were cooled and incubated.

Results 1. Spores from a seven months old culture in bouillon were killed at a temperature of 100° in 1 hour and 20 minutes.

2. Spores from a $2\frac{1}{2}$ months old culture on agar were killed in two hours and a half.

3. Spores from agar nine days old,—slight growth after 2 hours and 45 minutes ; no growth after three hours.

4. Spores 14 days old and 21 days old,—in each case after two hours boiling, one of the duplicate tubes formed a growth ; another after $2\frac{1}{2}$ hours, whilst the remainder had no growth. All were killed in 3 hours.

I used also fine capillary glass tubes. A suspension of the spores in water was drawn up into sterile tubes, which were then sealed at both ends. The tubes were placed in boiling water and withdrawn at stated intervals. The contents of the tubes were then introduced into agar, which was incubated at 37°C. ; and great care was taken to have a suspension of the spores by filtering them through glass wool.

The results were : With a temperature of 98°C. (about the boiling point in this locality), spores from a 7 days' old culture on agar were killed in $2\frac{3}{4}$ hours ; and spores from agar 9 days old were killed in 3 hours.

Another experiment was made to determine the thermal death point in honey. The honey was of two kinds, clover and buckwheat. The former had a specific gravity of 1.042 at 60°C. and contained 0.057% of formic acid, while the latter had a specific gravity of 1.040 at 60°C. and contained 0.170% of formic acid. The spores used were from agar three weeks old, and three methods were followed :

1. Silk threads with dry spores thereon ; 2. Test tubes containing honey with a heavy inoculation of spores ; 3. Capillary tubes containing a suspension of spores in distilled water. The spores used were not filtered through sterile glass wool, as it seemed desirable to imitate as far as possible the conditions met with in infected honey. The following are the results :

1. *Silk threads with dried spores, from an agar culture two weeks old.*

Time.	Temperature.	Result.
15 minutes..........	115°G.	growth.
30 "	113 "	"
45 "	115 "	"
60 "	113 "	"
1 hour 15 minutes ...	114 "	"
1 " 30 " ..	115 "	"
1 " 45 " ..	115 "	"
2 hours	114 "	"
2 " 15 minutes...	116 "	"
2 " 30 " ..	115 "	"
2 " 46 " ..	115 "	no growth.

2. *Tubes containing honey and spores mixed together.*

30 minutes..........	115°C.	growth.
45 "	114 "	"
60 "	114 "	"
1 hour 15 minutes ...	114 "	"
1 " 30 " ..	114 "	"
1 " 45 " ..	115 "	"

2 hours	115°C		growth.
2 " 15 minutes	116 "		"
2 " 30 "	115 "		no growth.
2 " 45 "	115 "		"

3. *Capillary tubes with spores in distilled water.*

30 minutes	114°C.	growth.
1 hour	114 "	"
1 " 30 minutes	114 "	"
2 hours	114 "	"
2 " 15 minutes	115 "	"
2 " 30 "	115 "	"
2 " 45 "	115 "	no growth.

The temperatures were taken in a large vessel containing 10 pounds of boiling honey. The experiment was repeated, using buckwheat honey instead of clover and with like results.

Relation to Light. A few experiments were made to ascertain the behaviour of spores toward light. Coverglasses spread with spores and dried, were exposed to bright sunlight during the month of February. The exposure was in the open air and the glasses were on black tile. The temperature varied from—12° C. to—22° C After exposure, the glasses were placed film side downwards on agar plates, and then incubated at 37° C.

	Time.	Result.
Results—	3 hours sunlight.	Abundant growth in 16 hours
	6 " "	" " " "
	9 " "	" " " "

These experiments were repeated in September, when the outside temperature varied from 24° to 30° C., with the result, that there was growth after 4, 6, and 7 hours' exposure.

Agar plates exposed after inoculation showed great differences For instances, spores 21 days old was killed by 5 hours' exposure, whilst plates made the day after with spores 2 months and 21 days old, required 7 hours' exposure. Spores 10 days old showed no growth after 5 hours' exposure ; and spores 5 days old, no growth after 6 hours' exposure. From a large number of determinations, the average length of exposure necessary to kill spores within the above range of temperature was found to be 5 hours.

Vitality on various media. The cultures seem to live longer on agar than in liquid media. The vitality of old gelatine and bouillon cultures seems to be lessened by the products of the bacilli growing in these media. The spores taken from these sources have also decreased resisting power.

Effect of growth on reaction of media. Ordinary bouillon becomes slightly more alkaline as growth proceeds, the presence of ammonia being detected by Nessler's reagent ; but control bouillon does not give the reaction. In bouillon, with the addition of glycerine and various sugars, the acidity of the media is increased, but more in the case of glucose broth than in any other. In these experiments accurate titration was made with phenolphtalein as indicator. Cheyne tried the reaction, "making the infusions faintly alkaline, and after the growth of this organism in it, it is faintly alkaline."

Sensitiveness to Antiseptics and Germicides. This subject is taken up in connection with the chemical remedies used for the disease.

Pathogenesis. Besides being pathogenic to the larvae of bees, Cheyne has inoculated two mice and one rabbit with spore-bearing cultivations without effect. "Half a syringeful of a spore-bearing cultivation injected into the dorsal subcutaneous tissue of each of two mice resulted in the death of one of them in 23 hours, while the other seemed unaffected. In the case of the mouse which died, the seat of injection and the neighbouring cellular tissue was found to be very œdematous; but no microscopic changes were apparent in the internal organs. Numerous bacilli were found in the the œdematous liquid, as also a number of spores which had sprouted; and there were likewise a few bacilli in the blood taken from the heart. This was proved by cultivation as well as by microscopic examination. On examining sections of various organs no morbid changes were found, and only a few bacilli were seen in the blood vessels. A syringeful of the same culture was injected into a guinea pig; and the animal died 6 days later, with extensive necrosis of the muscular tissue and skin; and cheesy looking patches were distributed through it, but there was no true pus. On making sections of the necrosed tissue, numerous bacilli, apparently *B. alvei*, were seen; but there were also other bacilli and micrococci. No micro-organisms were seen in the internal organs. It thus remains questionable whether the necrosis was due to *B. alvei* or not, more especially as I have since injected three guinea pigs subcutaneously with spore bearing cultivation, but without effect.

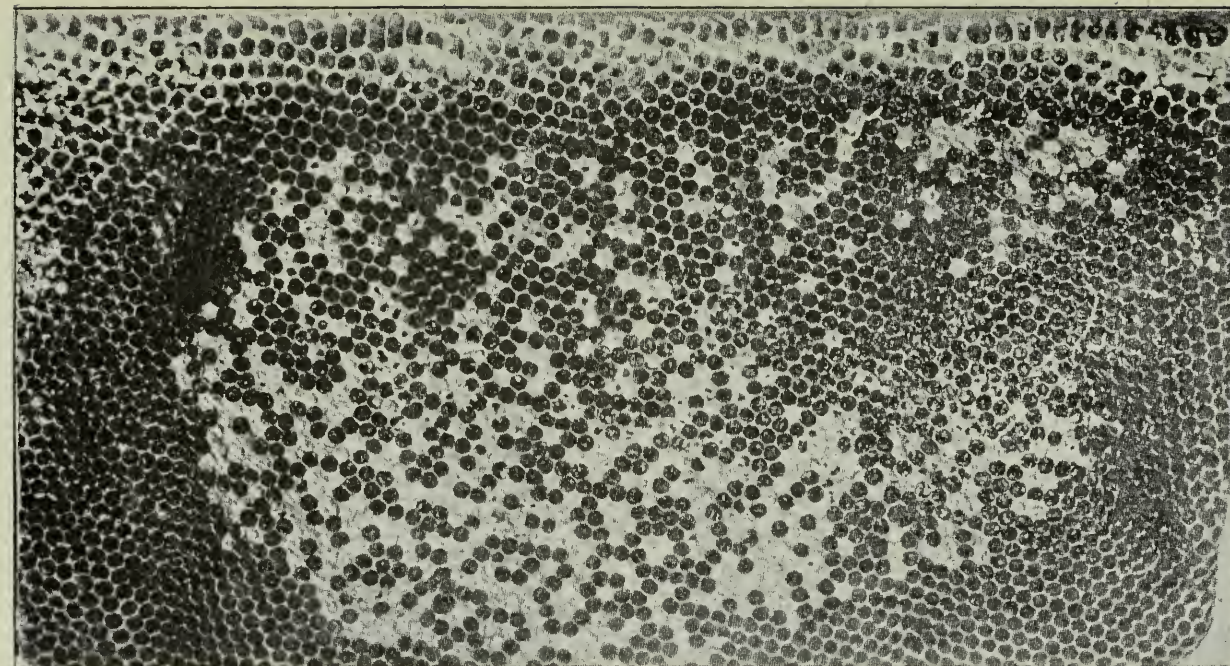
"The effect of feeding flies with material containing spores results in death of the flies, and bacilli were found in its juices as shewn by the microscopic examination and cultivation. Cockroaches were not killed" (28).

Fly blow larvae fed for three days on spores were not killed. With regard to the prevalence of the disease amongst wild bees. very little can be found on this subject in bee literature, but a correspondent of the *British Bee Journal* (43) found the disease among wild bee larvae in a tree, recognising it by the smell from the entrance and also from the appearance of the brood in the combs. The correspondent remarks that this tree had probably in former years been the cause of a great deal of trouble to neighbouring bee keepers. In all probability the disease is present among the various varieties of wild bees and wasps. Knight (54) mentions an epedemic among wasps in 1807; Kirby & Spence (55) another in 1815; and Bevan (13) one in 1824; but in none of these cases was any positive evidence given to show the epidemic was foul brood.

Economic Aspects.

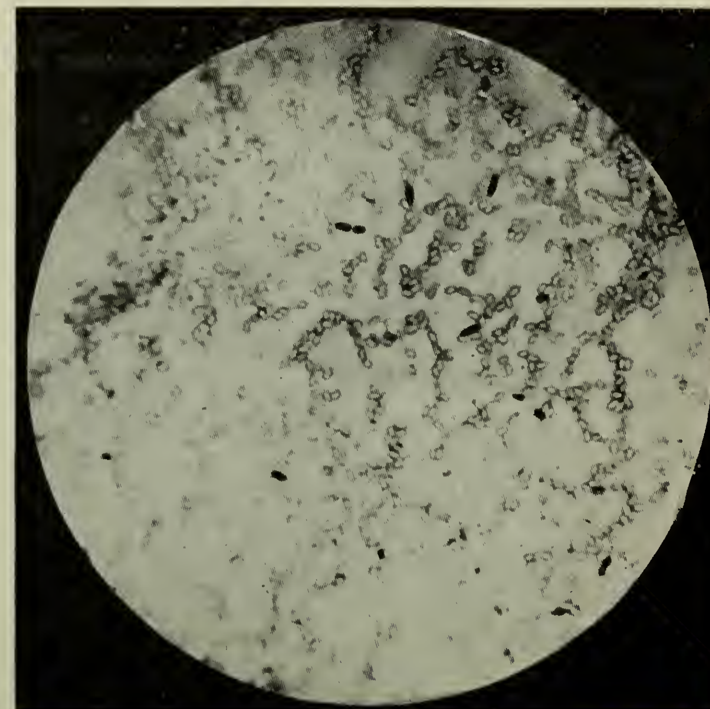
Losses. Della Rocca (loc. cit.) in 1790 stated that the whole of the bees in the Island of Syra were carried away during 1777 to 1780 by the disease. Dzierzon (46) relates his losses from the disease. In 1868 he lost his entire apairy of 500 colonies from it. In Switzerland, the disease, at times, is extremely bad. Bertrand's apiaries have suffered severely, and the German papers make constant reference to its devastation. In England, Cowan (4) thinks that the "only visible hindrance to the rapid expansion of the bee industry is the prevalence of this pestilential disease which is so rapidly spreading over the country as to make bee-keeping a hazardous occupation"; and again, (47) "So rapidly has foul brood spread by contagion that in one season, unless precautions are taken, a whole neighborhood may become seriously infected, and the chances of successful beekeeping seriously imperilled, if not utterly destroyed.

The committee on the Beekeeping Industry and Foul Brood in the United Kingdom, report that the destruction of stock by foul brood and the

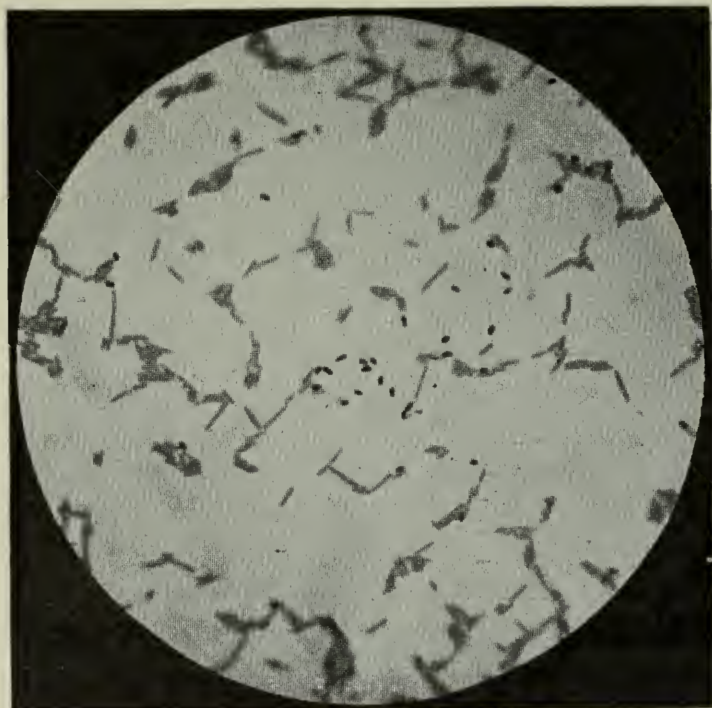


A diseased comb, (after N. E. France), showing sunken and darkened cappings. Also many cells with holes in the cappings.

B alvei and spores x 1000, from gelatine 7 days old at 20° C., stained with methyl violet. (Original.)

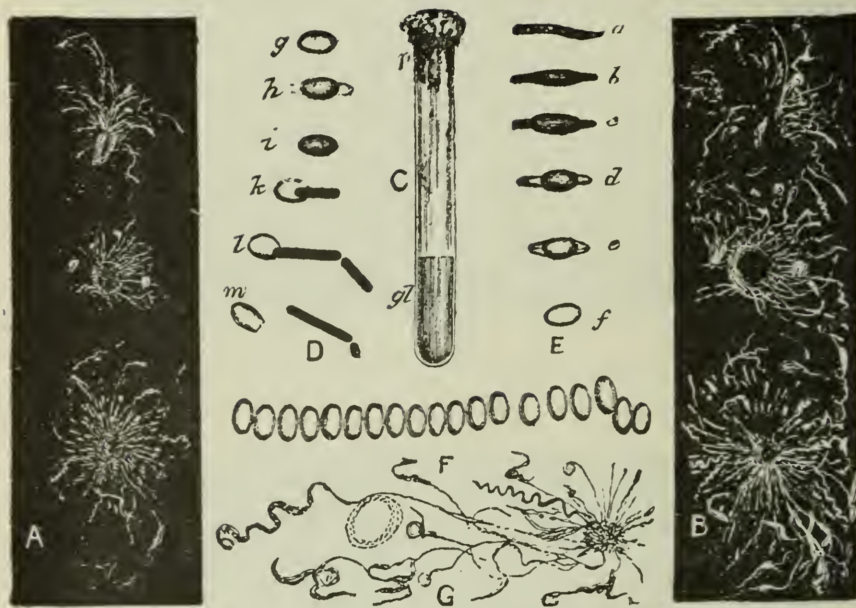


Spores of *B. alvei* x 1000, from agar 3 weeks old at 37° C., stained with methyl violet. (Original.)



B. alvei and spores x 1000, from agar 10 days at 37° C., stained by Moeller's method. (Original.)

B. alvei x 1000, from blood serum 7 days old at 37° C., stained with methyl violet. (Original.)



Cultures of *B. alvei* (after Cheyne). A. Colonies on the surface of gelatine (6 diameters). B. The same colonies 24 hours later. C. Culture tube; gl. gelatine; p. cotton wool plug. D. Spore becoming bacillus (1800 diameters.) E. Bacillus becoming a spore. F. Spores in line, taken from a gelatine culture. G. Colony developing.

discouragement arising therefrom is one of the two influences that retard the development of the bee industry.

In the United States, serious harm has been done, but no definite statistics can be cited. The disease causes great losses and several States have enacted laws for the prevention of the disease, making it a legal offence for a person to keep in his apiary a colony of bees affected with foul brood.

In Canada, the Ontario Foul Brood Inspector (56) reports in the years 1890-1892 inclusive, 622 apiaries inspected and 2,395 cases; in the years 1893-1898, 527 apiaries inspected and the disease present in 212, or about 40 per cent.

In New Zealand and Australia, the disease is looked upon as being very wide spread. It will thus be seen that wherever bees are kept, serious losses are caused annually by this disease.

Natural method of Infection. With regard to the natural methods of infection, a good deal depends on the natural predisposition of the bees to disease and the state of health of the colony. Weak, sickly, or badly nourished bees are as a rule the most susceptible. We must also remember that germs themselves vary in their ability to produce disease. As in diphtheria, we may get a light or severe type of the disease; so also in foul brood, we may have a light or a severe attack; but the facts demonstrating the variability of this capacity are not well known; I have, however, noticed that after prolonged cultivation of *B. alvei* in which more than 30 transfers have been made, and the bacteria with spores have been given to bees in syrup, the virulence of the germ has seemed to be considerably impaired. In one case the colony experimented with was rather weak, was confined to the hive all day, and allowed flight only in the evening, and the spores were given in large quantities in syrup every day, nevertheless it was several weeks before the disease established itself, and then only in a light form So we may have mild or severe epidemics and the liability to take the disease may be increased by chilling the bees or otherwise unfavourably modifying their metabolism; and in all such cases, they succumb more easily to the disease than when in a normal, healthy condition.

With regard to the manner in which the disease is carried from hive to hive, Cheshire (26) thinks that the larvae are most usually affected by the antennae of the nurse bees, and also that the tramp of the bees frequently detaches numbers of spores, which fly about in the air and settle here and there, often where they take effect. I think that in comparison with other diseases which are air borne there is usually not very much danger from this cause in the case of *B. alvei.* The spores are generally found in very sticky surroundings, which, even if dry, serves to fix and keep them *in situ.* Cheshire also states that he has not found the bacillus from honey or pollen in infected hives. This statement, however, is directly contradicted by the experience of practical bee-keepers and others. I have myself repeatedly found *B. alvei* in capped honey cells, and in the pollen masses found in diseased hives, the examination in the former case having been made by removing the capping with sterilized forceps and plunging a heated platinum needle into it and then putting the needle into melted agar, from which plates were poured, cooled and incubated.

Probably the chief method of carrying the disease from one hive to another is by the bees from healthy hives robbing colonies that have become weak and diseased. In such cases the robbers carry with them the germs of the disease. There is likely nothing to be feared from using wax foundation from the regular makers; for, as we have already stated, the wax, in the process of making, is subjected to a temperature sufficiently high to kill any spores that may be present.

I may add that I found spores of *B. alvei* in two samples of wax sent me by R. F. Holtermann of the *Canadian Bee Journal*, but both samples were from hives which were very badly infected with the disease.

In 1897, about ten pounds of wax was infected with large numbers of spores grown upon agar. The wax was cut up into small pieces, and heated at a low temperature, only just sufficient to melt it; and as McKenzie (28) had shown that the spores settled to the bottom, the wax was vigorously stirred from the time the spores were added until it had set again. The wax, thus infected, was sent to Holtermann for foundation-making. He manufactured it by the usual process of melting and gave the foundation made from it to bees, and no foul brood developed in the colony supplied with it during the years 1897 and 1898. The probability is that the spores are fixed in the wax, and are thus unable to infect the bees.

Healthy bees may pick up spores of *B. alvei* from flowers previously visited by diseased bees; wasps, which are noted robbers, may also carry the disease, and thus infect a locality.

The very large traffic in bees and bee-keeping supplies where agriculture is carried on, probably favors the spread of the disease. In fact, many instances are cited in bee journals of infection carried from one locality to another by the importation of bees and bee supplies.

Persons manipulating diseased hives and then examining healthy ones may be the means of spreading the disease. The practice of using a knife for cutting out diseased comb and then using the same knife for work amongst healthy comb (which I have seen done) is by no means wise, as the spores may thus be transferred from diseased to healthy hives. Cowan (4) observes that beekeepers who have not succeeded with their bees in consequence of foul brood have been known to sell by auction hives in which the bees have died. In such cases the purchasers are usually beginners who have no idea of the danger they are incurring.

Conditions favoring the spread of the Disease, Besides the weak or badly nourished condition in which bees may be, and lack of other hygenic conditions which favour the spread of this disease, great humidity in winter is said to be favourable and probably great heat is also conducive. (45.)

Predisposition of Varieties. No definite statements can be made as to the predisposition of various races to this disease. Quinby (49) says that black bees are more subject to foul brood than Italians. Aspinall (51) also affirms that common bees are more liable to the disease than Italians, but de Layens (47) states that Italians are more easily infected than black bees. (See also page 17.)

Remedies.

Three remedies have been tried :

1. Stamping out.
2. Starvation.
3. Treatment by chemicals : (a) by feeding chemicals in food; (b) by putting certain chemical substances into the hive and allowing them to evaporate at the temperature of the hive. This latter method may be regarded as rather preventitive than curative.

1. *Stamping out Method.* By the stamping out method all affected bees, combs and frames are destroyed, and the hives thoroughly disinfected. Cowan (4) thinks that if foul brood were under government inspection, and all cases promptly dealt with by destruction, the disease could be stamped out. The British Bee-Keepers' Association has asked the Board of Agriculture to secure legislation on this line, because it thinks that in this way the trouble would be removed and the industry would receive an impetus which would benefit bee-keepers, farmers and fruit growers.

The earliest advocate of this system was Della Rocca (18), who maintained "in extreme cases that it was necessary to burn everything without pity, as there was no other resource." Since Della Rocca's time, this method has been frequently resorted to in severe cases that would not yield to treatment either by starvation or by the use of chemicals; but to have any lasting effect, it would have to be universally carried out, and would involve the difficult question of compensation.

2. *Starvation Methods.* The starvation method was first proposed by Schirach (3) who advised that the combs be removed and bees allowed to fast during two days, and then be placed upon clean new comb, and fed on a syrup prepared with a little hot water mixed with honey, nutmeg and saffron.

Since Schirach's time different modifications of this method have been made, and it has been largely used in the United States and Canada, whilst in Europe treatment by medicated syrups has been more in vogue. In 1879 L. C. Root (58) gave his approval to this method, but he advised that the bees be confined in a cool, dark place for 24 hours, in order that all the honey which they carried with them might be consumed, and that the bees be then put into a hive filled with healthy comb or foundation and the condemned hive scalded with boiling water and thoroughly scraped. At a later date McEvoy (44), the Ontario Provincial foul brood inspector, introduced another modification and has himself described his method as follows: "In the "honey season, when the bees are gathering freely, remove the combs in the "evening and shake the bees into their own hives; give them frames with "comb foundation starters on and let them build comb for four days. The "bees will make the starters into comb during the four days and store the "diseased honey in them, which they took with them from the old comb. "Then in the evening of the fourth day take out the new combs and give "them comb foundation to work out, and then the cure will be complete. "By this method of treatment all the diseased honey is removed from the "bees before the full sheets of foundation are worked out. All the old foul "brood combs must be burned or made into wax after they are removed "from the hives, and all the new combs made out of the starters during the "four days must be burned or made into wax, on account of the diseased "honey that would be stored in them.

"All the curing or treating of diseased colonies should be done in the "evening, so as not to have any robbing done or cause any of the bees from "the diseased colonies to mix and go with bees of sound colonies. By doing "all the work in the evening it gives the bees a chance to settle down nicely "before morning and then there is no confusion or trouble.

"This same method of curing colonies of foul brood can be carried on at "any time from May to October, when the bees are not gathering any honey "by feeding plenty of maple syrup in the evenings to take the place of the "honey flow.

"It will set the bees robbing and spread the disease to work with foul "broody colonies in warm days, when bees are not gathering honey, and for that "reason all work must be done in the evenings, when no bees are flying.

"Where the diseased colonies are weak in bees, put the bees in two, "three or four together, so as to get a good sized swarm to start the cure with, "as it does not pay to spend time fussing with little weak colonies.

"When the bees are not gathering honey, any apiary can be cured of "foul brood by removing the diseased combs in the evening, and giving the "bees frames with comb foundation starters on. Then, also, in the evening "feed the bees plenty of sugar syrup, and they will draw out the foundation "and store the diseased honey which they took with them from the old combs; "in the fourth evening remove the new combs made out of the starters and "give the bees full sheets of comb foundation and feed plenty of sugar syrup "each evening until every colony is in first-class order.

"Make the syrup out of granulated sugar and put one pound of water to "every two pounds of sugar, and then bring it to a boil. As previously "stated, all the old combs must be burned or made into wax when removed "from the hives, and so must all the new combs made during the four days.

"The empty hives that had foul brood in them do not need any disin-"fectant in any way. I have handled many hundreds of colonies in the Pro-"vince of Ontario and cured them of foul brood without getting a single hive "scalded or disinfected in any way, and these colonies are cured right in the "same old hives."

McEvoy positively states that "No colony can be cured of foul brood by "the use of any drug. All the old combs must be removed from every dis-"eased colony and the hive got away from the bees before brood rearing is "commenced in the new clean combs."

Howard (40) is most emphatically opposed to the drug treatment. "I regard," says he, "the use of any and all drugs in the treatment of foul brood as a useless waste of time and material, wholly ineffectual, inviting ruin and total loss of bees. Any method which has not for its object the entire removal of all infectious material beyond the reach of both bees and brood will prove detrimental and destructive and surely encourage the recurrence of the disease."

A. I. Root (45) says that "The starvation plan in connection with burning the combs and frames and boiling the hives has worked best in treating foul brood. It never reappeared after such treatment, though it did in all cases where the hives were not boiled, thus confirming the theory or fact of spores."

These two authors, therefore, go further than McEvoy in both advising the disinfection of the hives.

McEvoy (56), however, admits that his method as described above cannot be used for every case. His reports frequently refer to burned colonies; and he acknowledges that his method does not always cure. In 1890 he used the expression, "600 cases of foul brood and over 360 cured"; and again in a subsequent report, after mentioning the number of cases, he added the words, "*mostly cured*"

In a personal communication, M. Bertrand of Nyon, Switzerland, states that he does not believe in and will not recommend in his periodical (*Revue Internationale d' Apiculture*) the starvation method as used in America.

3. *Treatment by Chemicals* —In the treatment of bees by chemicals, we assume that such substances as are used are employed as antiseptics, and that their efficiency is due to the fact that they destroy the bacillus or prevent the germination of the spores, and thus bring about an internal disinfection; but we must remember that many of the substances used are more poisonous in their effects upon the cells of the bee than upon *B. alvei*. As is well known, quinine is frequently used as a specific for malaria; and in such cases the

cure is effected by the intervention of the body cell. The effectiveness of the remedy is due to the fact that it acts as a stimulus and exalts the natural forces of the body.

Whether the drugs used in the treatment of foul brood act antiseptically or by stimulating the cells of the bee and making them more active to ward off the disease, is a matter of doubt; but it must be admitted that certain drugs do seem to effect a cure, and some of them are regarded as specifics by practical beekeepers.

In taking up the different methods of chemical treatment, I shall as far as possible describe them in the chronological order.

(1) *Carbolic acid.* Carbolic acid was first proposed by Butlerow (52), who recommended one part of acid to 600 of syrup, this proportion being the limit in which one can give the remedy to bees. Cech (53) in a work published in 1877, also recommended carbolic acid

The Cheshire treatment (26) consists in using a treatment containing half a decilitre of carbolic acid in a litre of water, thoroughly shaking it up until the acid is entirely dissolved, and using half a decilitre of this in a litre of syrup. In this treatment it is also necessary to reduce the infected stock to the number of frames it can use, and if the queen is diseased to destroy her and substitute a healthy one. The syrup is given by pouring it into the empty cells of the brood nest.

This method of treatment has been frequently reported to be successful; but there have been many failures, perhaps partly owing to the fact that it is difficult to get the bees to take the medicated syrup

Experiments on the Antiseptic Value of Carbolic Acid According to McKenzie (28), two per cent. carbolic acid does not kill the spores in six days. One per five hundred of the acid prevented the germination of the spores. but when taken out of the solution and placed in ordinary beef broth it gave luxuriant growth. Hence McKenzie thinks that the explanation of the value of carbolated syrup in the treatment of foul brood consists in preventing the germination of the spores. The bee journals refer to numerous instances in which feeding carbolated syrup produced an improvement in diseased stock; but as soon as the treatment stopped, the disease broke out afresh.

Salycylic Acid. The salycylic acid treatment was first used by Hilbert in 1876. The following is the method of use:

Solution of Hilbert No 1—Pure salycylic acid, 12½ grams; alcohol, 100 grams.

Solution of Hilbert No. 2—200 drops of solution No. 1 (about five grams) in 200 grams of distilled water or rain water.

Fumigation—One or two grams of the pure acid for fumigation.

Syrup—From 200 to 240 drops of Solution No. 1 (or about 5 to 6 grams) in a litre of syrup, well mixed before the syrup cools.

As soon as the disease is noticed the hive is disinfected and the syrup fed; and this treatment is also used for other colonies as a preventive treatment. The fumigation is accomplished in a kind of tin lantern furnished with a small alcohol lamp, suspended over which is a small movable trough for placing the acid in. The flame of the lamp is regulated in such a manner that the acid is liquified and slowly evaporated without burning. Too great heat will decompose it and render it ineffective. The fumes of the acid spread through the hive in the form of a white vapour. Whilst the fumigation is in progress the entrance boards and all parts that can be disinfected are washed with No. 2 solution. Fumigation and washing are repeated every 4 or 5 days until a cure is effected. The diseased colonies receive, every second evening, $\frac{1}{6}$ of a litre of acid syrup ; and it is wise to give the same treatment to the neighbouring hives. A cure is usually effected in 3 or 4 weeks. If later, it is generally regarded as a sign that the queen is diseased, in which case it would be well to replace her. Occasionally the queens die during the treatment ; but this is not frequent.

This treatment was very successful in diseased hives belonging to Bertrand (59). All the hives that were treated, were cured. Cowan (60), who has also used Hilbert's treatment with some slight modifications, has had the same success ; and such is his confidence in the treatment that he does not fear to introduce into his apiary foul brood colonies for treatment. Some have found the treatment ineffective ; but Bertrand thinks (59) that in all such cases there has been something lacking in the work, some precautions overlooked or neglected.

Experiments on the antiseptic value of salycylic acid. Salycylic acid agar was made containing 5 grams of $12\frac{1}{2}$ per cent. solution of salycylic acid in one litre of agar. Petrie plates were made from this and streaked on the surface with *B. alvei.* At the same time control cultures on ordinary agar were made. The results were abundant growth on the control plates and good growth, (but somewhat less than on the control plates) on the salycylic acid agar.

Salycylic acid Vapour. One gram of the acid was evaporated in our laboratory according to the directions given by Bertrand (59), in a box about the same size as a hive. Agar plates streaked with spores of *B. alvei* were left in different parts of the box during the fumigation for 10 minutes. The plates were then taken out, the covers put on and the plates incubated at 37°C. for 48 hours.

Results. Fumigated plates—no growth.
Control plates—abundant growth.

From these experiments it will be seen that the vapour of salycylic acid acts antiseptically, and that the feeding of the acid in the syrup, in the proportions specified, probably acts as a stimulant to the bees, enabling them to withstand or throw off the disease.

(3) *Camphor.* Ossipow (61) was the first to use camphor as a curative ; and Bertrand (59) describes the use of it as follows : " There is," says he, " placed upon the bottom board of the hive, enveloped in a piece of muslin, " a piece of camphor about the size of a walnut, which is replaced when it has " evaporated. The presence of the camphor permits the bees to clean out the " cells containing dead larvæ and stop the development of the disease. So " long as a hive contains some of the substance foul brood will not develop, " at least according to our experience and to that of several other beekeepers. " The first thing to do then, when one doubts the state of health of a colony, " is to employ the Ossipow remedy before proceeding to more radical means. " One can administer camphor in food by dissolving it in its own weight of " alcohol."

Experiments on the antiseptic value of Camphor. Sloped agar in tubes was inoculated with one loopful of spores of *B. alvei*, and a crystal of camphor about the size of a large pea was dropped into the tube. The tubes were then capped with tin foil paper and kept at 22°C. and 37°C.; and control cultures were made at the same time. At 22°C., after two days, there was good growth in the camphor tube. At 37°C., after two days, compared with the control tube, the camphor tube showed slight restriction of growth, the extra heat having evaporated the camphor more quickly.

Another series was made by using agar Petri plates streaked with 2 loopfuls of spores. In each plate was placed a portion of camphor about the size of a large pea; and the plates were incubated at 37°C. In 24 hours there was good growth; but close to the lump of camphor, growth was slightly inhibited.

Thus, camphor in the quantity in which it might be kept in a hive has no antiseptic effect, the amount used in the experiments being far larger than would be used in a hive. This substance, therefore, if it has the effect mentioned by those who have used it, must act as a stimulant, strengthening the bees to overcome the disease.

(4) *Thyme.* Klempin (62) has used branches of dry thyme with success, burning them in the smoker for disinfecting his hives; but their effect, like that camphor, is not radical, and beekeepers are not all in accord as to their efficacy.

(5) In connection with thyme *thymol* may be mentioned. Zehetmayr (63) has recommended the use of thymol, and has made a little machine by which he steams the bees with this substance. If a little of it is placed in a hive it will prevent infection, because bees from uninfected hives will not come near it,—they object to the smell, until they become accustomed to it. Blow (63) thinks it very valuable, and Jones (65) remarks that, even in great dilution, it prevents the growth of the germ; but Cowan criticises its use, because it is disagreeable to bees, and if used in sufficient quantity, acts as a poison, and therefore cannot be good in food.

Experiments on the antiseptic value of Thymol. Crystals of thymol were placed in test tubes of sloped agar in our laboratory and inoculated with one loopful of spores of *B. alvei*. These were capped with tin foil paper and incubated at 22° and 37°C.

Result. Control tubes--abundant growth.
Thymol tube at 22°C.—slight growth.
" " 37°C.—very slight growth.

Agar plates, poured and streaked with two loopfuls of spores of *B. alvei*, were used in another experiment; and a piece of thymol the size of a large pea was placed in each plate. The plates were incubated at 37°, along with control plates, with the following results:

24 hours, control plate—abundant growth
" thymol plates—good growth, but close to the lump, no growth.

Hence we conclude that this substance has a very slight antiseptic effect.

(6) *Carbolic Acid and Tar.* These substances were first used by Schreuter (66) and they are applied as follows:—"A piece of felt wool is placed in a small box, and soaked with a mixture of carbolic acid and Norwegan tar, in equal proportions The cover of the hive is slightly raised, in order to permit of the evaporation of the carbolic acid. The box is left upon the platform of the hive beneath the brood, and remains there permanently. The dose can be renewed as often as required. The addition of tar to the acid is for the purpose of making evaporation take place more slowly." This remedy has not been used to a very great extent. Borel (67) reports success with it; but others have not had the same results, and it is probable that it should be used only as a preventive.

Experiments on the antiseptic value of Carbolic Acid and Tar. Four drops of the mixture placed on blotting paper and inserted in a Petri dish containing agar streaked with spores, inhibited growth, from which we see that the mixture is antiseptic.

(7) *Creolin or Phenyle.* Creolin has been recommended by Cowan (68) and has been used with success by other apiculturists.

Recipes : Solution No. 1—for sprinkling, disinfecting, etc.—half a teaspoonful of soluble creolin in a litre of water.

Solution No. 2 For washing hives, platforms, etc.—two teaspoonfuls of soluble creolin to a litre of water.

Solution No. 3—for feeding—a quarter of a teaspoonful of soluble creolin in a litre of syrup.

The water of the syrup ought always to be poured upon the top of the creolin and thoroughly mixed with it; and the mixture should be well shaken before using.

Use. Prepare a hive and a proper floor board, which has been washed with solution No. 2. Then, after having taken out the comb from the infected hive, shake off the bees, and sprinkle the comb with solution No. 1. Take out all superfluous comb and spray it with solution No. 2, and extract the honey from it. The honey can then be boiled, and if it is used for feeding the bees, it can be diluted and phenol added in the proportion of one quarter to a teaspoonful to a litre of the diluted honey. The combs are then put back and the bees fed with medicated syrup. If the bees take the syrup, the dose can be gradually increased; but we must be careful not to give more than one teaspoonful to a litre of syrup. If the bees refuse to touch it, which is not at all improbable, if they have access to other food, pour the medicated syrup upon the neighboring combs, when the bees will quickly become habituated to it, and afterwards will take it in the ordinary manner. The vapour of creolin also acts as a disinfectant. A small phial of concentrated creolin may be placed in a corner of the hive, and lightly stopped with a cotton plug; and the lower part of the cotton being in contact with the liquid, capillarity will take place and draw up the creolin, and the heat of the hive will produce the necessary evaporation. A piece of blotting paper can be used by saturating it with creolin, and placing it upon the floor board or in a box covered with perforated zinc, so that the bees will not come into contact with the disinfectant.

Creolin is neither poisonous nor corrosive for man; but, in strong doses, it kills insects. Consequently it is necessary not to give greater strengths than those mentioned above. In the use of this remedy it is necessary to stimulate the production of brood by feeding liberally with medicated syrup; if the disease does not yield to this treatment. the queen should be removed.

Experiments on the antiseptic value of creolin. *a.* Sloped agar—each tube, inoculated with one loopful of spores, was plugged with cotton wool, saturated with creolin, and then capped with lead foil Tubes were kept at 22° C. and 37° C.

Result : After four days at 22° C.—No growth, except beneath the condensation water in the tubes.

After four days at 37° C.—No growth.

At the end of this time new cotton plugs were inserted into the tubes in the place of the creolin ones, and the cultures again incubated, when good growth ensued in 24 hours.

b. Agar plates were made and streaked with two loopfuls of spores. In each plate was placed a square inch of thick blotting paper, with four drops of creolin on it. The plates were kept in the incubator at 37° C., and removed in 48 hours, when very slight growth was manifest. On removal of the creolin and further incubation of the plates, good growth was obtained. Control plates gave copious growth. These experiments were repeated with only one drop of creolin.

Result, after 24 hours—abundant growth. With two drops of creolin, the growth was restricted to the inoculation track after 48 hours at 37° C.

c. In addition to the above experiments, agar was made containing the same proportion of disinfectant as was used in feeding the bees of diseased hives; 15 c. c. of this agar was taken for making a plate culture, and several plates were streaked with two loopfuls of spores, and incubated at 37° C. Strength of agar,—2 c. c. creolin to 1 litre of water, i.e., about half a teaspoonful to a quart.

Results —Creolin agar, four tests—no growth.
Control agar, abundant growth.

This antiseptic in the strength used by Cowan for feeding purposes, would prevent the germination of the spores; and if there was a large amount evaporating in the hive, a slight antiseptic result would take place.

(8) *Eucalyptus.* This substance was introduced by Beauverd (69). A small tin box, with a cover pierced with small holes, is placed upon the floor board of the diseased hive, and filled with essence of Eucalyptus. The colony receives every four or five days a litre of syrup containing a teaspoonful of tincture of eucalyptus (oil eucalyptus, 1; alcohol, 9). Then from time to time some drops of the same tincture are dropped into the hive. Auberson, who was the metayer of Bertrand's Apiary and was managing his own higher up the mountains, cured a number of colonies by means of this method. He finds that there is a great difference in the effect produced by the remedy. In some cases, the effect follows the remedy quickly; in others, the effect is slower. Sometimes more than a year passes without resulting in a complete cure. When the disease is of long standing, the remedy must be proportionate to the gravity of the evil. When there are only a few diseased cells, Auberson simply pours some drops of the essence along the back wall of the hive. He renews the dose every eight days; and in six weeks, sometimes sooner, the colony is cured. In cases where the hive is badly affected, he takes a clean hive and floor board and impregnates the interior, floor board, and division board with eucalyptus, and then transfers combs, brood, and bees to the new hive. He leaves the foul brood colonies their rotten combs, as this is the only handy means of disinfecting them. Three weeks later, during which he has twice poured eucalyptus on the floor board, he examines the new brood. If it exists in healthy patches he simply pours a few drops of the essence on the floor board until the cure is complete. If, however, the fresh brood still disclose some diseased spots, the queen is killed and replaced by another, and every fifteen days the essence is spread on the floor board until the cure is completed. If the colony is very weak, he strengthens it by the addition of bees and healthy brood. If he has to feed a diseased hive, he never fails to put the essence in the syrup.

Besides these well authenticated cases of cure by the essence of eucalyptus, there are a number of others, and the method has been extensively used in Europe. The great drawback to the use of this remedy is that it is liable to cause robbing.

Experiments on the antiseptic value of eucalyptus. (*a*) Eucalyptus oil. The cotton plug of a spore-inoculated sloped agar tube was saturated with the oil, and incubated at 37° C. In eighty-four hours there was no growth, but a fresh plug being inserted good growth occurred in twenty-four hours.

(*b*) Agar plates inoculated with spores and containing four drops of eucalyptus on a piece of blotting paper were incubated at 37° C. No growth formed, but when the eucalyptus was removed good growth immediately ensued. On plates containing two drops the growth was restricted to the inoculation track, but when the oil was removed abundant growth took place. On plates containing one drop on blotting paper there was abundant growth in twenty-four hours.

(c) Eucalyptus agar was made by using a teaspoonful (4 c.c.) of tincture of eucalyptus to a litre of agar. Six plates were made with eucalyptus agar, each plate inoculated with spores, with the result that the growth on the medicated agar was only slightly less that that on the control agar. The medicated agar smelt slightly, but characteristically of eucalyptus oil.

A Queensland (Australia) correspondent of the *British Bee Journal* (71) is of the opinion that no foul brood exists among bees in that country. The reason of this is that the honey that goes into the combs is largely gathered from the eucalyptus, the medicinal qualities of which combat foulness in all forms. This statement, however, is not reliable, inasmuch as foul brood is known to be prevalent in Queensland.

(9) *Napthol Beta.* Napthol Beta was first used as a remedy by Lortet (72). The treatment is as follows:

The drug is administered in the food, in the proportion of one-third of a gram to a litre. This one third of a gram is at first dissolved in a little alcohol, as it is extremely insoluble in water. Afterwards it is mixed in a litre of water, and this liquid is used for making the syrup. In England the usage is to dissolve the napthol in the sugar, the proportion being about forty to fifty centigrammes to a kilo of sugar. It is, however, better to dissolve it in alcohol. Lortet thinks that external treatment by means of fumigation or spraying is helpful, as these methods contribute largely to the disinfection of hives, comb, etc; but as he believes that it is always the digestive canal of the nurse bee which is infected and that it is by the act of feeding that the adult bee infects the digestive canal of the larvæ, therefore all efforts should be directed to the digestive canal of the worker bees, and the treatment ought to be internal and as energetic as possible. He states that when administered in the proportion of 0.33 gram per 1,000 of liquid it prevents all fermentation and decomposition and other changes caused by microbes. He further maintains that in addition to the use of this preparation first-rate hygienic conditions are necessary in order to give the bees vitality and recuperative power, which play an important part in enabling living organisms to resist the inroads of virulent microbes.

McKenzie found that (28) a beef broth containing one per thousand of B. Napthol prevented spores of *B. alvei* from germinating, and consequently had an equal value with one per five hundred of carbolic acid.

This remedy has been widely used and with considerable success.

Experiments on the antiseptic value of Napthol Beta. Napthol Beta agar was made in our laboratory the same strength as that recommended by Lortet for feeding, that is 0.33 gram B. Napthol to one litre of agar. Eight tests were made in Petri dishes, inoculated with spores of *B. alvei*, and in no case did growth result; from which we learn that a dilution of one-third of the solution used by McKenzie completely inhibited growth. Napthol Beta agar containing 0.165 gram of the drug to a litre of agar was also tried, and the result of a number of tests was that some growth took place on the medicated plates and abundant growth on the control plates.

From these experiments, also those of Lortet and McKenzie, it will be seen that Napthol Beta has a strong antiseptic action.

(10) *Naphthaline.* This substance is regarded as a preventive rather than as a curative, although there are cases known in which it has effected a cure of diseased hives. A small quantity of the drug is placed on the floor board of the hive, a crystal about 2 c m. in diameter as far from the entrance

of the hive as possible. The evaporation is rapid and with very strong odour. Hence, if too much used, the brood will be deserted by the workers and death of the bees may take place. As soon as the dose has evaporated it is renewed.

As a preventive, naphthaline has been very favourably reported upon by a number of writers; and Cowan (73) states that he inspected very thoroughly a hive belonging to Merney which had been cured by this substance.

Experiments. In our laboratory, crystals of naphthaline about the size of a large pea were put into test tubes containing sloped agar, inoculated with one loopful of spores, capped with tin foil paper and kept at 22° and 37° C.

Results. After 48 hours—good growth in all tubes. Inoculated agar plates containing a crystal of naphthaline likewise gave good growth in 24 hours at 37° C, as did also the control tubes and plates. Hence, we conclude that naphthaline has no antiseptic power; and we are forced to look upon its use rather doubtfully. It may, perhaps, act as a stimulant.

(11) *Formic acid.* This substance was first suggested by Dennler in 1885 (74), but he did not ascertain the strength in which it could be used. Sproule (75) states, that since the year 1882 he had successfully treated foul brood with formic acid. He was the first apiculturist to use the remedy and give the treatment. The solution used is pure acid, 10 parts; water, 90 parts; and the treatment is as follows:—

A part of the comb is taken from the hive and as many bees as possible are shaken from the diseased comb; and then two or three empty combs are used, into one of the sides of which 100 grams of the solution are poured, while it is held inclined so as to allow the liquid to run into the cells and stay there. These combs are placed on each side of the brood, the side containing the solution next the brood. Eight or ten days after, an inspection is made; and if there is no cure, the dose is renewed and continued every week until the cure is complete, which is often after the first treatment. In fact the disease rarely resists the second or third application. To hasten the cure, this remedy can be given in the food of the bees—a teaspoonful to a litre of syrup.

Experiments Formic acid probably has an important rôle to play in the keeping properties of honey. As long ago as 1878, formic acid was found in honey; and Muhlenhoff (76) observed that when honey is not intended for immediate use, the bee deposits in each cell a drop of formic acid, secreted by the venom glands, and then seals the cell. Erlenmeyer (77) says that formic acid of the strength of 1.205 gr. to a thousand parts of water was antiseptic, Planta (78) refutes Muhlenhoff's idea that 100 grams of sealed honey contains .0186 grams of 22% formic acid. "100 grams is the capacity of 165 worker cells, but the smallest droplet of venom contains at least .0254 grams of formic acid, which would make for 165 cells, 4 1910 grams; that is to say, 200 times more than there is in reality." This opinion is, however, contrary to one expressed before by the same writer, in the year 1884 (79).

Formic acid seems to help bees to ward off the disease, especially when we supply it to them ready made; and that found in certain kinds of honey has probably an antiseptic effect. Two samples of clover honey and two samples of buckwheat honey were analyzed in our chemical laboratory with the following results:—

1	Buckwheat honey	0 15	grains of formic acid	in	100 grains	of honey.
2	"	0.17	"	"	"	"
1	Clover honey	0 0579	"	"	"	"
2	"	0.057	"	"	"	"

Formic acid agar was then made containing the same proportion of formic acid as was found in the first sample of buckwheat honey, and weaker formic acid agar containing the same percentage of formic acid as was present in the first sample of clover honey; and spores placed upon the stronger formic agar did not germinate, while on the weaker formic agar the germination was only slightly retarded; and after the weaker agar was two days in the incubator, there was a large growth. Spores transferred from the strong formic agar (after being in contact with it for six days in the incubator) failed to grow on the weaker formic agar within two days; but after four days in the incubator they grew abundantly. The culture growing on the weaker formic agar was then transferred to the strong formic agar, to ascertain whether the germ could be accustomed to more unnatural food by previous cultivation on the weak formic agar. This transfer was, however, unsuccessful.

The germs used in these tests were isolated from samples of diseased comb from Ontario, Austria and Florida, U.S.A.

Formic acid bouillon was also made containing .15% of formic acid; and spores kept in this broth for eight months continued to germinate when transplanted to suitable material.

Formic acid agar was likewise made in the same proportion as suggested by Bertrand (59); that is, formic acid 10, water 90; and a tablespoonful of this mixture to a litre of syrup; but instead of syrup, agar was used. Fifteen c.c. of this acid agar was poured into each Petri plate, and the surface inoculated with spores.

Results: On 14 plates, no growth.

On 2 plates, very restricted growth, limited to one-eighth of an inch of the needle track (60 hours).

On control plates, abundant growth.

From these investigations, viz., the analysis of the honey, the experiments based thereon, and the tests with agar made in the proportion suggested by Bertrand, we would note three things: (1) That the amount of formic acid recommended by Bertrand for the cure of foul brood is almost identical with the amount found in buckwheat honey; (2) that formic acid is a good antiseptic; (3) that the formic acid in buckwheat honey may possibly tend more or less to ward off foul brood.

We may add that our analysis, showing a larger proportion of formic acid in buckwheat honey than in clover honey, is an interesting explanation of a fact well known among practical bee-keepers, viz., that the sting of bees when working on buckwheat is much more irritant than when working on clover.

In conclusion under this head, we may say that formic acid has given good results when used in the treatment of foul brood; and it is in a sense a natural remedy, being manufactured to some extent by the bees themselves.

(12) *Other substances used for treating this disease.* Among other substances that have been used for treating this disease are sulphuric acid, sulfaminol, various modifications of substances already mentioned, and some recommended in the McLean method (80), the Muth method, and others; but these have not had so wide application as those referred to in the preceding paragraphs.

Experiments on the Use of Drugs for Combatting the Disease.

I have already mentioned that, in one of my experiments, I endeavoured to find out if the virulence of the germ was attenuated by prolonged culture in artificial media, with the result that considerable attenuation occurred after a large number of transfers; and in the following experiments I have endeavoured to meet any objections that might be made as to the virulence of my cultures, by isolating *B. alvei* from a badly diseased hive and then growing at once sufficient spores for the purposes of the experiment. Thus but three transfers from a diseased larva were made; and all the spores used in the following experiments were obtained in this manner:

Two small hives, each containing strong healthy swarms, were selected and placed side by side.

Hive A was given spores of *B. alvei* in syrup containing one-third of a gramme of napthol B. to a litre of syrup

Hive B was given spores of *B. alvei* in syrup containing from 1.6 to 1.8 c.c. formic acid to a litre of syrup.

The spores given were scraped from the surface of an agar slope culture, put into 10 c.c. of sterile water, and well shaken in order to obtain a good suspension of spores. The water and spores were poured into medicated syrup and the mixture thoroughly stirred. It was then given to the bees and was readily accepted. This procedure was continued four days a week for three weeks, and at the end of this time each hive had received the whole of the growth from twelve sloped agar tubes. During the feeding period the combs containing the brood were carefully examined, but none of the usual symptoms of the disease appeared, although cultures were obtained from different parts of the hives and from the digestive tract of the workers. At the end of three weeks the medicated syrup was discontinued for a week. Then ordinary syrup containing spores was given, and at the end of ten days typical symptoms began to be noticed, and after sixteen days the disease was well establshed. Both hives, so far as I was able to judge, were the same—no disease to be seen in either whilst medicated syrup was fed, but infection manifest in both soon after the formic acid and napthol B. were discontinued. This experiment goes to prove the benefit of feeding with syrup a substance which is antiseptic and which hinders the germination of the spores. It also confirms Lortet's opinion that the digestive canal of the nurse bee is alone infected. I have never been able to obtain Cheshire's results, viz., the isolation of the bacillus from the blood of the worker, but I have frequently found it in the digestive canal of bees from diseased colonies.

From the results of the above experiments I conclude that in certain cases the use of chemicals is beneficial, but I would not say that other measures, such as starvation and stamping out, should be abandoned as unnecessary or useless. Some of the drugs used are of very little, if any, value; but others, such as formic acid and napthol B., are undoubtedly very useful. In some cases, especially those in which the disease is very virulent, it may be advisable to resort to more drastic measures.

Toxins.

I endeavoured to find out whether or not the feeding of toxin (filtrate from a two weeks old culture of *B. alvei* in saccharose bouillon) mixed in syrup would enable healthy bees to withstand the disease. Small amounts of this filtrate were given in syrup to a healthy colony every other day for three weeks. The amount of filtrate fed was gradually increased, but as the amount got larger the bees refused to take it, so it had to be poured over the combs. At the end of three weeks spores of *B. alvei*, freshly isolated, were fed, and symptoms of the disease followed about fourteen days later. So the toxin had little or no effect, but further experiments are being made.

Legislation.

In the United States, six States have laws for the suppression of foul brood among bees. These are New York, Wisconsin, Michigan, Utah, Colorado and California. In Canada the Province of Ontario has enacted a foulbrood law. In Europe Mecklenburg also has a law.

These statutes differ a good deal from one another, and some of them are so drafted that evasion of the law is easy. The best are probably those of Wisconsin and Ontario, and the principal points in these acts are as follows:

1. The appointment of an inspector.
2. The inspection of all apiaries reported as diseased, and the duty of the inspector, if satisfied that the disease is present, to give full instructions as to treatment.
3. The enactment requiring the inspector, who is the sole judge, to make a second visit to all diseased apiaries, and, if need be, burn all colonies and combs that he may find uncured.
4. Various penalties (fines, and, in default, imprisonment) for—
    (*a*) Selling or giving away diseased colonies or infected appliances.
    (*b*) Selling bees after treatment, or exposing infected appliances.
    (*c*) Obstructing the inspector.
5. Persons who are aware of the disease either in their own apiary or elsewhere are to notfiy at once the proper authorities, and in default of so doing shall, on conviction, be liable to a fine and costs.
6. The inspector of apiaries to make an annual report, which shall include a statement of the number of colonies destroyed by his order, the localities where found, and the amount paid to him for his services.

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