CROP ROTATIONS AND SOIL MANAGEMENT FOR EASTERN CANADA

By
E. S. HOPKINS, P. O. RIPLEY AND W. DICKSON

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THE ADVANTAGES OF CROP ROTATIONS

The main advantage of improved crop rotations is to assist in maintaining the fertility of the soil and thereby to increase the yields of farm crops. Unless the soil is in a fertile condition, it is impossible to produce large crops and large crops are a prerequisite of profitable farming. To produce in this way a large yield per acre requires very little additional expense beyond that necessary for the production of a small crop and the value of this increased crop may bring a profit where otherwise there might be a loss. The adoption of a good rotation requires no additional expense; it involves merely an arrangement of the cropping plan so as to produce one crop after another in the proper sequence.

Other advantages, however, are derived from good rotations in addition to assisting in the maintenance of soil fertility. If proper methods of tillage are followed on the rotations, weeds are controlled more satisfactorily than in continuous or haphazard cropping. Intertilled crops require considerable cultivation and thereby favour the germination of many weed seeds in the soil and permit the subsequent destruction of the weed plants. If heavy crops of hay are produced, some kinds of weeds are prevented from growing.

Insect pests and fungous diseases are kept in check better by rotations than where the same kind of crop follows itself. This is particularly true of some crops which are subject to the attacks of certain insects or fungus. The tilth of the soil is improved by rotations in which sod is ploughed under frequently. The labour on the farm is better distributed throughout the season when suitable acreages of various crops, which are planted and harvested at different times, are grown in rotations.

THE IMPROVEMENT OF SOIL FERTILITY

Many factors influence soil fertility. While some tend to add to the soil's productivity others tend to decrease it. Moreover, the changes in the fertility of the soil, either of improvement or of deterioration, are usually so slow and gradual that it is difficult to detect what practices are actually beneficial and what are not. On some soils it may take from ten to twenty years before much difference in crop yields can be observed, especially on account of the potent influence of the season which profoundly affects the yields of crops.

Among the chief factors which exert a beneficial effect and increase the fertility of the soil may be mentioned the use of crop rotations, the growth of leguminous crops, the practice of good tillage methods and the application of farm manure and commercial fertilizers. In addition to these may be mentioned the precipitation, which brings down a small amount of nitrogen and sulphur; and also certain soil organisms, which, although not associated with legumes, withdraw nitrogen from the atmosphere. On the other hand, other factors are at work reducing the fertility of the soil. Not only do crops withdraw fertility but the loss of constituents by leaching is quite considerable. Even when all the crops are fed to animals some loss of fertility occurs although, when care is taken in the handling of the manure, it is reduced to a

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minimum. The loss of fertility by soil erosion on hilly fields may be quite large when intertilled crops are grown, making it advisable to leave such fields in sod as long as they continue to give profitable yields.

The practice of good rotations alone even with the addition of very little manure or commercial fertilizers is very useful in maintaining at a fairly high level the yields of some crops. This is particularly true with such grain crops as oats and wheat, to a less extent with hay and corn, while, with root crops, such as mangels or turnips, a considerable amount of farm manure or commercial fertilizer is necessary if fair yields are to be secured. It is always advisable to handle the manure produced on the farm as carefully and as intelligently as possible in order that its beneficial effect may be added to that of the rotation so as to produce the largest crop yields at the least cost.

The amount of manure which will be available on a farm will depend upon the number of stock which is kept, the amount of feed given and litter used, the number of months the animals are fed in the stable, and upon the care which is taken in the handling of the manure. Even when all the crops grown on the farm are fed to the stock and the animals are stabled for seven months of the year, it is doubtful whether under average conditions an application of manure could be given larger than that equivalent to 2·5 tons per acre per year or, on a four-year rotation, to one application of 10 tons of manure per acre. This quantity might be obtained when the yield of corn was 10 tons per acre, hay 2 tons per acre, and oats 50 bushels per acre; if larger crop yields were secured, greater quantities of manure would be available. When fed in the stable, each cow produces approximately one ton of manure per month; the amount which will be available for distribution to the land will depend upon the care and method which is employed in handling the manure. Animals utilize themselves over one-half of the organic matter in the food, about one-quarter of the nitrogen and phosphorus, and about one-eighth of the potassium. Unless care is taken in the handling of the manure, considerable additional losses of fertility will take place by fermentation, by leaching, and by failure to conserve the liquid portion of the manure.

Many farmers find it impossible, on account of not having a sufficient supply, to make any application of manure to a considerable acreage of their farms. Frequently, the front fields are manured while the back fields are left without manure. It is possible that an improvement on this system might be accomplished by making a somewhat smaller application of manure per acre, thereby manuring a larger acreage, and also by adopting better rotations. In order to conserve as much fertility as possible, the manure should be applied to the land as soon as possible. When this cannot be done, it should be placed in a compact pile on a watertight floor having a low side wall to prevent losses through leaching. The pile should be built up with square sides and with a flat or saucer-shaped top. It is not necessary to cover the pile with a roof to protect if from the rain. Another satisfactory method of storing manure consists in placing it in a covered shed. As the roof prevents access of rain there is little loss from leaching and hence a watertight floor is unnecessary. It is very desirable to allow the stock to tramp over the manure because this packs it and reduces the losses caused by fermentation. Except where bad weed seeds are present it is not economical to rot the manure, but where these are present rotting is very advisable. It is more economical to apply smaller applications of manure at more frequent intervals to the land than heavier applications at longer intervals. Care should be taken to spread the manure uniformly so as to derive the greatest returns. Root and silage crops in the rotation make the most response to applications of manure, followed by hay, and then by grain crops. However, the value of the crop may also determine whether it should receive any manure.

A COMPARISON OF CROP ROTATIONS

On the Dominion Experimental Farms throughout Canada, many trials have been made, over a long period of years, with different kinds of rotations. Most of these rotations in Eastern Canada have been arranged for dairy farming or to some extent, for mixed farming. A few rotations, however, are also given in this bulletin for farmers who desire to obtain a considerable proportion of their revenue from grain and clover seed. It must be remembered that the rotations mentioned are given only as illustrations and that an infinite variety of modifications may be made depending upon individual circumstances, crop yields, and upon the type of farming which is found to be most profitable. In many cases it will be found desirable to have two rotations on the same farm instead of one in order that a better utilization of the land may be made. Some kinds of soil are particularly suited to certain crops, such as heavy clay for hay crops or sandy loam for intertilled crops, and it is usually wise to take advantage of these adaptations rather than to force some crops on soils to which they are not adapted.

In the plan of some rotations too large an acreage of corn or silage or of roots is sometimes devoted to these crops. It must always be borne in mind that only such an acreage of these crops is required as will yield sufficient to feed the stock which is to be kept on the farm. Knowing the number of stock, it is easily possible to figure the amount of these crops that will be required and the acreage that should be grown, keeping in mind the fact that yields vary considerably from year to year and, to avoid a shortage of feed, a somewhat larger acreage should be grown than is just sufficient with an average crop. If the intertilled crop does not require all the land indicated by the plan of the rotation, the remaining acreage may be left in hay or pasture or may be seeded to grain, either for feed or for sale.

Pasture is often a limiting factor in arranging rotations on stock farms. The amount of pasture which should be allowed per season for each animal unit varies considerably from one year to another but usually two acres of good pasture must be given. If rough pasture on uncultivated land is available, in addition to the pasture land in the rotation, obviously less pasture land will be required in the regular rotation. In some parts of Ontario and in any other districts where it will grow satisfactorily, sweet clover has been found to pasture more animals per acre than many other crops, although little definite information on this point is available. The amount of hay which should be grown will depend upon the yield which can be secured from this crop. In some districts, alfalfa can be grown successfully and, as it yields considerably heavier than ordinary hay crops, it will be possible in these districts either to increase the amount of stock carried or to produce some cash-crops on the land which would otherwise be devoted to hay. Where gain is mentioned in the various rotations, either oats or barley may be grown depending upon which gives the better results. On rich land in some of the warmer districts barley will outyield oats, while, on the poor land, oats will give the better returns.

In order to make a ready comparison of the advantages and disadvantages of some rotations for stock farms, the feed requirements have been based on a 100-acre farm having about 65 acres under cultivation and carrying the equivalent of 20 cows, that is to say, 20 animal units, or mature cattle; if there are any young stock kept, there would be a corresponding increase in the number. In order to facilitate the estimation of the acreages of the various crops required, certain yields have been tentatively assumed; it is very probable that considerably increased yields could be obtained after a few years' operation of a good rotation. It is assumed that all the crops grown on these rotations are fed to live stock but a statement is subsequently given showing how these rotations may be modified for mixed farming in which both animal products and cash-crops are sold. Other rotations are also given for grain farming, potato production, and for other special conditions.

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Good crop rotations promote the production of heavy crops.

THREE-YEAR ROTATION

First year: Corn, roots, etc.
Second year: Grain
Third year: Clover hay

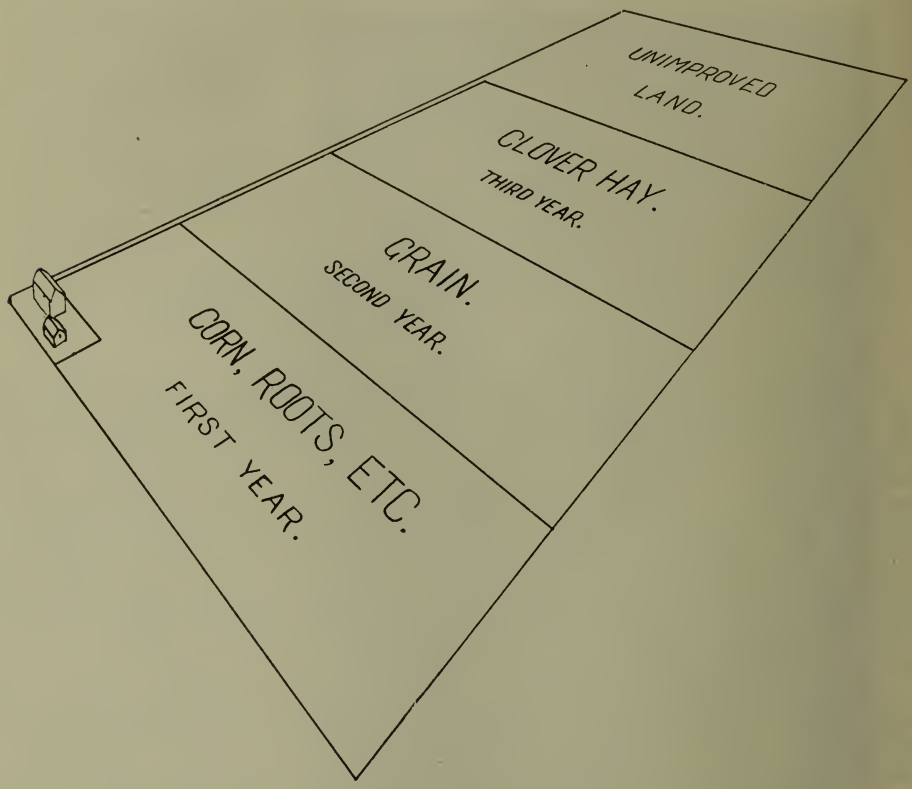
First year: Corn, roots, etc.	1933—corn. 1934—grain. 1935—clover hay.
Second year: Grain	1933—grain. 1934—clover hay. 1935—corn.
Third year: Clover hay	1933—clover hay. 1934—corn. 1935—grain.

This rotation provides an equal acreage of corn silage, grain, and clover hay. It is suited only to some dairy farmers who require a large amount of silage and who have only a small acreage of land; it is also suited to farms which have only a small acreage of good land on which this rotation may be located and which have other land available that may be used for additional hay and pasture. This short rotation is admirably suited to maintain the fertility of the soil. It permits a large number of stock to be kept on a small acreage thus providing a maximum amount of manure. The clover crop coming once every three years helps to maintain the nitrogen and organic matter supply of the soil. This rotation is not suited to the average farmer because it contains a rather larger acreage of corn and a smaller acreage of hay than is desired.

Taking an average-sized farm in Eastern Canada having a total of 100 acres of land of which 66 acres are under cultivation it will be seen that in a regular three-year rotation there would be 22 acres in corn. If corn gave an average yield of only 10 tons per acre, this would give a total of 220 tons of silage or sufficient to feed 31 cows, 40 pounds a day for the entire year. However, to feed this number of cattle all year would require, in addition to the silage, 62 tons of hay, while the horses would require an additional 7 tons, or 69 tons in all. But as there are only 22 acres in hay, if these yielded 2 tons per acre there would be produced only 44 tons leaving a shortage of 25 tons. It is obvious, therefore, that a rearrangement of the acreages is necessary and a reduction in the number of cows carried. It is clear that a portion of the area allotted to corn in the three-year rotation must be left in hay a second year in order to decrease the amount of corn silage and to increase the amount of hay required. If 17 acres are devoted to corn silage and the remaining 5 acres are left in hay for the second year, this rearrangement will feed 23 cows all the year with the crops grown on this farm. It will allow for each cow, averaging 5,000 pounds of milk a year, 7·3 tons of silage, 2 tons of hay, and 1 pound of grain for each 4 pounds of milk. This rotation is only applicable where it is desired to feed the cattle indoors the entire year or where other land is available for pasture. The practice of feeding cows indoors all year without pasturing is rather uncommon, but if outside pasture is available, this rotation may also be used where the practice of summer pasturing is followed. It is obvious that if pasture is available, more stock could be handled on this rotation.

It may be of some interest to figure the amount of stock which this three-year rotation would carry provided the same yields of crops were obtained as have been obtained at the Central Experimental Farm, Ottawa. As an average

of fourteen years at Ottawa, corn has yielded 15 tons of silage per acre, oats 61·4 bushels per acre and hay 3·5 tons per acre. With these yields, 35 cows could be fed inside all the year instead of 23 cows with the yields previously mentioned.



PLAN OF A THREE-YEAR ROTATION

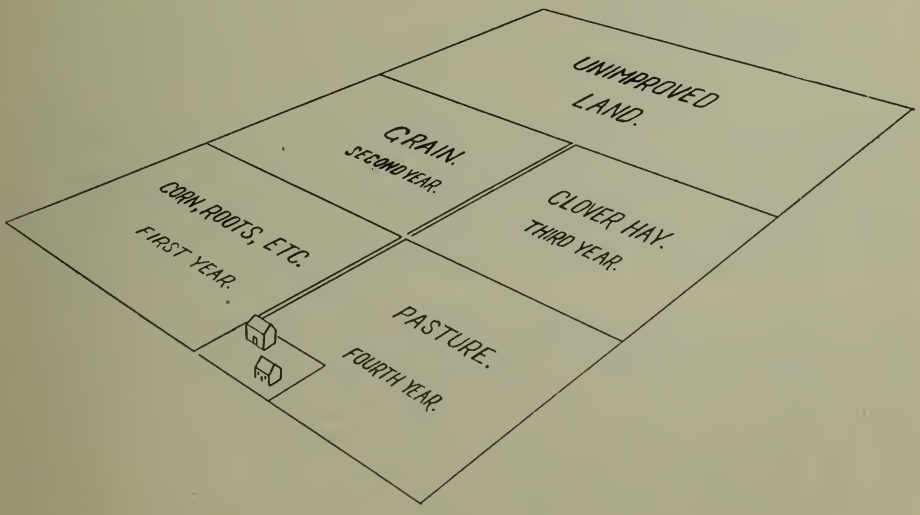
The farm manure should be applied in this rotation for the benefit of the corn crop. Unless the land is too rolling, it is customary on most soils to spread the manure on the sod land during the winter and to plough it under the next spring. The manure which is produced in other seasons may be applied to the land as soon as possible. The amount of manure which will be available will depend upon the number of cattle kept, upon whether they are fed inside all year or are pastured during the summer months, and upon the care which is taken in the handling of the manure. In the instance which has previously been given, where on a farm having 66 acres of cultivated land, 23 cows have been fed inside all year, there would be available sufficient manure to apply on the 17 acres of corn 15 tons per acre for the corn crop; on the remaining 5 acres in hay a top dressing of 8 tons per acre could be given. In the other example, where, owing to the larger crop yields, 35 cows could be fed inside all year, there would be available sufficient manure to apply on the first year of the rotation 20 tons per acre. However, these quantities would be available only when great care was taken in the preservation of the manure and when the cattle were fed inside all the year. Where the cattle were pastured during the summer months less manure would be available.

FOUR-YEAR ROTATION

First year: Corn, roots, etc.
Second year: Grain.
Third year: Clover hay.
Fourth year: Timothy hay or pasture.

First year: Corn, roots, etc.....	1933—corn 1934—grain 1935—clover hay 1936—hay or pasture
Second year: Grain.....	1933—grain 1934—clover hay 1935—hay or pasture 1936—corn
Third year: Clover hay.....	1933—clover hay 1934—hay or pasture 1935—corn 1936—grain
Fourth year: Timothy hay or pasture.....	1933—hay or pasture 1934—corn 1935—grain 1936—clover hay

This rotation allots one-fourth of the acreage to corn for silage or to roots or other crops, one-fourth of the acreage to grain, one-fourth to hay, and one-fourth to hay or pasture. It differs from the preceding three-year rotation only in that the hay crop is allowed to stand two years instead of being ploughed after one crop of hay has been secured. If there is difficulty in getting a stand of new grass and clover, there is less risk with the four-year rotation than with the



PLAN OF A FOUR-YEAR ROTATION

three-year rotation owing to the fact that one-half of the acreage of hay has been seeded two years previously while with the three-year rotation all the hay comes from the preceding year's seeding.

In a four-year rotation there would be 16 acres in hoed crop such as corn, roots, etc., on a farm having 64 acres under cultivation. This acreage of corn would supply sufficient silage for about double the number of cattle for which there would be sufficient grain, hay and pasture. It is probable that 8 acres of corn would be sufficient to feed the equivalent of 20 cows 40 pounds a day for seven months and that the remaining 8 acres could be seeded to grain. There would then be 24 acres in grain, 16 acres in hay and 16 acres in hay or pasture; this would be sufficient to feed, in addition to the silage to each cow averaging 5,000 pounds of milk, 1·1 tons of hay, and 1 pound of grain to each 4 pounds of milk. These acreages would be sufficient to carry this number of cattle provided there was some additional rough land for pasture.

The farm manure should be applied, in this rotation, principally for the benefit of the corn or root crops, while the remainder should be applied to the grain crop in the second year of the rotation, on that portion of the land where grain had been grown the previous year. The amount of manure which will be available will depend upon the number of cattle kept and upon the care which is taken in the handling of the manure. In the instance which has previously been given, where 20 cows have been fed inside for seven months, there would be produced in this period approximately 140 tons of manure while the work horses would produce in the stable about 21 tons making a total of 161 tons of manure. This would be equivalent to a dressing, in addition to the droppings received on the pasture land, of 2·5 tons per acre per year. For the eight acres of corn an application of 14 tons per acre could be given, while for the grain crop in the second year of the rotation, on that portion of the land where grain had been grown the year previous owing to the fact that corn was not required on the entire acreage of the first year of the rotation, a small application of 6 tons per acre of manure could be given.

FIVE-YEAR ROTATION

First year: Corn, roots, etc.
Second year: Grain.
Third year: Clover hay.
Fourth year: Timothy hay or pasture.
Fifth year: Grain.

First year: Corn, roots, etc.....	1933—corn 1934—grain 1935—clover hay 1936—hay or pasture 1937—grain
Second year: Grain.....	1933—grain 1934—clover hay 1935—hay or pasture 1936—grain 1937—corn
Third year: Clover hay.....	1933—clover hay 1934—hay or pasture 1935—grain 1936—corn 1937—grain
Fourth year: Timothy hay or pasture.....	1933—hay or pasture 1934—grain 1935—corn 1936—grain 1937—clover hay
Fifth year: Grain.....	1933—grain 1934—corn 1935—grain 1936—clover hay 1937—hay or pasture

This rotation allots only one-fifth of the acreage to corn for silage or to roots, while allowing two-fifths for grain, one-fifth for hay and one-fifth for hay or pasture. This proportion is perhaps better adapted to the needs of a larger number of farmers than the two preceding rotations. It will be observed that in this rotation, corn or roots follow a grain crop rather than hay. In the preparation of land for roots this is perhaps somewhat of an advantage, but for corn, there is little if any difference.

In a five-year rotation there would be 13 acres in corn on a farm having 65 acres under cultivation. If the corn yielded 10 tons per acre there would be produced 130 tons of silage which would be sufficient to feed more cattle than the farm could support with hay and pasture. It will be seen that 8 acres of corn would provide 80 tons of silage or sufficient to feed 20 mature cattle 40 pounds a day for 7 months. The remaining 5 acres could be devoted to hay. An additional acreage of rough pasture would be required to supplement the pasture-field in the rotation.

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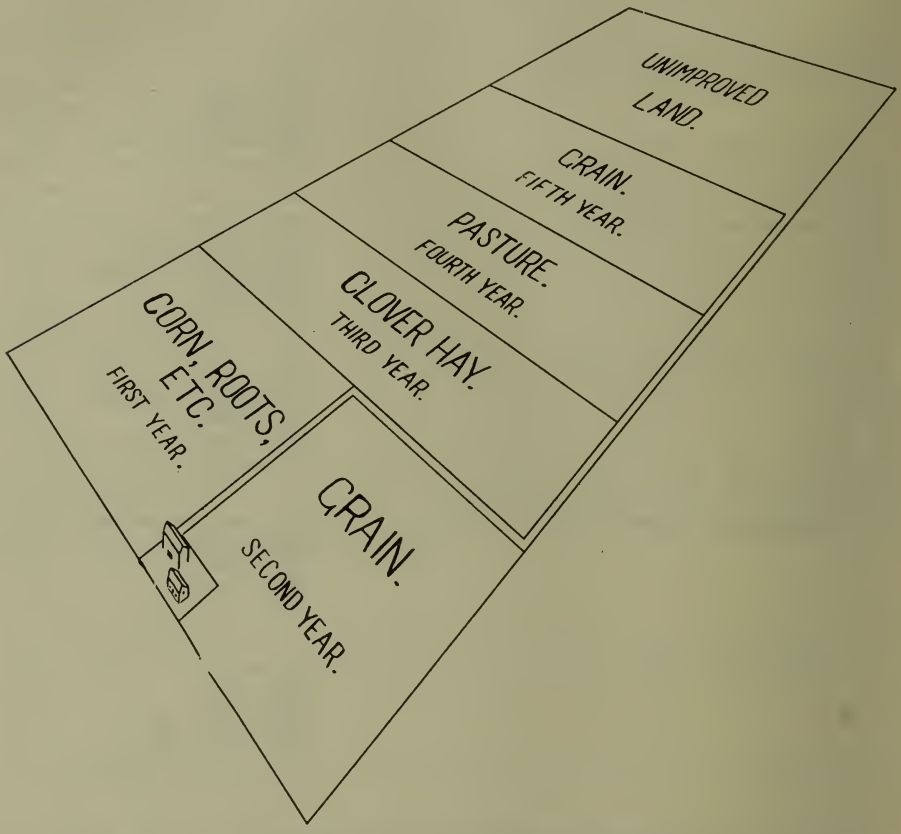
Farm manure should be applied to the first year of this rotation. To the 8 acres of corn or roots there could be applied 15 tons of manure per acre while to the remaining five acres in hay a light top dressing of 8 tons per acre could be given. This quantity of manure would probably be as much as could be produced on a farm where all the crops grown were fed to stock which was housed seven months of the year. However, if more manure were available a small top dressing could also be given to the clover hay.



PLAN OF A FIVE-YEAR ROTATION

FIVE-YEAR ROTATION

First year: Corn, roots, etc.
Second year: Grain.
Third year: Clover hay.
Fourth year: Grain.
Fifth year: Hay or pasture.

First year: Corn, roots, etc.	1933—corn 1934—grain 1935—clover hay 1936—grain 1937—hay or pasture
Second year: Grain	1933—grain 1934—clover hay 1935—grain 1936—hay or pasture 1937—corn
Third year: Clover hay	1933—clover hay 1934—grain 1935—hay or pasture 1936—corn 1937—grain
Fourth year: Grain	1933—grain 1934—hay or pasture 1935—corn 1936—grain 1937—clover hay
Fifth year: Hay or pasture	1933—hay or pasture 1934—corn 1935—grain 1936—clover hay 1937—grain

This rotation, like the preceding five-year rotation, devotes one-fifth of the acreage to corn for silage or to roots, two-fifths to grain, one-fifth to hay, and one-fifth to hay or pasture. It differs from the preceding rotation only in the order of the sequence of the crops and in the fact that no timothy hay is grown. Clover hay is seeded down twice during the rotation which increases the expense and also the risk, in some years, of failing to get a catch of new seeding. The object of growing two clover crops instead of one clover and one timothy crop, is to try to maintain the nitrogen supply of the soil and to produce a larger amount of legume hay or pasture which would have a higher feeding value than timothy. On the Central Experimental Farm, Ottawa, where the two five-year rotations were compared for a period of twelve years, no increased yields were obtained on this rotation; the soil on this farm, however, is fairly fertile which may account for the failure of this rotation to give increased yields over the other five-year rotation.

As this rotation has the same acreages of the various crops as the preceding five-year rotation, the modifications mentioned for that rotation in order to provide the required amount of the various feeds for stock, apply also to this rotation. The applications of farm manure could likewise be applied in a similar manner.

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Thorough and frequent cultivation of the land is the most effective means of controlling weeds.

SIX-YEAR ROTATION

First year: Roots, corn, etc.
Second year: Grain.
Third year: Clover hay.
Fourth year: Timothy hay.
Fifth year: Hay or pasture.
Sixth year: Hay or pasture.

First year: Corn, roots, etc.	1933—roots, etc. 1934—grain 1935—clover hay 1936—timothy hay 1937—hay or pasture 1938—hay or pasture
Second year: Grain	1933—grain 1934—clover hay 1935—timothy hay 1936—hay or pasture 1937—hay or pasture 1938—roots, etc.
Third year: Clover hay	1933—clover hay 1934—timothy hay 1935—hay or pasture 1936—hay or pasture 1937—roots, etc. 1938—grain
Fourth year: Timothy hay	1933—timothy hay 1934—hay or pasture 1935—hay or pasture 1936—roots, etc. 1937—grain 1938—clover hay
Fifth year: Hay or pasture	1933—hay or pasture 1934—hay or pasture 1935—roots, etc. 1936—grain 1937—clover hay 1938—timothy hay
Sixth year: Hay or pasture	1933—hay or pasture 1934—roots, etc. 1935—grain 1936—clover hay 1937—timothy hay 1938—hay or pasture

This rotation allots one-sixth of the acreage to roots or corn, one-sixth to grain, one-third to hay and one-third to hay or pasture. This rotation is suited to heavy land, which is adapted to timothy, rather than to light soils. Farm manure may be applied to the first year of the rotation at the rate of 15 tons per acre. If any additional manure were available it might be top-dressed on the timothy hay in the fourth year of the rotation.

This six-year rotation has been followed to some extent in the province of Quebec, roots being planted where corn would not grow well. On a farm having 66 acres of land under cultivation, there would be 11 acres in roots. If 60 pounds of roots were fed a day for 200 days, 10 acres of roots yielding 12 tons per acre would be sufficient to feed 20 head of cows. As the rotation stands, there is not a sufficient acreage of grain which would either have to be purchased or about 6 acres of hay land would have to be ploughed and seeded to grain. If a yield of 2 tons per acre of hay were obtained there would still be

sufficient hay for both the cattle and the horses. While the hay or pasture acreages would be more liberal in this rotation than in those previously described, nevertheless, some additional rough land would be required.

SEVEN-YEAR ROTATION

First year: Roots, corn, etc.
Second year: Grain.
Third year: Clover hay.
Fourth year: Timothy hay.
Fifth year: Hay or pasture.
Sixth year: Hay or pasture.
Seventh year: Grain.

First year: Roots, corn, etc.	1933—roots 1934—grain 1935—clover hay 1936—timothy hay 1937—hay or pasture 1938—hay or pasture 1939—grain
Second year: Grain	1933—grain 1934—clover hay 1935—timothy hay 1936—hay or pasture 1937—hay or pasture 1938—grain 1939—roots
Third year: Clover hay	1933—clover hay 1934—timothy hay 1935—hay or pasture 1936—hay or pasture 1937—grain 1938—roots 1939—grain
Fourth year: Timothy hay	1933—timothy hay 1934—hay or pasture 1935—hay or pasture 1936—grain 1937—roots 1938—grain 1939—clover hay
Fifth year: Hay or pasture	1933—hay or pasture 1934—hay or pasture 1935—grain 1936—roots 1937—grain 1938—clover hay 1939—timothy hay
Sixth year: Hay or pasture	1933—hay or pasture 1934—grain 1935—roots 1936—grain 1937—clover hay 1938—timothy hay 1939—hay or pasture
Seventh year: Grain	1933—grain 1934—roots 1935—grain 1936—clover hay 1937—timothy hay 1938—hay or pasture 1939—hay or pasture

This rotation provides one-seventh of the acreage in roots or corn, two-sevenths in grain, two-sevenths in hay and two-sevenths in hay or pasture. It is particularly suited to farmers who desire considerable hay or pasture and, also, to fertile, heavy clay land which is well adapted to timothy. It is not adapted to poor land owing to the fact that the hay is left down for four years before being ploughed. Farm manure may be applied to the roots or corn at the rate of 12 tons per acre and a top dressing of 6 tons per acre may be given to the timothy in the fourth year of the rotation. If more manure were available some larger applications of manure might be made.

This seven-year rotation has been followed rather extensively in the province of Prince Edward Island, roots being planted where corn would not grow well. On a farm having 63 acres of land under cultivation, there would be 9 acres in roots. This would give 54 pounds of roots a day for 20 cows over a period of 200 days, provided the roots yielded 12 tons per acre. There would be sufficient grain, hay and pasture to carry this number of stock very satisfactorily provided there was some additional acreage of rough pasture to supplement the pasture on the rotation.

COMBINATION ROTATION

First year: Corn, roots, etc.
Second year: Grain
Third year: Clover hay or pasture
For three-year period: Alfalfa hay

First year: Corn, roots, etc.
Second year: Grain
Third year: Clover hay or pasture
For three-year Period: Alfalfa hay

This combination rotation provides one-quarter of the acreage in corn or roots, one-quarter in grain, one-quarter in hay and one-quarter in hay or pasture. It is really a rotation within a rotation. One-quarter of the land is left in alfalfa for three years or longer and then it is included in the three-year rotation while a new area is taken to grow the alfalfa. This combination rotation may be varied to suit many conditions both as to different crops being used instead of those mentioned here, and as to a different duration of the rotation.

This combination rotation has the same acreages and proportion of crops as has the regular four-year rotation. The modifications mentioned for that rotation, therefore, would, in some measure, apply to this rotation except that the alfalfa hay, giving a yield much larger than that secured from ordinary hay, would provide an additional amount of this crop. The application of farm manure could be made in the same manner as that described for the regular four-year rotation.

MULTIPLE ROTATIONS

It is frequently desirable to use two or more rotations on the same farm. On the fields near to the buildings a rotation may be used which includes intertilled crops, while on the more remote fields, or, on the heavy or wet land, another rotation may be employed which uses only grain and pasture or grain, hay and pasture.

First Rotation (near buildings)—
First year: Corn, roots, etc.
Second year: Grain
Third year: Clover hay

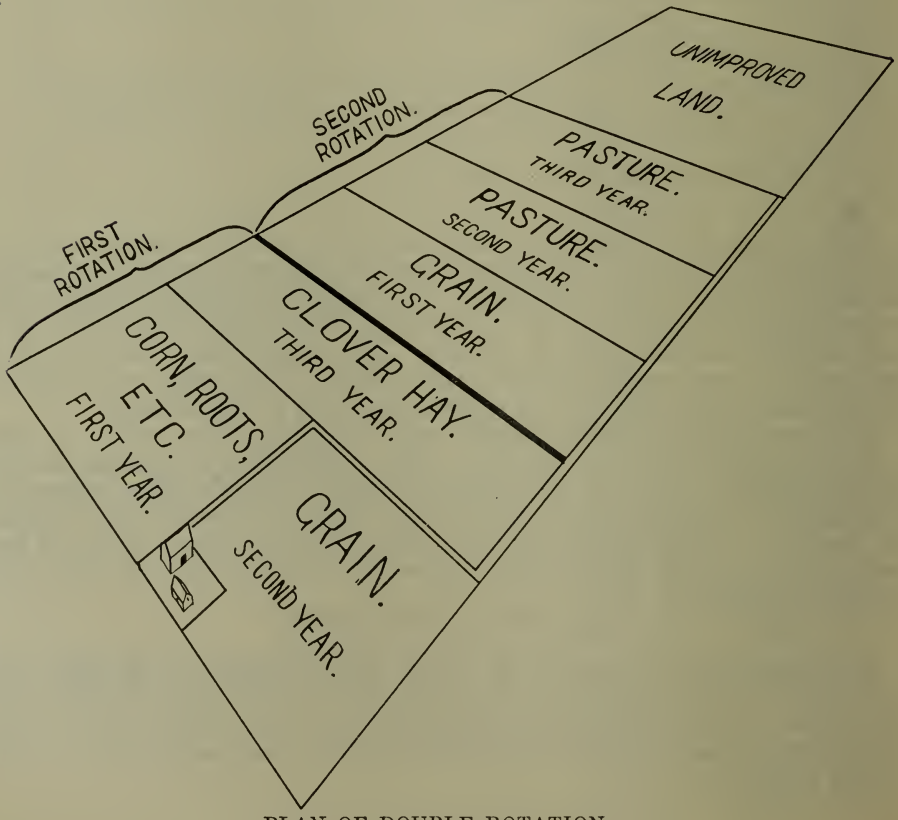
Second Rotation (on remote fields)—
First year: Grain
Second year: Pasture or hay
Third year: Pasture or hay

First Rotation—

First year: Corn, roots, etc.
Second year: Grain
Third year: Clover hay

Second Rotation—

First year: Grain
Second year: Pasture or hay
Third year: Pasture or hay



PLAN OF DOUBLE ROTATION

These rotations allot one-sixth of the acreage to corn or roots, one-sixth to hay, two-sixths to grain and two-sixths to pasture. If it is desired, more hay may be obtained by taking one of the pasture fields. The first rotation near the buildings provides the corn or roots while the rotation occupying the more distant fields is mainly devoted to pasture. Manure may be applied to the corn or roots at the rate of 12 tons per acre while any remaining manure may be applied for the second-year crop in the second rotation.

On a farm having 66 acres of land under cultivation, there would be 11 acres in corn. This would be slightly more than would be required, as 8 acres of corn at 10 tons to the acre would give sufficient corn to feed 20 cows, 40 pounds per day for 200 days. If it were desired to reduce this acreage the first rotation near the buildings could be arranged into a four-year rotation of corn, grain, clover and timothy which would give the exact acreage of corn necessary for this amount of stock. With this arrangement, there would be sufficient grain, hay, and pasture, provided there were some additional rough pasture available.

It may be desirable, under certain circumstances, to locate the crops which are to be harvested, in one part of the farm and to pasture the live stock on another part. Under these circumstances the crops which are to be harvested may be grown on fields which need not be fenced. The pastured fields could be fenced and arranged into permanent or rotated pasture as desired.

If the texture of the soil is very variable and the topography and drainage conditions very different on different parts of the farm, it may be necessary to have several rotations on the same farm. Certain fields may have to be handled separately, each being cropped perhaps in a special rotation and requiring as many years to complete the cycle of the rotation as there are crops in the rotation. The difficulty with this system, however, is the trouble experienced in some years of having too large an acreage in one crop and too little in another. Nevertheless, certain conditions may necessitate the adoption of this system of arranging the rotations. The soil on some fields may consist of heavy clay, perhaps poorly drained, which would not be suitable for certain crops such as corn or potatoes but would grow timothy and oats fairly satisfactorily. Such a field may be left in timothy for several years provided it is given adequate applications of farm manure or commercial fertilizers. It is impossible, however, to produce satisfactory crops of timothy hay on land which receives no added fertility beyond that supplied through pasturing the aftermath. Some soil might be suitable for alfalfa which could be grown successfully for several years on the same land until winter-killing or weed infestation injured the stand.

GRAIN-HAY-PASTURE ROTATION

In some localities there is frequently employed a cropping practice which consists simply of grain, hay and pasture. Each year a part of the pasture acreage is ploughed and seeded to grain. The hay consists usually of a mixture of red clover, alsike and timothy; two or three crops of hay are taken and then the land is pastured for several years, the pasture consisting principally of timothy. Unless the land is well supplied with fertility, the yields of hay and pasture, in such a cropping practice, become so small that they are no longer profitable.

In districts where alfalfa will grow satisfactorily, it could be used to very great advantage to replace to a large extent this hay and pasture mixture. On soil to which it is adapted, alfalfa gives a much larger yield per acre than do other hay crops while its feeding quality is also very much superior. Moreover, as the alfalfa derives its supply of nitrogen from the air and as it has such very deep roots, its manurial requirements are probably less than any other farm crop. It must be remembered that alfalfa pasture has a tendency to bloat

On the Central Experimental Farm, Ottawa, a hay mixture including alfalfa along with red clover, alsike, and timothy has given during the last fourteen years, an average yield of 3·5 tons per acre.

ruminant animals and that considerable care would have to be exercised in placing the animals on the pasture. It might be advisable to have in addition to the alfalfa pasture, some mixed clover and timothy pasture both from the standpoint of avoiding bloating when the alfalfa pasture is wet and also to reduce the risk of failure in the event of the alfalfa winter-killing.

It will be observed that this cropping practice does not include corn silage or roots. The writers of this bulletin do not recommend alfalfa hay and grain alone as an ideal feed for cows but the results of experiments conducted at the Utah and New Mexico Agricultural Experiment Stations show that alfalfa and concentrates have given almost as good results as when corn silage has been fed in addition to the alfalfa and concentrates. If a very small amount of roots were grown, say enough to feed only 15 pounds a day, this rotation might be somewhat improved. To produce this amount of roots for 20 cattle, would require, with a yield of 16 tons per acre, only about 2½ acres of land which would not require a great deal of labour. For information relating to the feeding value of various rations, readers are referred to the Division of Animal Husbandry, Central Experimental Farm, Ottawa.

ROTATIONS FOR MIXED FARMING

All the preceding rotations have been designed for stock farms where all the crops which are grown on the farm are to be fed to stock. Where it is desired to keep a smaller number of stock and to sell both animal products and cash crops, it is necessary to modify these rotations to meet these requirements. The main changes that will be necessary will be to reduce the acreage of silage crops and hay, and to devote this acreage to such cash crops as grain, potatoes or clover seed.

The three-year rotation of corn or roots, grain, and clover may easily be changed by reducing the acreage in corn or roots and planting this to some cash-crop. In some districts winter wheat is a profitable cash-crop, in other districts potatoes, clover seed or any other crop may be grown that offers a good prospect of giving satisfactory returns.

Perhaps the double rotation, in which two rotations are located on the same farm, may be as easily re-arranged as any from a live stock to a mixed farm rotation. In the first rotation, the acreage in corn or roots may be reduced and a part of this used for some cash-crop. In the second rotation, the pasture in the third year of this rotation may be eliminated and a cash-crop substituted. Other live stock rotations may be re-arranged in a somewhat similar manner so as to provide sufficient feed for the live stock and at the same time to produce some cash-crops for sale.

ROTATIONS FOR GRAIN FARMING

In Eastern Canada there is not a large percentage of farms devoted to grain farming. Most of the farms are mixed farms or dairy farms. In the Prairie Provinces of Canada, on the other hand, grain farming is pre-eminently the predominant type of farming. However, in Eastern Canada, there are some sections where grain farming is followed, and it may be of interest to give a few examples of rotations designed for this purpose. It must be understood that in Eastern Canada, the term grain farming rarely means the production of grain exclusively. It means that over fifty per cent of the income is derived from grain crops. Some additional revenue is derived from stock, poultry, fruit or other source.

With this system of farming in Eastern Canada, it is more difficult to maintain the fertility of the soil. The soil does not contain, in its virgin

condition, the high degree of fertility that is common in the Prairie Provinces where grain farming is practised. For this reason, it is clearly advisable to include in grain rotations as large a percentage of legume crops as can be grown with profit, and also to return to the soil all surplus straw that is not made into manure. The production of red clover, alsike or alfalfa for seed is a very useful practice on account of its removing from the soil only a small amount of plant-food constituents and of adding a considerable amount of nitrogen. This is particularly the case when the straw of these seed crops is returned to the land. It is possible that the available phosphorus supply in the soil might become a limiting factor in crop production under a system of grain farming but the application of superphosphate to the land could correct this deficiency without very heavy expense. It goes without saying that whatever farm manure is produced on the farm should be carefully protected and applied to the land.

Where winter wheat can be grown successfully the following rotation has given good results:—

First year: Summer-fallow.
Second year: Winter wheat.
Third year: Clover for seed.
Fourth year: Barley.
Fifth year: Clover for hay.
Sixth year: Oats.

Some criticism may be offered against this rotation owing to the inclusion of a summer-fallow. It is often claimed that inasmuch as the summer-fallow loses the returns from the land for one year it is, therefore, very wasteful. Whether this is true or not depends upon the weediness of the land. If the land is very weedy, the summer-fallow may be the most effective and, in the end, the most economical means of eradicating weeds. Certainly, in those sections of the country where this type of rotation is followed, many farmers are strong advocates of the summer-fallow. If it is not desired to seed the winter wheat on summer-fallow, it may be seeded on sod which has been ploughed early and allowed to rot, or it may be seeded after a grain crop.

In regions where winter wheat will not grow satisfactorily, winter rye will usually be found to be a safe winter crop, but, unfortunately, the price of rye is usually not sufficiently high to warrant the growing of this crop. Spring rye gives a very much smaller yield than fall rye and only under very rare circumstances is it a profitable crop. Spring wheat is frequently used as a grain cash-crop where fall wheat does not grow well. On very poor soil, fall rye may sometimes prove to be a profitable crop. Under such conditions buckwheat may also be found useful and these two crops might be included in a rotation for such soils. Peas are frequently a profitable grain cash-crop but they should always be seeded on clean land as they do not hold weeds in check very successfully. It is advisable also to seed peas on well-drained land, if possible, after sod.

ROTATIONS FOR POTATOES

A very good rotation for potatoes is to have this crop follow sod and especially clover sod. The following three-year rotation is very satisfactory:—

First year: Potatoes.
Second year: Oats.
Third year: Clover hay.

Sometimes this rotation is extended to a four-year rotation by growing a crop of timothy hay and following then with potatoes. It is not regarded to be a good practice to plant potatoes on old sod that has been in hay or pasture for several years, not because the potatoes would not grow well, but on account of the danger from wire worms and white grubs. On such land, it is advisable to first grow another crop, such as oats, and then follow with potatoes.

Where soils are too acid to grow red clover, alsike clover may be substituted or the potatoes may follow grass. It is regarded as somewhat inadvisable to apply lime to acid soils, so as to be able to grow clover, on account of the risk of causing scabby potatoes but if the potatoes are grown not oftener than once in four years and lime applied three years before the potatoes are grown, the danger is reduced. If the soil is too acid to grow clover satisfactorily the potatoes might be grown continuously on the same land for a number of years as suggested on page 29 of this bulletin.

ROTATION FOR PASTURE OR GREEN FEED ESPECIALLY ADAPTED FOR SMALL FIELDS

In adidtion to the rotation or rotations followed on the large fields of the farm, it is sometimes advisable to use a few small fields near the buildings for soiling crops or for pasture for stock. In order to obtain the largest yields from these fields, the crops grown on them should be arranged into a rotation. The choice of crops to be grown depends upon the kind of live stock kept and upon the relative yields of various crops on each particular soil and in different regions.

If two fields are available it is possible to arrange on them a four-year rotation so that one field may be pastured for two years and then the other field for two years. The rotation is as follows:

First year: Oats and peas.
Second year: Oats.
Third year: Pasture.
Fourth year: Pasture.

The crops in the first and second year of this rotation are placed on one field, each crop occupying one-half the acreage, while the crops in the third and fourth year are placed on another field which is used for pasture. In the second year, the oats are seeded on the oat and pea ground while the oats and peas are seeded on the oat ground, both areas being seeded down. The other field is pastured again the second year. In the third year of the rotation the field in sod is ploughed and seeded one-half to oats and the other half to oats and peas, while the other field is in clover for pasture. In the fourth year of this rotation, the crops are arranged in a manner similar to that described for the second year in the rotation. An important advantage of this four-year rotation consists in being able to arrange it on two fields without extra fencing while pasturing stock. If desired a two-year rotation could be arranged on the two fields in which a mixture of oats and peas were grown in the first year and clover in the second year. In order to avoid injuring the new seeding of clover, however, the mixture of oats and peas would have to be cut for hay or silage, or pastured very carefully.

A three-year rotation may be arranged so as to grow rape, a mixture of oats and peas, and clover.

First year: Rape.
Second year: Oats and peas.
Third year: Clover or alfalfa.

This rotation provides a large amount of pasture for hogs or for other stock on the farm. The oats and peas may be either pastured or cut for green feed. The land may be heavily manured without danger of lodging crops as is frequently the case when land is heavily manured for grain production. Where alfalfa will grow successfully it has been found to be the most desirable crop for hog pasture.

Another minor rotation may be arranged so as to grow oats and peas, fall rye, rape, oats and barley, and clover. This rotation will provide a large amount of pasture and, if it is desired, a considerable amount of green feed.

First year: Oats and peas, fall rye seeded in fall.
Second year: Fall rye, rape seeded in summer.
Third year: Oats and barley.
Fourth year: Clover.

This rotation provides very early pasture in the fall rye in the second year of the rotation. Perhaps to a small extent, late pasture may be obtained from the fall rye in the first year of the rotation although this is not very probable. The clover is available as pasture throughout the entire season while the oats and peas may be used either for pasture or may be cut for green feed.

As none of these crops are used for grain production, the land may be heavily manured. Probably the best place to apply the manure would be in the second year of the rotation in preparation for the rape crop.

THE USE OF CATCH-CROPS IN ROTATIONS

A catch-crop is a crop which is grown to take the place of a regular crop in the rotation which has been killed by unfavourable climatic conditions or it is a crop which is grown along with or between the seasons of regular crops. Most frequently the catch-crop is grown to take the place of some crop which has been winter-killed, such as, clover, or winter grains.

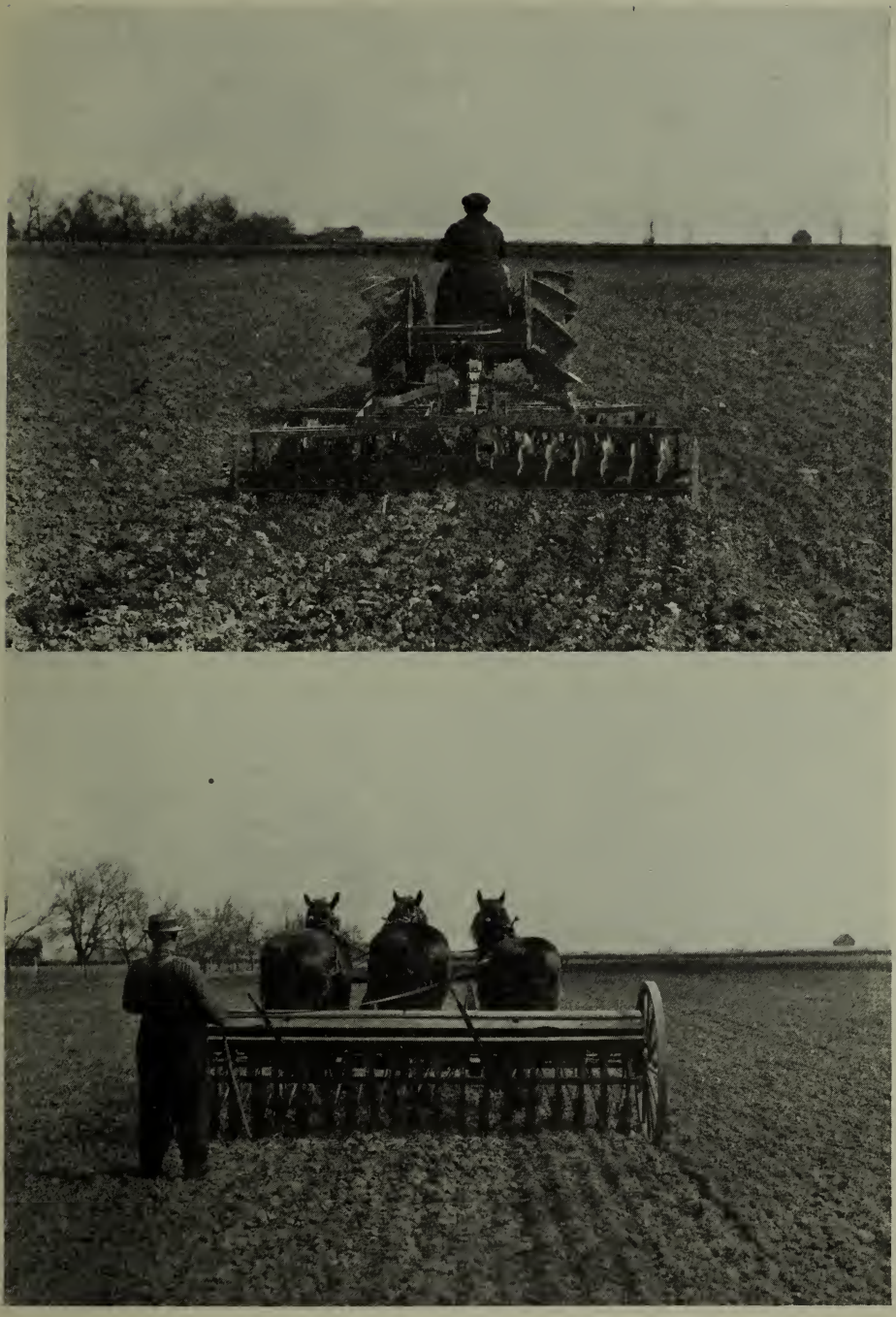
When clover winter-kills it is always a problem to know what is the best plan to follow. The first step is to decide whether the stand of clover is worth leaving, which cannot be done until growth starts in the spring. If the stand is too thin to leave, the best plan is to plough the land and seed it to some other crop. It is usually unwise to attempt to thicken the stand of clover by broadcasting clover seed early in the spring because such seed will not produce a crop of hay until the following year and hence will leave a very poor and unprofitable crop on the land for that year. Moreover, as the clover seed falls upon hard ground it frequently fails to get covered and does not germinate.

Under these circumstances, it is usually best to plough the land and plant it to a mixture of oats and peas for hay, seeding down the land again with clover and timothy. This plan undoubtedly entails more work and expense than would have been the case had the clover crop not winter-killed, but it is much better than allowing the land to produce a half crop of hay and become polluted with weeds.

Where fall wheat has been winter-killed throughout portions of a field, it is customary to re-seed the patches with oats or barley or an early variety of spring wheat. Barley ripens at nearly the same time as the winter wheat but the threshed grain is difficult to separate from the wheat; oats are much better in this regard, but are later than wheat in maturing. When stooking the grain, care should be taken to keep any sheaves of mixed grain separate from the wheat sheaves in order to secure a good grade of wheat. The use of spring wheat obviates these difficulties.

GREEN MANURE CROPS IN ROTATIONS

The practice of ploughing under crops for green manure to enrich the soil is very uncommon and very rarely profitable. Where the land is even in a fair state of fertility, where the crops are rotated, or where some manure is applied to the land, it is usually more economical to harvest the crop than to plough it under to enrich the soil. However, where grain-farming is con-



Large outfits reduce the cost and permit more timely work.

ducted on poor land, it may be necessary to plough under some green manure crops to maintain the crop producing power of the soil. In some fruit sections, also, it is considered good orchard practice to plough under some crop for green manure.

The best crops for green manure are legumes. The clovers are usually the best adapted for this purpose, being reasonably inexpensive for the seed and being planted along with the grain crop in the preceding year. Sweet clover, red clover, alsike clover or vetches may be used depending upon which will give the most luxuriant growth to plough under.

REARRANGING THE FARM FOR IMPROVED ROTATIONS

The first step in making any rearrangement of a farm, is to decide what acreages of the various crops are to be grown and what rotation is to be followed. It may be advisable to have two rotations on a farm in which a short rotation, including some of the more intensive crops, is located near the buildings while a longer rotation, using such crops as grain, hay and pasture, is placed on the more distant fields. Nearness to the buildings cannot in all cases be the determining factor in deciding the selection of the fields for the two rotations because the character of the soil in some fields may not be suitable for certain crops. Timothy hay, for example, grows much better on heavy soil or on wet land than do corn or potatoes.

As far as possible, large, oblong fields are much preferable to small or irregularly shaped fields. Small fields require very much more fencing than large fields, wasting considerable land and leaving a greater space where weeds can grow and infest the cultivated land. Moreover, small fields are much more difficult to work than those of larger acreages owing to the frequent turning and to the difficulty of utilizing larger machinery. However, it is impossible and inadvisable to attempt to make too much change in one year on account of the expense involved. Only such changes should be made in any year as can be done by the regular farm help in off seasons without necessitating the hiring of extra help. A plan should be made out in advance and all the subsequent work done in accordance with this plan. It may take five years or more to complete the work, but it is worth while. In the meantime, no one need be deterred from starting a rotation because the number of fields on the farm does not happen to be exactly correct for the number of years in the rotation one has in mind, even though one or two fields were allotted to each year in the rotation. It is easily possible to re-arrange the acreages so as to overcome this difficulty.

The drainage of certain fields or parts of fields is frequently necessary in order to make the following of a rotation possible. Good surface drainage is the first requisite. If water is allowed to stand for any considerable length of time on fields, serious injury to crops is almost certain. Surface drainage is easy to construct and is inexpensive. However, if open ditches cross fields, they occupy considerable land and make the work of the field very inconvenient. Unless the volume of water is too large, it often pays to put in an underdrain and thereby overcome these disadvantages. Underdrains are also frequently necessary to drain wet portions of fields so as to increase the yields on these spots and, also, to permit the seeding of the entire field at the same time. The removal of stone piles, stumps, and trees from all cropped fields is very desirable. It requires considerable labour to handle these jobs, but when once done the work is finished for all time. As in the re-arrangement of the fields the removal of all these obstructions may take several years to complete. It would scarcely pay to hire extra labour in order to finish the work in one or two years but such jobs afford very profitable employment for the regular help on the farm when there is little other work to be done.

THE VALUE OF AN ANNUAL CROP PLAN OF THE FARM

In order to keep a record of what crops have been grown each year on all the fields of the farm, it is very desirable to draw each year a small plan of the farm, showing the location of each field. On this plan may be written the crops which have been grown in each field and the yields per acre which have been obtained. When this plan is made every year it facilitates the following without error of any rotation which may be desired. It enables one to learn what fields produce the largest yields of certain crops, providing information to enable the improvement of the rotation along the line of adapting certain soils to crops to which they are adapted. Above all, such a plan provides a definite record of the results of each year's work on the land and over a period of ten years is very instructive. Farming is a long-time business and records are necessary if much improvement is likely to be made.

Such a plan of the farm may be drawn in a book so that many years records will be kept easily available. It is possible to use a few pages in the book to make a record of all cash receipts and expenditures and to record once a year an inventory of the value of all the equipment, live-stock and crops on the farm. These records, together with the cropping plan of the farm, give accurate information of each year's progress on the farm and are the best means of studying how to improve the farm business. No commercial enterprise would consider the conduct of its business without yearly records and neither should any farm. This method of keeping farm records is perhaps the most simple of any system but it gives, undoubtedly, the most fundamental information, and it has the great advantage of being extremely simple. If a more elaborate system of accounting is desired it may be adopted later.

THE EFFECT OF ROTATION ON CROP YIELDS

The best evidence of the value of crop rotation is to be found at those Experimental Stations where rotation experiments have been conducted over a period of many years. The effects of different cropping systems on the productivity of the soil are not always evident in a few years. The oldest experimental work with crop rotations in the world has been done at Rothamsted, England. Other long continued experiments have been conducted at the Agricultural Experimental Stations in Illinois, Missouri, and Ohio.

At Rothamsted, England, a four-year rotation of turnips, barley, clover, and wheat was commenced in 1848. As an experiment on the growing of wheat continuously had been started in 1843, and another experiment on the growing of barley continuously was started in 1852, comparisons are available, over a long period of years, between continuous and rotated cropping to wheat and barley. The following table shows the average yields per acre of 77 successive crops each of wheat and barley grown continuously and 20 crops each of wheat and barley grown in rotation.

EFFECT OF ROTATION AT ROTHAMSTED, ENGLAND

Average Yields per acre

Crop	Not fertilized	Fertilized
Continuous wheat.....bush.	11·8	21·7
Continuous barley.....bush.	13·4	39·3
Clover rotation		
Swedes.....tons	0·63	16·92
Barley.....bush.	20·2	35·4
Clover.....tons	1·52	2·94
Wheat.....bush.	22·3	30·4

On unfertilized land the yield of wheat was almost twice as great in the rotation as in continuous cropping. Where fertilizers were applied the rotated wheat also yielded considerably more than that grown continuously. Moreover, the continuous wheat received fertilizers every year while the rotated wheat received only the residual influence of the fertilizer applied three years previously to the turnip crop. The wheat in the unfertilized rotation yielded slightly more than that grown in fertilized continuous cropping.

Barley responded more to fertilizer than to rotation in the Rothamsted experiments. On continuous cropping the yield of barley was nearly three times as great on the fertilized land as on the unfertilized. Wheat yielded only twice as much on the fertilized land. In the rotation experiments it should be observed that inasmuch as the entire application of fertilizer is made for the turnip crop, the barley receives more benefit from the fertilizer than does the wheat. On the other hand the wheat, which follows a legume crop, receives more benefit from the rotation than does the barley.

The turnip crop was grown only in rotation, so that no comparison can be made for this crop with continuous cropping. It is clear, however, from the results obtained on rotation, that this crop cannot be successfully grown in rotation unless manure or fertilizers are applied.

The oldest rotation experiments in progress in America were started at Urbana, Illinois, in 1876. Comparisons are available between corn grown continuously and in a two-year rotation of corn and oats, as well as in a three-year rotation of corn, oats, and clover. In the following table are presented the average yields of corn obtained in these rotations, in comparison with the corresponding yields obtained on continuous cropping.

EFFECT OF ROTATION ON CORN AT URBANA, ILLINOIS

Average yields in bushels per acre

Cropping system	Not fertilized	Fertilized
Continuous corn (1904–1928)	22·6	36·0
Corn, oats clover rotation (1904–1928)	49·3	67·2
Continuous corn (1905–1925)	25·4	43·8
Corn, oats rotation (1905–1925)	35·6	59·2

The yield of corn in these experiments was considerably higher in rotation than in continuous cropping. In fact the yield of corn in the unfertilized three-year rotation was greater than in the fertilized continuous cropping. The three-year rotation yielded considerably more than the two-year rotation, due to the beneficial influence of the clover crop in this rotation.

Crop rotation experiments have been in progress at Columbia, Missouri, since 1888. In the Columbia experiments corn, oats, wheat, and timothy are grown continuously and in rotation. These experiments were originally designed to include continuous and rotated clover, but it was found impossible to grow this crop continuously. In the following table are presented the yields obtained in rotative and continuous cropping.

EFFECT OF ROTATION AT COLUMBIA, MISSOURI

Average yields per acre (1890–1915)

Crop	Not fertilized	Fertilized
Continuous corn.....bush.	21·0	30·7
Continuous oats.....bush.	19·5	33·6
Continuous wheat.....bush.	12·5	23·4
Continuous timothy..... lb.	2,894	5,850
Rotated corn.....bush.	38·9	44·8
Rotated oats.....bush.	27·3	34·6
Rotated wheat.....bush.	20·1	30·9
Rotated timothy..... lb.	2,446	5,379

The most outstanding point in connection with the Columbia rotation experiments is the fact that continuous timothy, on both fertilized and unfertilized land, has yielded slightly higher than timothy in rotation. This fact would seem to indicate that timothy may be advantageously grown in continuous cropping, especially where adequate amounts of fertilizer are applied. Some difficulty was experienced at Columbia in growing timothy continuously on unfertilized land, owing to weed encroachment. Where fertilizers were applied, however, timothy was able to compete successfully with the weeds, and satisfactory yields were secured.

With corn, oats, and wheat at Columbia, Missouri, rotation gave much better results than continuous cropping. The effect of fertilizer was nearly as great in rotation as in continuous cropping, the best results being obtained on rotated fertilized land.

At Charlottetown, Prince Edward Island, a comparison has been made, over a period of six years, of potatoes grown continuously and in a four-year rotation of potatoes, oats, clover and timothy. While this experiment has not been in progress for a long period, the results already obtained may be of some interest. The following table gives the average yields of potatoes for various treatments in this experiment.

EFFECT OF ROTATION ON POTATOES AT CHARLOTTETOWN, P.E.I.

Pounds per acre (1923–1928)

Treatment	Continuous	Rotation
Manure	11,657	11,574
Fertilizer	7,666	9,121
Manure and fertilizer	10,732	10,798
No manure nor fertilizer	2,321	3,649

It will be seen that where manure was applied the yield of potatoes was as large on continuous cropping as in rotation. Where no manure was applied, rotation gave a relatively large increase in yield over continuous cropping, but the actual yield in either case was very low. This experiment indicates the possibility of growing potatoes continuously provided adequate manuring or fertilizing is followed. Whether continuous culture of potatoes will lead to appreciable loss from plant disease, experiments as yet afford very little definite information. It must not be supposed that the foregoing discussion is intended to convey the idea that continuous cropping is preferable to rotation for potatoes. The object is to show that under certain conditions potatoes may be grown continuously with satisfactory results.

The influence of a leguminous crop in the rotation, as has been shown at Urbana, Illinois, assists in maintaining the productivity of the soil. Legumes are beneficial in maintaining the nitrogen content of the soil. It has been estimated that approximately two-thirds of the nitrogen content of a leguminous plant is derived from the air and one-third from the soil and that two-thirds of the total is stored in the leaves and stems of the plant and one-third in the roots. If this be the case, when the legume crop is removed from the field, it will take with it only the amount of nitrogen derived from the air. In other words, there will be no loss of nitrogen from the soil, the amount remaining practically the same as before the crop was grown. This result may be expected in soils containing an average amount of nitrogen. However, when the soil is very rich in nitrogen, there is a tendency for the legume to derive a greater amount of its nitrogen from the soil while, when the soil is poor in nitrogen, there may be an increase in this element even when the legume is removed from the land. If the leguminous crop is ploughed under instead of being removed it will obviously increase the amount of nitrogen in the soil. To what extent this increase will take place is not known, because the richer the soil is in nitrogen, the smaller is the percentage of nitrogen derived by legumes from the air. However, even where legume crops do not actually increase the amount of soil nitrogen, the decomposition of their residues activates the existing supply of soil nitrogen and frequently increases the yields of subsequent crops. Not only is the influence of leguminous crops which are harvested as regular crops in rotation very beneficial on the yields of subsequent crops but legume cover crops or catch crops, which are grown to be ploughed under for green manure, are also beneficial on certain poor soils. These crops, however, are not as profitable, ordinarily, as the use of leguminous crops which are harvested and should be used only where small trials have shown them to be beneficial.

METHODS USED IN PRODUCING CROPS IN ROTATIONS

CORN FOR SILAGE

Loamy or sandy soil may be spring-ploughed for corn but clay land should be fall-ploughed. Where land may be spring-ploughed, more time is usually available in the spring to do the work than is available in the fall. Manure which is produced during the winter may be spread during the winter or spring and ploughed under, while, if fall ploughing is done, it is sometimes a little difficult to disc the manure into the soil, especially if it is strawy. Where corn is grown on sod, there is usually quite a growth of material to plough under which is of considerable advantage if the soil is lacking in organic matter. Notwithstanding these advantages in favour of spring ploughing for corn on light land adapted to spring ploughing, on heavy clay soil fall ploughing must be done if maximum yields are to be obtained. Where possible corn should be grown on fairly light soils, as such soils are better adapted for the growing of this crop than are the heavy soils. If couch grass or other similar weeds are present, all kinds of land should be ploughed in the summer as soon as the preceding crop has been harvested. The land should then be cultivated frequently during the fall, and again ploughed late in the fall. Where the land is weedy there is no substitute for frequent ploughing and cultivating, but if weeds are not prevalent there is no advantage in its favour over one fall ploughing.

The land should be fairly fertile to produce corn for silage and it is customary to apply the manure to the corn crop in the rotation. An application of 12 tons to 16 tons per acre usually gives the most economical results. Larger applications, while producing in some cases slightly increased yields, would be better divided so that one dressing would be given to the corn and another, and usually smaller top dressing, given to the hay crop in the rotation. Two appli-

Where the land is weedy, early and frequent cultivation of corn is absolutely necessary.

cations of manure, even at small rates per acre, are more valuable than one heavy application which is equal to the sum of the two smaller applications. It is usually most economical to spread the manure on the land direct from the wagon in the winter or spring, but if the fields are too rolling this is not advisable owing to the leaching and waste of the manure in the surface drainage water.

Where no manure is available an application of commercial fertilizers may be used, consisting of 75 pounds of sulphate of ammonia or other equivalent nitrogenous fertilizer, 300 pounds of superphosphate and 40 pounds of muriate of potash per acre.

If a commercially mixed fertilizer is preferred a 3-10-4 mixture may be applied at the rate of 450 to 500 pounds per acre. Where a limited supply of manure is available an application of 6 to 8 tons of manure per acre may be used together with one-half the amount of fertilizer mentioned above. Fertilizers for various soil types are discussed later in this bulletin under the sections dealing with the management of various soils.

On the Central Experimental Farm, Ottawa, Wisconsin No. 7 corn is used for silage. In cooler regions medium-maturing varieties such as Bailey or Golden Glow may be used, while, if early varieties are desired, Compton's Early, Longfellow or Northwestern Dent would be suitable. Corn should not be planted until all danger of frost is over. Corn is very susceptible to frost injury and if frozen back will not resume growth from the root very successfully as is the case with cereal crops. It is usually necessary to replant corn if it has been frozen. Moreover, corn will not grow very well until warm weather commences. At Ottawa, corn for silage is seeded during the last week in May, as June frosts in this locality are unknown. In cooler regions slightly later planting may be necessary. The corn is seeded with a grain-drill in rows 35 to 42 inches apart, by closing up certain spouts of the grain-drill. The rate of seeding is approximately one-half bushel per acre. The plants are then thinned to about 6 inches to 8 inches apart in the row. Corn may also be seeded in check-rows so as to permit cultivation in both directions thus enabling a better control of weeds with much less hand labour. This method of seeding, however, is rarely used with corn for silage because the yields are slightly lower than where the corn is seeded in rows and because it requires a special corn-seeder to plant the corn, while, when the corn is seeded in rows, the ordinary grain-drill, which every farmer owns, may be used.

Thorough cultivation is very essential for the production of good corn crops. Corn will not compete with weeds and if these are allowed to grow the yields will be seriously reduced. Before the crop is up, the land may be harrowed to destroy small weeds and, if necessary, another harrowing may be given when the corn is about three inches in height. The cultivation should be started early and repeated as frequently as is necessary to keep the weed growth under control. The late cultivations should be fairly shallow to avoid cutting off the roots of the corn plants. The crop should be hoed by hand once or twice depending upon the condition of the land. One object of an intertilled crop is to destroy weeds but unless the tillage is actually done, the land may become more weedy after the crop than before it was grown. If the land is very weedy, an effort should be made the preceding fall to eradicate some of the weeds so as to reduce the amount of hoeing and cultivation necessary during the year when the corn is grown.

Corn may be cut at any one of several stages of maturity and still make fair silage but probably the best results are obtained when the corn is cut in the late dough or glazing stage. If the crop is cut too early, it contains an excess of moisture and, moreover, has not produced its maximum yield.

SUNFLOWERS FOR SILAGE

The preparation of the land for sunflowers is practically the same as for corn. The Mammoth Russian variety gives the largest yield per acre. It is seeded at the rate of 10 pounds per acre with a grain drill in rows 35 to 42 inches apart, the plants being thinned to 6 inches apart in the rows. It is possible to seed sunflowers somewhat earlier than corn both because the plant stands more frost and because it grows better at lower temperatures. The crop is cut when it is about 50 per cent in bloom.

In regions where corn does well, it should be preferred to sunflowers. In such regions, corn gives a slightly larger yield than sunflowers and, besides, makes a little better quality of silage; moveover, corn is somewhat easier to ensile. In regions as warm or warmer than Ottawa, there is no object in growing sunflowers except on very heavy land that is not adapted to corn. On very heavy clay land, however, sunflowers will give a much larger yield than corn and, furthermore, under these conditions, the sunflowers need not be thinned. Wherever the crop does not make a maximum growth, the plants should be left closer together and the distance between the rows should be 36 inches.

Manure and commercial fertilizer requirements for sunflowers are similar to those for corn and will be found under the discussion for corn in the previous section.

OATS AND PEAS FOR SILAGE

In regions where the temperatures are quite cool, it is probable that a mixture of oats and peas, or of oats, peas and vetches will give better results than sunflowers, and, of course, very much better results than corn. This crop is more adapted, in fact, to a cool climate than to a warm one; indeed, in a warm climate, like that of Ottawa, its yield is much smaller than that of corn or sunflowers. In the cooler regions of Canada, however, the mixture of oats and peas gives not only a very good silage crop but also, if it is desired, a crop which may be cured for hay. It is customary to seed this mixture in the proportion of 2 bushels of Banner oats to 1 bushel of Arthur, Chancellor or Early Blue peas to the acre, or, in districts where common vetches grow well enough to warrant planting, in the proportion of 2 bushels of oats, $\frac{3}{4}$ bushel of peas, and $\frac{1}{4}$ bushel of common vetches. When used for silage this crop should be cut when the oats are in the late milk to early dough-stage, but when it is used for hay, it should be cut a little earlier.

In view of the comparatively high cost of seed of peas it is recommended that a small area of land be seeded to peas in order to produce seed for the oats and peas mixture for silage.

SWEET CLOVER AS A SILAGE CROP

Sweet clover makes very palatable silage and where the crop produces good yields it is sometimes desirable to store it in the silo for winter feeding. The white blossom variety is usually sown in preference to the yellow variety. The rate of seeding is usually about 20 to 25 pounds per acre with a nurse crop of grain. Sweet clover appears to make the most desirable silage if it is cut when about half the plants are showing their first blossoms. If the crop is cut for silage before it blossoms or after it is all well into bloom it will usually produce

good silage, but the silage produced from the crop at these stages of maturity is not quite as palatable as if the crop is ensiled when the first blossoms are just beginning to show. It has not been found to be wise to allow sweet clover to wilt in the field after cutting for more than three of four hours, especially if the sun is shining. While the wilting of the cut material for this length of time is more likely to improve than injure the resulting silage, the excessive loss of moisture from the green cut material when it is left to wilt longer than 3 or 4 hours in hot summer weather may result in the formation of mouldy spots in the silage, because the material is too dry. Cutting and binding the green sweet clover with a grain binder, wherever possible, facilitates the rapid and economical handling of the crop into the silo. The addition of water will not improve sweet clover silage, except possibly when it is very dry. Ensiling without cutting with the silage machine will likely produce mouldy silage unfit for feed. Until the cattle become accustomed to the sweet clover silage they will not eat it as readily as they do the well made silages from other crops but after they acquire a taste for it no further trouble in this regard is experienced.

Manure and commercial fertilizer treatments for sweet clover, red clover and alfalfa are recommended in the section dealing with hay crops later in this bulletin.

RED CLOVER AS A SILAGE CROP

In regions where red clover grows with success it is usually made into hay but this crop will also produce very palatable silage. As red clover cut in full bloom yields a larger amount of feed nutrients than when cut later, and as earlier cut clover tends to be watery and undesirable for silage, this crop should be cut for silage when it is in full bloom. Two or three hours of wilting in the field is not likely to make the silage too dry but longer periods of wilting in dry sunny weather might result in too great a loss of moisture from the red clover lying in the swath. If the cut crop should become very wet from rain it should be allowed to dry off well before ensiling.

ALFALFA AS A SILAGE CROP

As alfalfa is superior for hay production to all other commonly grown hay crop it should generally be used for hay rather than for silage. Besides, it appears to be more difficult to make alfalfa into good silage than other legume crops and is therefore seldom used by farmers as a silage crop. Some advance has been made, however, by the Division of Field Husbandry in finding out methods of handling this crop in the form of silage which will result in the production of palatable winter feed. Alfalfa has been cut and ensiled when it was one-tenth in bloom and when it was in full bloom, without wilting, and after several hours of wilting. In all the experiments where pure alfalfa was ensiled immediately after cutting, the resulting silage was of poor quality. The larger the amount of moisture the crop contained, the more undesirable was the silage. This very moist silage did not turn mouldy but it became rancid and developed an acrid odour which was apparently almost as disagreeable to the dairy cows as to human beings. In one trial where the alfalfa was ensiled while still wet from rain, the silage was of particularly poor quality. Outside moisture such as rain or heavy dew on any of these legume crops at the time of ensiling increases the moisture content of the silage and lowers its quality. Cutting alfalfa when it had reached full bloom and allowing it to wilt in the swath in the field for 5 hours in the sun, or for a longer period if the sun was not shining, before drawing to silage cutter, resulted in production of silage which was eaten and relished by

the cattle. The difficulty with the wilting of the crop in the field is the danger of over-wilting which may dry the alfalfa too much and result in mouldy ensilage. Care and experience in the handling of this crop, however, will lessen the danger of the alfalfa becoming too dry before ensiling. The mixing of straw with the alfalfa when it was being put into the silo did not improve the palatability of the silage.

In one year's trials the alfalfa crop which was used for silage contained 25 per cent couch grass. This mixture of alfalfa and couch grass made good silage. Experiments have since been conducted with alfalfa to which has been added various amounts of green timothy. Twenty to 30 per cent of timothy which had been grown with the alfalfa, or mixed with it at the silo, improved the silage. The alfalfa was cut in full bloom and neither it nor the timothy was wilted in the field. Although the alfalfa and timothy mixture made fair silage it was not sufficiently good to generally recommend it to farmers. Leaving the alfalfa until a week past full bloom before cutting it for the silo and not allowing it to wilt at all has given good results. The addition of 1 or 2 per cent by weight of crude sugar or 2 to 4 per cent of molasses to alfalfa has improved the quality of the silage very materially. Excellent results have also been obtained by mixing 1 ton of second cut alfalfa with each ton of corn. The second crop of alfalfa is ready to cut about the same time as corn and not only is the alfalfa silage improved by the addition of corn but the protein in the mixture is higher than in corn alone and, therefore, the feeding value of corn silage is increased. Further experiments in regard to methods of making alfalfa into silage are being continued by the Field Husbandry Division at the Central Experimental Farm, Ottawa, in the hope of learning of more successful methods of making this splendid fodder crop into silage.

ROOTS

The land devoted to root crops should be in good tilth and should be rich in fertility. These crops are expensive to grow and unless very large crops are secured they are produced at a loss. If roots are grown on sod, the land should be ploughed in the late summer, cultivated during the fall, reploughed or ribbed in the fall. If manure is available it could be ploughed under when the land is ploughed in the summer but if it is not available then it could be applied in the winter or spring.

Manure should be applied at the rate of about 16 tons per acre. Where no manure is available a mixture of 100 pounds of nitrate of soda or 75 pounds of sulphate of ammonia, 300 pounds of superphosphate and 75 pounds of muriate of potash per acre may be applied. If a commercially mixed fertilizer is more economical 500 pounds of a 3-10-7 fertilizer may be used. If the manure supply is limited an application of 8 to 10 tons of manure supplemented with commercial fertilizers applied at one-half the rate mentioned above is recommended. Further discussion on manure and commercial fertilizers appears later in this bulletin in the sections dealing with the management of various soils. In the spring the land is disked or cultivated, harrowed, rolled and ridged up in ridges 27 inches apart. Where roots follow stubble crops the land should be fall-ploughed but there is not the same necessity of reploughing or ribbing as is the case where roots follow sod land. If couch grass or sow thistle are present two ploughings with thorough fall cultivation are very desirable.

It is customary to seed from 6 to 8 pounds of mangel seed per acre, or about 2 to 3 pounds of turnip seed per acre. The plants should be thinned to about 9 inches apart in the rows. Thorough cultivation and hoeing should be done to keep the land clean so as to produce a good crop.

POTATOES

Potatoes grow best on comparatively light but fertile soil. A good practice is to plant potatoes following clover in a rotation. This may be a clover sod or clover which has been seeded with a grain crop and ploughed down after the grain has been harvested. With plenty of fertility added potatoes may be satisfactorily grown for a number of years on the same soil. Care must, however, be taken to guard against various diseases to which potatoes are very susceptible.

The soil for potatoes should be thoroughly worked. It is good practice to apply manure if available at the rate of about 16 tons per acre and plough it down. The land should then be worked and the potatoes planted as soon as danger of frost is past. They may be planted in rows about 26 to 30 inches apart with the sets about 12 inches apart in the row and approximately 4 inches deep. The planting may be done by dropping the sets in a furrow and covering them with the plough. For larger areas, however, a potato planter may be used which will plant the potatoes and also apply commercial fertilizer if necessary. Potatoes respond to fairly liberal applications of commercial fertilizer. Where sufficient manure is available little or no commercial fertilizer is necessary. Where the manure is limited, however, an application of 8 to 10 tons of manure may be supplemented with 300 to 500 pounds of a 4-8-6 fertilizer. If the fertilizer ingredients are to be mixed at home a mixture of 60 to 90 pounds of sulphate of ammonia, 150 to 250 pounds of superphosphate, and 40 to 60 pounds of muriate of potash per acre may be used, the actual amount depending upon the state of fertility of the soil. If no manure at all is available an application of 500 to 1,000 pounds of a 4-8-6 mixture should be applied or 90 to 190 pounds of sulphate of ammonia, 250 to 500 pounds of sulphate and 60 to 120 pounds of muriate of potash per acre of a home mixed fertilizer.

After planting the land may be harrowed with a smoothing harrow once or twice to kill any small weeds which may appear. After the potatoes are up a cultivator may be used to keep down the weeds and to hill the potatoes slightly in order to keep the tubers covered and so prevent sunburn.

Potatoes must be watched for the appearance of the Colorado potato beetle or potato bug. At the first appearance of the larvae or young bugs the potatoes should be sprayed with a solution of arsenate of lead or Paris green. Paris green should be mixed with water in the proportion of 8 ounces of Paris green to 40 gallons of water. Four ounces of lime should also be added to neutralize the "burning" effect of the Paris green. Arsenate of lead paste should be mixed in the proportion of 2 to 3 pounds to 40 gallons of water. Later, sprays should be used against blight and may be made up of 4 to 6 pounds of copper sulphate, 4 pounds of unslaked lime to 40 gallons of water. Poisons for the Colorado potato beetle may be mixed with this solution.

For more detailed information in regard to growing of potatoes write the Publications Branch, Department of Agriculture, Ottawa, for free bulletin No. 90, "The Potato in Canada," by W. T. Macoun.

GRAIN CROPS

In practically all parts of Eastern Canada, fall ploughing of sod or stubble land is much superior to spring ploughing for grain. This is particularly true on clay land but it is also true to some extent on sandy soil. On clay land the action of the frost on the ploughed soil puts it in much better tilth than is possible when spring ploughing is practised. On sandy soil, where a good condition of tilth is not difficult to secure, spring ploughing will give nearly as large yields of grain as will fall ploughing, if the seeding is done early. Owing to the danger of a delay in seeding, however, fall ploughing is preferable. Where grain follows corn or roots, ploughing is unnecessary unless the land is infested with

couch grass or some other weed having an underground root-stock. Where other types of weeds are present, or where the land is reasonably clean, it is preferable to disc or cultivate rather than to plough as the surface of the land has already received considerable cultivation during the year of the intertilled crop. In those regions where the corn-borer is present, it is not advisable to disc the corn stubble but it is necessary to fall-plough the land.

The practice of applying manure directly to grain crops is not usually recommended. Manure being high in nitrogen content will generally produce a rank succulent growth which is required in a crop like corn or hay. With grain crops, however, seed is primarily the product which is needed and straw more or less of secondary importance. Manure is likely to produce a rank growth of straw which is usually followed by lodging and low grain yield. Manure should, therefore, be applied to the crop preceding grain and if applied in sufficient amounts and the soil fertility is not too low, grain should grow well with no further addition of manure or fertilizer. If the fertility is low, however, a light dressing of 8 tons of manure per acre might be applied to the grain. Commercial fertilizer is more commonly used as a source of fertility for grain crops. If manure has been applied fairly liberally in the rotation, an application of about 200 to 250 pounds of superphosphate would satisfy the fertilizer requirement. Where no manure is available or the supply is limited a mixture of 25 pounds sulphate of ammonia, or 35 pounds of nitrate of soda, 200 pounds superphosphate and 30 pounds muriate of potash per acre might be used. If commercially mixed fertilizer is preferred, about 250 pounds of a 2-12-6 fertilizer would be a good general mixture. Type of soil and other factors will have some influence on the fertilizer to apply and, these are discussed later in this bulletin in the sections dealing with management of various soils.

Good varieties of grain suitable to the district should be grown. The seed grain should be of good quality and should be free from weeds. It should be treated for smut. Naked and covered smut of oats, bunt of wheat and covered smut of barley may be controlled by treatments with formalin. The formalin should be mixed with water at the rate of 1 ounce of formalin to 2½ gallons of water. For accurately measuring the formalin a four or eight-ounce graduate, such as that sold for photographic purposes at most drug stores may be used. The grain is placed in a pile on the floor and the above solution sprinkled on with an ordinary watering can. The pile should be stirred by turning with a shovel in order that every kernel becomes thoroughly wet.

One gallon of solution will treat about 2 bushels of grain. The grain should then be piled in a heap and covered with bags for two or three hours after which it is spread out to dry and then seeded.

For oats the spray treatment may be used in which one pound of formalin is mixed with one pint of water. This may be sprayed on the grain while it is being shovelled over at the rate of ½ pint of solution to every 12 bushels of grain. After spraying the grain should be covered with bags for about 5 hours when it may be sown immediately. For more detailed information on smut treatment write to the Publications Branch, Department of Agriculture, Ottawa, for free bulletin No. 81 "Smut Diseases of Cultivated Plants" by H. T. Gussow and I. L. Conners.

The various grains should be seeded at the rates of oats 2½ bushels, barley 2 bushels, rye 1½ bushels, wheat 1½ bushels, peas 2 to 3½ bushels depending on size, buckwheat, 1¼ bushels and mixed grain at the rate of barley 1 bushel and oats 1 bushel per acre.

A very important factor which increases the yields of crops is early seeding. With no additional labour or seed, the yield on land planted early in the spring is very much larger than on land seeded later. It is obvious that this increased yield is reflected in larger returns and greater profits. While this point is already known by the majority of farmers, the magnitude of it cannot be realized without reference to figures.

The following table gives the yields of wheat, oats, barley and peas when seeded at six different dates in the spring. The first seeding was made as soon as the land was ready to sow and five successive seedings were made at one-week intervals. The experiments were undertaken at Ottawa, commencing in 1890, and continuing ten years with the wheat, oats and barley and five years with peas.

INFLUENCE OF DATE OF SEEDING ON YIELD OF GRAIN: OTTAWA

——	Oats	Barley	Spring Wheat	Peas
	bush.	bush.	bush.	bush.
First sowing	53·3	38·4	17·9	30·4
Second sowing	59·5	44·2	20·5	33·9
Third sowing	50·7	33·5	14·1	32·8
Fourth sowing	45·9	31·5	12·2	29·9
Fifth sowing	40·2	26·1	10·3	26·3
Sixth sowing	31·9	23·7	8·6	23·8

The advantage of seeding wheat, oats, barley and peas early in the spring is very outstanding at Ottawa. If seeding should, for any reason, be considerably delayed it is probable that barley would give relatively better results than the other grains.

HAY CROPS

The principal consideration in the production of hay crops is the selection of the heaviest-yielding kind of crop or mixture of crops which will make the best quality of hay. Usually a few years' experience in trying a number of crops, will supply this information. Within a given climatic region the texture and acidity of the soil very largely determines the kind of hay which will be grown. If the land is somewhat acid or sour alsike clover will have to be grown; red clover requires a neutral or basic soil, alfalfa demands a basic soil, while sweet clover is the most susceptible of all these crops to acid conditions. The common grasses are not nearly so sensitive to acid conditions of the soil as are the legumes. Timothy will grow on a wide range of soils but red top should be added where the soil is exceptionally wet and sour. Tall oat grass might be added to a mixture for light soils but it is probable that legumes such as alfalfa or sweet clover, if they can be started, are the best hay and pasture crops for light sandy land.

A mixture of timothy, red clover and alsike is perhaps the most commonly grown hay crop. It is frequently seeded at the rate of 8 pounds of red clover, 2 pounds of alsike, and 8 pounds of timothy per acre, although it is possible that on good soils somewhat smaller quantities of seed would be equally productive. On acid or wet land, where red clover does not grow very satisfactorily, a mixture of 8 pounds of timothy, 4 pounds of red clover, and 3 pounds of alsike per acre would be preferable. Where red clover will not grow at all the mixture might consist of 8 pounds of timothy and 5 pounds of alsike per acre. On exceedingly wet land which is flooded for a time in the spring, a suitable mixture would consist of 5 pounds of timothy, 5 pounds of alsike and 5 pounds of red top per acre.

Alfalfa is undoubtedly the most productive hay crop and in districts where it can be grown, it should constitute a considerable proportion of the hay acreage. In many parts of Ontario and in some parts of Quebec, the acreage in alfalfa has increased enormously during the last few years but in other parts of Quebec and in the Maritime Provinces, alfalfa has been more difficult to grow. However, even in these parts, experimental work has shown that this crop may be grown in many cases if proper methods are followed.

On farms which have not previously grown alfalfa, it is wise to select a field on which to make a start, that offers the best chances of success. A well-drained field is the first requisite. It is not necessary to have underdrainage but it is necessary to have good surface drainage. The land should not be acid or sour; if it is, this condition must be corrected by the application of lime. A fertile soil is very necessary in getting a start with alfalfa although, after this crop has become established, its manurial requirements are not heavy.

The safest and most economical method of trying alfalfa is simply to add a few pounds of alfalfa seed to the regular seeding of the ordinary hay mixture.

The bare spots in this second crop of alfalfa produced alsike and timothy in the first cutting. It is wise to add some alsike and timothy when seeding alfalfa to avoid losses where alfalfa kills out.

By adding only six pounds of alfalfa seed per acre, or even less, it is possible to learn if alfalfa will grow satisfactorily. If it does not grow satisfactorily, there will be lost only the cost of the seed, while if it does grow an increased yield of hay will be obtained. After a field has grown alfalfa along with other hay crops for a number of years, or if observation indicates that this crop is likely to prove a success, it may be desirable to seed a field of alfalfa and leave it down a number of years. Even under these circumstances it is wise to add a few pounds of timothy and alsike in order to produce a crop in any low parts of the field where the alfalfa might become killed. A satisfactory seeding for a field to be left in alfalfa might consist of 15 pounds of alfalfa, 3 pounds of timothy and 2 pounds of alsike per acre. It is very desirable to use only Canadian-grown alfalfa seed because it is more likely to be superior to imported seed in winter-hardiness. On all fields where alfalfa or sweet clover has not previously been grown, it is necessary to inoculate the seed with nitro-culture. The nurse-crop of grain, with which the alfalfa is ordinarily seeded, should be planted at a somewhat smaller rate per acre than is customary when the grain is seeded alone. Barley or wheat is preferable to oats as a nurse-

crop but the latter is also satisfactory. An early variety of oats, such as Alaska, gives the new seeding a better chance than a late variety. Where red clover and alfalfa do not grow as successfully or yield as well as sweet clover, the latter crop is sometimes used for hay. The white blossom variety is grown more exclusively than the yellow blossom variety. The seed is sown at 20 pounds per acre with a nurse crop of grain. The crop should be cut for hay before it blooms but after the flower buds are well formed.

Manure applications for hay crops are usually limited to light top-dressings on clover or timothy in the fall for the crop the following year. A procedure which is recommended is to apply part of the manure to one of the other crops in a rotation such as roots or corn and then follow this two or three years later with a dressing of 6 or 8 tons on the timothy hay crop. The objection to manure is the fact that when the crop is harvested it is impossible to rake the hay without raking up some of the manure. Thus while the manure may increase the growth of hay, the quality may be lowered due to the manure mixed in the hay. A dressing of commercial fertilizer will probably bring about as large increase in yield and overcomes the above objection. For timothy hay a dressing of 75 pounds of sulphate of ammonia or 100 pounds nitrate of soda may be all the fertilizer necessary. Where fertility is low, however, it might prove economical to apply a complete fertilizer of 60 pounds sulphate of ammonia or 75 pounds nitrate of soda, 200 pounds superphosphate and 70 pounds muriate of potash per acre or a commercial 4-10-8 mixture at 300 pounds per acre.

PASTURE

The principal reason for the decline in the carrying capacity of old pasture land is because the soil has become exhausted of fertility. Frequently it has been cropped without manure for so many years that it has ceased to produce a profitable crop of grain or hay, after which it has been allowed to stand in pasture. It must be remembered that pasture crops, like cultivated crops, require fertility and that good pastures cannot be produced on poor soil.

Commercial fertilizers are used quite extensively to increase the fertility of permanent pasture. A mixture of 100 pounds of sulphate of ammonia, 300 pounds superphosphate and 75 pounds of muriate of potash applied in early spring with an additional 50 pounds of sulphate of ammonia about one month and a half later has given good results. The sulphate of ammonia or any other nitrogen carrier should be applied every year. The mineral fertilizers, superphosphate and muriate of potash, need only be applied about every 4 years. If preferred a complete fertilizer applied once in four years may be made up of a commercial 4-10-8 mixture applied at the rate of 500 pounds per acre.

Perhaps the most effective and most economical method of improving pasture land is to plough it and put it into some kind of rotation which includes clover or other leguminous crop. Pasture land is liable to be deficient in nitrogen, and leguminous crops will prove, therefore, very useful in such circumstances. If the land is too light, too steep, or too stony to plough and improve for pasture, it may be most profitable, in the long run, to re-forest it with trees suited to the soil. At a slight initial cost, worn-out land may be covered with productive forest growth which requires but little attention and which, in a few years, will return a good income.

As a rule, it is unsatisfactory to attempt to re-seed old pasture land without first ploughing the land and putting it into good condition to receive the seed. It is simply a waste of seed to attempt to thicken the stand by broadcasting seed on the surface of unploughed pasture sod. When the land has been ploughed and cultivated, it is most economical to seed it down again with a grain crop, such as oats or barley or green feed, not seeding the grain at too heavy a rate per acre.

Permanent pasture mixtures should include a few additional grasses and clovers beyond those ordinarily employed for hay

If manure is not available, a small dressing of commercial fertilizers will frequently increase the grain yield considerably and also help the stand of grass. An application at seeding time of 75 to 100 pounds of nitrate of soda or sulphate of ammonia, 300 pounds of superphosphate and 75 pounds of muriate of potash, or approximately 500 pounds of a 4-10-8 mixture, will usually give good results on poor land that has just been broken out of old pasture sod. If the pasture land cannot be ploughed, this application of commercial fertilizers may also prove profitable if there is a fair stand of grass, but ploughing and re-seeding are very desirable. If the land is acid, a small application of ground limestone should be given.

If the land included in the regular farm rotation is to be used for pasture the hay mixtures recommended in the previous section may be employed. When re-seeding the land with the object of having it remain in pasture for a number of years, it may be advisable, in order to produce a more permanent stand, to include a few additional grasses and clovers beyond those ordinarily employed for hay. On loam or clay soil, the following mixture may be seeded per acre: timothy 6 pounds, red clover 6 pounds, alsike clover 2 pounds, white clover 2 pounds, Kentucky blue grass 2 pounds, red top 2 pounds, and orchard grass 2 pounds. In very wet or acid land where red clover may not grow well, the red clover may be eliminated from the mixture and the alsike seeding increased to 4 pounds per acre. Where alfalfa will grow successfully it produces the largest yield of any pasture crop and for hogs it makes an ideal pasture. For ruminant animals, however, great care must be taken to avoid bloating.

For temporary pasture, white-blossom sweet clover is very useful in regions where it will grow satisfactorily. When seeded with oats, at the rate of $2\frac{1}{2}$ bushels of oats and 20 pounds of sweet clover per acre, pasture may be afforded the year in which the crop is seeded and also, by the sweet clover, during the following year. The land, however, must then be ploughed. In regions where sweet clover will not grow, an annual pasture may be secured by seeding a mixture of oats and peas at the rate of 2 bushels of oats to 1 bushel of peas per acre; even a seeding of oats alone, at a rate of 3 bushels per acre, gives a fairly good annual pasture.

ROTATIONS AND TILLAGE METHODS TO CONTROL WEEDS

While rotations will not of themselves alone control weeds, they afford an opportunity of using such tillage methods as may be necessary to keep the weeds in check. Thorough and frequent cultivation of the land is the most effective means of controlling weeds. The rotation should be planned so as to permit adequate ploughing and cultivation.

While many other good rotations may be used, the following five-year rotation has given very satisfactory results on the Central Experimental Farm, Ottawa. If other rotations are being employed, it may be found useful to follow the same tillage methods as are suggested for this rotation. The tillage methods described for this rotation refer to the control of couch grass and mustard but the methods applicable for these weeds will also be found applicable for many other weeds. Couch grass is an example of a bad weed having an underground root-stock, while mustard is an example of a weed producing a large number of long-lived seeds. The following sequence of crops is employed in this five-year rotation:—

First year: Grain.
Second year: Corn.
Third year: Grain.
Fourth year: Clover.
Fifth year: Timothy.

This rotation has the advantage of requiring considerable cultivation of the land and, on this account, gives a good opportunity of killing weeds. If

Proper method of cultivation control couch grass. On the right, land ploughed late in summer and cultivated during fall; on the left, land ploughed in the spring. Both are planted to potatoes.

couch grass is present, the timothy sod may be ploughed about August 1 after the hay has been removed; the land should then be disced at least once a week until it is possible to use the cultivator without tearing up the sod. This implement should then be used at frequent intervals until late fall when the land should be reploughed and left rough, to expose the roots of the couch grass. In the following spring, the land should be well cultivated before the grain is seeded. When the grain has been removed at harvest time, the land should be ploughed and cultivated frequently during the fall and again ploughed in the late fall and left rough over the winter. In the following spring, the land should be cultivated as soon as time permits after seeding the grain, and again cultivated before the corn is seeded. During the summer, the land should be well cultivated and hoed and then ploughed in the fall. In the following year, grain may be planted and the land seeded down.

It will be seen that this rotation permits sufficient cultivation to keep couch grass in check. It will be found, also, that other weeds which have underground root-stocks will be eradicated by this method of cultivation. Once these weeds have been controlled there is no advantage in ploughing the land twice during the year but, while they are prevalent, two ploughings are very useful. For other types of weeds, after-harvest cultivation should also be given; it is possible that if the disc harrow be used immediately after a grain harvest and repeated as necessary throughout the fall along with one final fall ploughing, this may be as effective as two ploughings. Circumstances will decide which plan is preferable.

If many weeds, such as mustard or stinkweed are present, it has been found to be preferable to merely disc or cultivate the corn stubble in preparation for grain, rather than to plough it. If the corn has been well cultivated, the surface soil should be fairly free from weeds, but when the land is again ploughed more weed seeds are turned up from the lower depths of the soil. If both mustard and couch grass exist, one must decide which weed is worse and plan his methods accordingly. If the couch grass is the more injurious, the land will have to be ploughed but if the mustard is worse, discing or cultivating the land will be preferable. However, in regions where the corn-borer is present, it is not advisable to disc the corn stubble but it is imperative to fall-plough the land as early as possible, burying completely all the crop residue.

Leaving the land in hay for a number of years is a fairly effective means of controlling some weeds especially if there is a thick stand of hay. Alfalfa is one of the best hay crops for this purpose but it must be remembered that it can be used only against certain weeds such as mustard and wild oats, and that the land must not be too weedy when attempting to get a new stand of alfalfa. A mixture of clover and timothy is also fairly effective but care must be taken not to allow the stand to get too thin. A top dressing of manure is very effective in thickening the stand of grass and helping to keep the weeds in check.

The use of rotted manure on weedy farms is preferable to unrotted manure in order to prevent the reseeding of the land with weed seeds. Considerable loss in manurial constituents is suffered by rotting the manure but this loss is less than the damage caused by spreading on the land more viable weed seeds. It is very difficult to control weeds if additional seeds are scattered each year over the land. Rotting the manure prevents one source of reseeding the land with weeds. Care should be taken in rotting the manure to make the manure pile with square sides and a somewhat dished top to catch the rain and thereby to keep the manure moist. It is best to place the pile away from the eaves of buildings and on a concrete bottom provided with low sides to prevent the leaching away of the constituents of the manure. The sides and top of the pile should be turned so that they will have an opportunity of rotting, otherwise this portion of the manure pile may be the cause of reseeding the land with weed seeds which have not been killed. It is obvious that the use of clean seed

grain is one of the most important and least expensive measures in keeping a farm free from weeds. The hand picking of small patches of weeds as soon as they are noticed is also very important, often eliminating the necessity of expensive cultivation in later years if the small patches of weeds had been allowed to grow unchecked.

THE SUMMER-FALLOW

An excellent method of eradicating weeds is to place the land for one season in summer-fallow. In Eastern Canada this method is very rarely employed but in Western Canada the summer-fallow is a regular part of the great majority of crop rotations. In Western Canada, the summer-fallow is used not only to eradicate weeds but to conserve moisture from one year to another. In Eastern Canada, on the other hand, where sufficient moisture is usually available, the summer-fallow is rarely used in rotations. Experiments show that, where weeds are not a factor, spring seeded crops do not give any larger yield, when following summer-fallow, than when grown on land which has been cropped the previous year.

On some fields, however, where the land is very badly infested with weeds, and where time or labour will not permit the necessary cultivation to handle these weeds in the regular rotation, a summer-fallow may be necessary. Under such circumstances, the land should be ploughed in the fall if possible or, if not, then as early in the spring as time permits. It is very important to cultivate the land very thoroughly and as frequently as is necessary to keep down the weed growth. If weeds with underground root-stocks are present, it is imperative that the land be kept free from any top growth of the weeds, because if these are allowed to grow, the roots receive additional nourishment and their life is revived. The use of a cultivator which will tear up the roots to the surface of the ground, where they will be killed by the sun, is very necessary. In some cases, where the weeds are especially troublesome, a horse-rake may be used to rake the weeds into windrows from which they may be hauled off the field. With this type of weed, the land should be cultivated if possible when it is dry and when the weather is hot and the sun is shining. It is usually wise to plough the summer-fallow twice both for the object of killing weeds with underground root-stocks and so that the weed seeds, in the lower depths of soil reached by the plough, may be brought to the surface, germinated, and killed.

PARTIAL SUMMER-FALLOW AND SMOTHER CROPS

In some cases a partial summer-fallow may be used, that is, the land may be handled like a summer-fallow up to the time it is necessary to seed some late-seeded crop like buckwheat. Buckwheat is a fairly good crop to smother out some weeds and, as it is not seeded in many districts until about June 21, time is available to give the land very thorough cultivation before the land is seeded. When a partial summer-fallow is used, it is advisable to plough the land the preceding fall, cultivate it thoroughly during the spring and again plough and cultivate before seeding the buckwheat. Rape is another crop which may be seeded to smother weeds and, as it also may be seeded late, an opportunity is given to cultivate the land before seeding the crop.

Other crops like winter wheat and winter rye may be seeded on the summer-fallow. These crops do not smother weeds like buckwheat and rape but as they are seeded much later in the season, they allow practically all the summer in which to cultivate the fallow. Moreover, these crops ripen fairly early the following year, permitting the land to be ploughed in the summer, cultivated during the fall and again ploughed late in the fall. This may seem like a considerable amount of cultivation but there is no royal road to the eradication of weeds.

THE VIABILITY OF WEED SEEDS

The seeds of many weeds live in the soil much longer than many people realize. The Michigan Agricultural College is now conducting an experiment to learn definitely just how many years the common weed seeds will lie dormant in the soil and then resume growth when suitable conditions are created. They planned an experiment in which weed seeds were mixed with sand and placed in uncorked pint bottles, buried 20 inches below the surface, and slanted with the mouth downwards to prevent the accumulation of water in the bottles about the seed. One of these bottles is removed every ten years and there are sufficient bottles to continue the experiment for 100 years. The experiment has already run 50 years and it has been found that some weed seeds still germinate quite satisfactorily. Black mustard, smartweed, wild primrose and curled dock germinated after 50 years in the soil. After 40 years, peppergrass, pigweed, ragweed, purslane and common plantain also germinated. It is interesting to know that some of these weed seeds failed to germinate when removed in the earlier years of the experiment but did so in later years. Ragweed, in fact, failed to germinate until it had been forty years in the soil. With such remarkable results as this, who knows how long the weed seeds will last? It is certain that no one should assume that he can ever let up in his war against weeds, especially if his land has once become infested. It is clear that preventing weeds getting a start on the land is pre-eminently the most important method of weed control. The neglect of weeds for one year only, may plague a man with this trouble all his life.

ADAPTING CROPS TO SOILS

In the adaptation of crops to soils there are five important soil factors to be considered, namely, fertility, acidity, drainage, physical characteristics and topography. A fertile soil is usually a productive soil and well adapted to most of our common farm crops. There are some crops, however, which are not well suited to very fertile soils. Buckwheat, for example, often produces too much straw and too little grain on rich soils, especially those soils which are very high in nitrogen. Oats are likely to lodge badly on soils too rich in nitrogen. On the other hand, a fertile soil is essential for profitable yields of wheat and barley. Rye will grow well on rich soils but it is also a particularly good crop for light infertile soils. Turnips require a fairly fertile soil but if it is unbalanced in its fertility by having an over abundance of nitrogen in comparison with other elements of fertility, there will be luxuriant tops but small roots. Mangels, however, do not appear to suffer to the same extent as turnips by a very large amount of nitrogen. For all kinds of root crops an abundance, and a balanced amount of nitrogen, phosphorus and potash is necessary. On soils lacking in fertility turnips are likely to do better than mangels. In Eastern Canada the soils as a rule are rather deficient in phosphorus and most field crops will benefit by dressings of fertilizers, like superphosphate, which carry phosphorus. A fair amount of fertility is needed to get alfalfa started, but after it is once well established it needs, as a rule, but small dressings of manure or commercial fertilizers. Fertilizers carrying phosphorus are usually the ones which give the best results for alfalfa. On soils inclined to be sandy, potash is also desirable. While sweet clover gives the largest yields on fertile soils, if they are not acid, this crop will usually produce successful crops on poor soils and may, moreover, make the soil richer in nitrogen, if the whole crop or even the second growth is ploughed under. Fertile soils will produce the largest yields of corn, sunflowers, mangels, peas and beans, but generally some other environmental factors such as drainage, and soil type must also be considered if the maximum yields are to be obtained.

Most of our commonly used farm crops grow best on soils which are slightly acid to slightly alkaline. Only a few will give maximum yields on a soil which

is quite acid. Potatoes, alsike clover, rye, red top, buckweat and millet are amongst those crops which do well on acid soils. Oats, turnips, sunflowers and corn are fairly tolerant to acid soil conditions. Sweet clover and alfalfa will not grow successfully on acid soils. Red clover grows better than these other two legumes on acid soils but makes its best growth on soils that are not acid.

The application of ground limestone is usually a profitable practice for improving crop yields on acid soils. It sometimes happens that the surface soil is acid but the subsoil is rich in calcium. In such cases a light dressing of limestone has resulted in getting alfalfa started and once the alfalfa roots get established in the subsoil profitable alfalfa crops are produced for a number of years.

There are a few crops which will grow successfully on poorly drained land. Alsike clover is probably one of the best. Red top and meadow fescue and orchard grass are also fairly successful under such conditions and timothy will make a little growth. Where conditions are such that even if the land were redeemed by drainage it would not be of much value, it would seem to be best to seed the land down with a mixture per acre of 5 pounds of alsike clover, 5 pounds of red top, 2 pounds of meadow fescue and 4 pounds of timothy, and leave the land in sod rather than go to the expense of making a general drainage system. Where drainage is needed and the value of the land warrants the expenditure, it must be drained if most farm crops are to be grown successfully. On many farms particularly where the land is clay, better yields might be secured if more attention were paid to surface drainage. This is especially true where the time of seeding can be hastened by such means. On many farms natural drainage takes care of most of the excess water and under-drains may only be profitable for main waterways and for low spots or potholes.

By an examination of the size of the roots of plants we can pretty safely judge the type or physical characteristics of the soils to which they are best adapted. Fine rooted crops, like grasses and cereals, are likely to find in such fine-textured soils as fertile clay and clay loam, environmental conditions well suited to their production, although they will grow fairly well on fertile sandy loams too. Corn and potatoes are examples of crops suited to the more open-textured lands like sandy and gravelly loams. On fertile clay and clay loams, alsike and red clover seem to yield a little higher than on the lighter soils. Alfalfa, sweet clover and oats seem to be rather versatile in their requirements, doing almost as well on heavy as on light soils. On some clay lands corn gives particularly poor yields. On an area of such land on the Dominion Experimental Farm at Ottawa sunflowers have greatly outyielded corn both in total green yield and in dry matter as well. Turnips usually give a little better results than mangels on the lighter soils. Clays are usually unsuited for most root crops because of the difficulty in securing a fine seed bed. Beans prefer a well drained loam, silt loam or clay loam, and peas do their best on clay loams. Light gravelly and sandy loams are not well adapted to the production of peas as the plants are liable to dry out. Muck soils produce large growth of vine but small yields of seed. Of the fibre crops, hemp requires a rather light well drained fertile soil, while flax does best on soils of a heavier type which are not too rich in nitrogen. For light soils lacking in fertility, rye and buckwheat, and where the soil is not sour, sweet clover, and in some cases alfalfa, are usually good crops to sow. Oats will usually also do fairly well on light infertile soils. Wherever rye is to be grown it is generally wise to choose fall rye rather than spring rye as the former crop yields more grain per acre.

Topography has also an influence on the choice of crops. Hillsides should usually be kept in sod crops because they are difficult to cultivate and, besides, when kept in sod they do not suffer from erosion. When cultivated crops are grown the fertile surface soil will slowly be carried down to the base of the hill by the rain. Low lands suffer more from frost than high lands. Too early sowing of crops like corn, turnips, beans and buckwheat on low lying land should be

avoided. Crops on muck lands also suffer from frost to a greater extent than crops on mineral soils. On spring nights the temperature which does not reach the frost point over upland soils may, over low-lying lands, become so cold as to destroy certain tender crops. The reason for this is that the heavier cold air settles in the lower levels and when there is little movement of the air it remains there. Moreover, muck and peat soils being open in texture, lose heat more rapidly than other soils and as they act as a kind of insulating material they prevent the upward movement of heat from the subsoil as is the case in other ordinary types of soils.

It is of course incorrect in most cases to say that certain farm crops are suited only to heavy and not to light soils or vice versa. Other soil conditions, such as fertility and acidity, must be considered in practically every instance before a soil is condemned as unsuitable for any crop. Potatoes, for example, though pre-eminently suited to the lighter soils are often grown with good success on fertile well drained clay soils.

Farmers should be guided by local conditions in the choice of their crops. Market facilities, climate and the peculiar type of farming which they pursue may require that they grow certain crops even though some other crops might probably give better yields. Moreover, it is often difficult to say exactly just what is the best crop under some conditions. If, however, there is a choice between different fields containing different types of soils, larger yields are likely to be secured if the soil preferences of the crops to be grown are carefully considered before seeding.

MANAGEMENT OF CLAY SOILS

Properly managed clay soils are very productive and farmers who understand their drainage requirements, how and when to plough and cultivate, and what crops to grow, usually prefer them to the lighter soils.

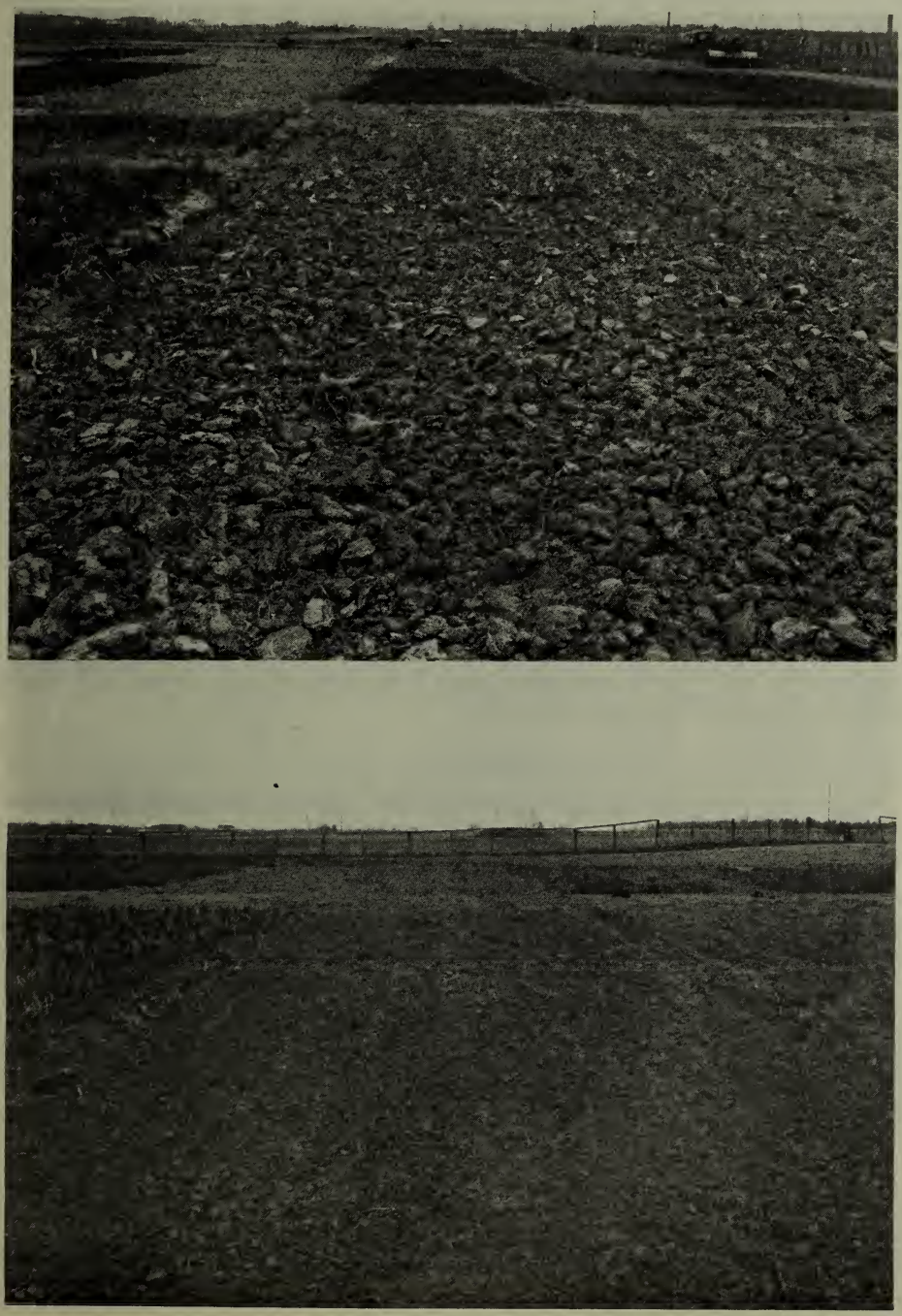
Clay soils owe their special characteristics largely to their fine texture. Their large water-holding capacity and poor under-drainage is the immediate result of this texture. As a secondary result, they are liable to be slow in warming up in the spring and seeding may consequently be delayed. The activity of bacteria which prepare the nitrogen of the soil for the use of the plants may be retarded also because of the lack of air and the prevailing low temperature. For general farming, therefore, everything possible must be done to secure good surface drainage when the expense of tile drainage is unwarranted. Clay soils bake easily and readily form clods, making cultivation difficult even under good methods of management. Lack of organic matter increases the tendency to become cloddy. Ploughing and other tillage operations must be conducted when the soil has the proper content of moisture, that is, when it is dry enough not to puddle when worked. Phosphorus and nitrogen are the elements of fertility most likely to be deficient in clay soils, while potash is usually found in sufficient quantities for the production of field crops. The liberal use of farm manure, the inclusion of legume crops in the farm rotations and, in some cases, the application of dressings of superphosphate are practices which if carefully followed, should maintain the fertility of clay soils. The production of fine-rooted crops such as cereals and hay are especially well adapted to clay soils.

PLOUGHING OF CLAY SOILS

Late summer or fall ploughing is the general practice for clay soils. For the control of weeds, summer ploughing is advisable, followed by frequent working until late fall. Some clays tend to " run together " if left in this cultivated state over winter; in this case, ribbing up late in the fall may prove of value. Where weeds are not troublesome clay soils ploughed late in the fall and left in the rough ploughed form, permit frost and weather to exert their beneficial influences in the breaking down of any clods which have formed. Soils which

have become puddled and cloddy from working when too wet tend to become mellow when exposed to the action of frost. Results of many experiments have shown that no profitable increases in yield will be secured from ploughing deeper than the ordinary depths of 5 or 6 inches.

All tillage operations for clay soils, as pointed out above, must be conducted only when the soil has the most desirable content of moisture. While



It is essential to work clay soil at the proper time if good tilth is to be secured.

the ability to determine this optimum moisture condition is largely a matter of experience, some farmers follow the rule of ploughing when the soil is still moist enough to be moulded in the hand but sufficiently free from excess moisture to crumble easily when the moulded ball is struck. This desirable condition may last only a few days. Those who have not had much experience with the handling of this soil type may, when they are doubtful of the suitability of the soil's condition for working, find it necessary to make a trial with cultivator or disc. If the soil is sticky and does not crumble down into a desirable granular condition further working should be delayed until more moisture has evaporated.

The bad effect of a single ploughing when the soil is too wet is believed to last for three or four years. The same is true to a somewhat less extent of discing and cultivation. Ploughing in the spring when too dry greatly increases the work and may result in a cloddy seed-bed. When, for any reason, ploughing of clay must be delayed until late in the spring when the land has become dry, the soil ploughed each day should be worked down with the harrow the same afternoon or evening. If clods still remain unbroken, and the seed-bed is likely to be rough and lumpy, by rolling and leaving for two or three days the clods sometimes become moist by capillary movement of moisture and may then be more easily worked down to a fine condition before seeding.

OTHER TILLAGE OPERATIONS FOR CLAY

The stiff-tooth cultivator is one of the best implements for the preparation of the spring seed-bed on clay soils which have been ploughed the previous summer or fall. This implement is especially valuable for stiff clays and for breaking up spots which have become particularly dry and hard. A cultivator is also useful in the control of couch grass. The disc is also a popular and most valuable implement for working clay soils and the drag-harrow is invaluable for making a fine seed-bed. Both these implements are very useful, too, in stirring the soil to germinate weed seeds and destroy weed seedlings. The roller is frequently used before seeding to break lumps and compact the soil. The destruction of weeds during the growing season by the use of the cultivator on intertilled crops and in extreme cases hand pulling and hoeing, will materially assist in securing good crop yields.

DRAINAGE OF CLAY

For clay soils not thoroughly underdrained, surface drains will be necessary to quickly remove surplus water in the spring. Narrow lands may be made with open well-cleaned furrows about 30 feet apart. The water which comes from these open furrows should be carried away by small drains which follow the line of natural drainage to a creek or gully. When ploughing the land in the fall the open or dead furrows should be filled and new furrows opened 15 feet from where the old furrows were located.

Wet clay land must be underdrained for the production of large yields. This applies in particular to soils on which in their natural state, no true grass grows but where sedges or other water-loving plants form the greater part of the vegetation. Most clay farms have wet areas where underdraining would be of great benefit.

MANURE AND FERTILIZERS FOR CLAY SOILS

Heavy clay soils are greatly benefited by the application of manure which not only supplies nitrogen, phosphorous and potash but also adds organic matter. Clay soils which have been poorly farmed are usually very deficient in organic matter and, if manure is not available for applications in liberal amounts, the ploughing under occasionally of a second crop of clover or even an entire crop

of clover will aid materially in improving such soils. Applications of phosphorus-carrying fertilizers are usually of value for cereal crops grown on clay and are particularly beneficial for those seeded down with clover; especially is this the case when manure is not available in substantial amounts for the cultivated crop which usually precedes the grain crop. A dressing of 200 to 400 pounds of superphosphate per acre broadcast on the land just before sowing the cereal crops generally results in a profitable increase in the yields of the cereals and of the clover crops following. When superphosphate or mixed fertilizers are used only for the benefit of the grain crop they are likely to have a more beneficial effect on the yield if the fertilizers are applied in the drill through the fertilizer attachment of a combined fertilizer and grain drill. In the building up of badly run-down clay, dressings of superphosphate as suggested above may be profitably applied even when manure is available. Potash fertilizers are rarely profitable for application to clay soils as this fertilizer constituent is usually abundant in soils of this type. For top-dressing meadows, manure is used extensively with excellent results. For back fields, where it is difficult to supply manure, a dressing in the early spring of a mixture of 75 pounds of nitrate of soda and 200 pounds of superphosphate may be used, generally with profitable results.

CROPS FOR CLAY SOILS

Clay soils are not as well adapted as sandy soils to crops such as potatoes and corn, which have coarse roots that cannot readily enter the soil. The fine roots of such crops as grasses and cereals, however, are able to make their way into the most dense clays and take advantage of the large water-holding capacity of these soils. Oats, barley, wheat, rye, peas, alsike clover, red clover, alfalfa, sweet clover and timothy generally give good success on clay soils. Even on stiff heavy clay, if the field is naturally fairly well drained, alfalfa will produce good crops of hay for a number of years. The addition of five pounds of timothy to the fifteen pounds of alfalfa usually sown per acre assures a crop of timothy in spots where alfalfa has a tendency to kill out. Oats will usually yield better than barley or wheat on clays which are lacking in fertility. If corn gives poor results, sunflowers may be grown for silage, as the latter crop will generally give better results than corn on clay soils. The sunflower seed should be sown at the rate of 10 to 12 pounds per acre and the plants may be left unthinned. Of the root crops, mangels yield, in many districts, a little better than turnips.

MANAGEMENT OF SANDY SOILS

Sandy soils warm quickly in the spring, are easily worked, are not greatly affected by excessive rains and when well supplied with plant food, principally in the form of farm manure, produce excellent crops. For these reasons sandy soils are used extensively for small fruits and vegetable production. There are also great areas of sandy soils devoted to general farm crops which are not suitably located for truck and fruit farming. Besides the sandy soils now under crops of various kinds, there are extensive areas not producing anything. Some of these areas once grew good crops while many others have never been brought under cultivation. Being coarse in texture, soils of this type dry out quickly, and as their content of organic matter oxidizes quickly, they are liable to drift.

ORGANIC MATTER ESSENTIAL FOR SANDY SOILS

The first essential step in bringing sandy soils into a profitable producing condition is usually the incorporation into them of organic matter. Frequent light dressings of manure are nearly always of value and the ploughing under

of clover crops, rye and buckwheat is also beneficial. The latter practice, however, is rarely profitable except where manure is not available and the soil is very deficient in organic matter; the harvesting and feeding of such crops as clover, and the returning to the land of the manure produced, ordinarily proves more profitable than using these crops entirely for green manure. The incorporation into the soil, by ploughing, of the second growth of clovers, however, may in many cases be a practice which will increase the returns from this soil. The economy of ploughing under the entire clover crop or the second growth instead of harvesting them, will vary in individual cases. The market value of the crops and of the live stock being fed, the amount of manure available and the fertility of the soil are factors which must be considered.

Eleven-year-old combined drive and wind-break.

Sandy soils well stocked with organic matter, yield up to growing crops more of the necessary fertilizing constituents and hold larger amounts of moisture during dry spells than those soils not well supplied. Moreover, because of their content of fibre, they do not blow as readily. The organic matter must be frequently incorporated, however, as rapid oxidation takes place, quickly depleting the supply of this material.

PLANTING OF WIND-BREAKS ON DRIFTING SANDY SOILS

Exposure of sandy soils to winds should be prevented by the planting of wind-breaks. Willows, poplars, box elders or other quick-growing trees may be planted at first, and in a few years' time more permanent sorts, such as pines, maples, Norway spruce or others suitable to the region, may be put in between the temporary rapid-growing kinds. In time the less desirable ones may be used for fence posts and fuel. Good wind-breaks are often absolutely essential to the successful cropping of many areas of exposed light sandy soils.

Two or three rows of fresh willow or poplar cuttings may constitute the first plantings. Each row should be 4 feet apart and each cutting 18 inches to 2 feet apart in the row. The cuttings are usually from 12 to 18 inches in length and not over $\frac{3}{4}$ of an inch in diameter at the butt end. They should be stuck from 10 to 12 inches into the sand. Scotch, Jack, red and white pines, and white spruce of about two feet in length (about 6-year-old transplants) are useful too, but they do not appear to stand the burying action of the sand or the uprooting action of the wind quite as well as the poplar and willow twigs. On very exposed places, such as knolls, a shelter made of birch boughs distributed between the rows of trees has proven very useful in retarding the progress of the wind and consequently reducing its carrying power.

Most of the provincial Governments distribute cuttings and small trees to those desiring to plant wind-breaks or to reforest areas of land. Inquiries for such materials should be directed to the Department of Lands and Forests at the provincial Capital.

Freshly cut willow poles, six to eight feet long driven into the sand, usually root and grow and are sometimes used instead of the smaller cuttings as a temporary protection along the margins of small areas of blow-sand.

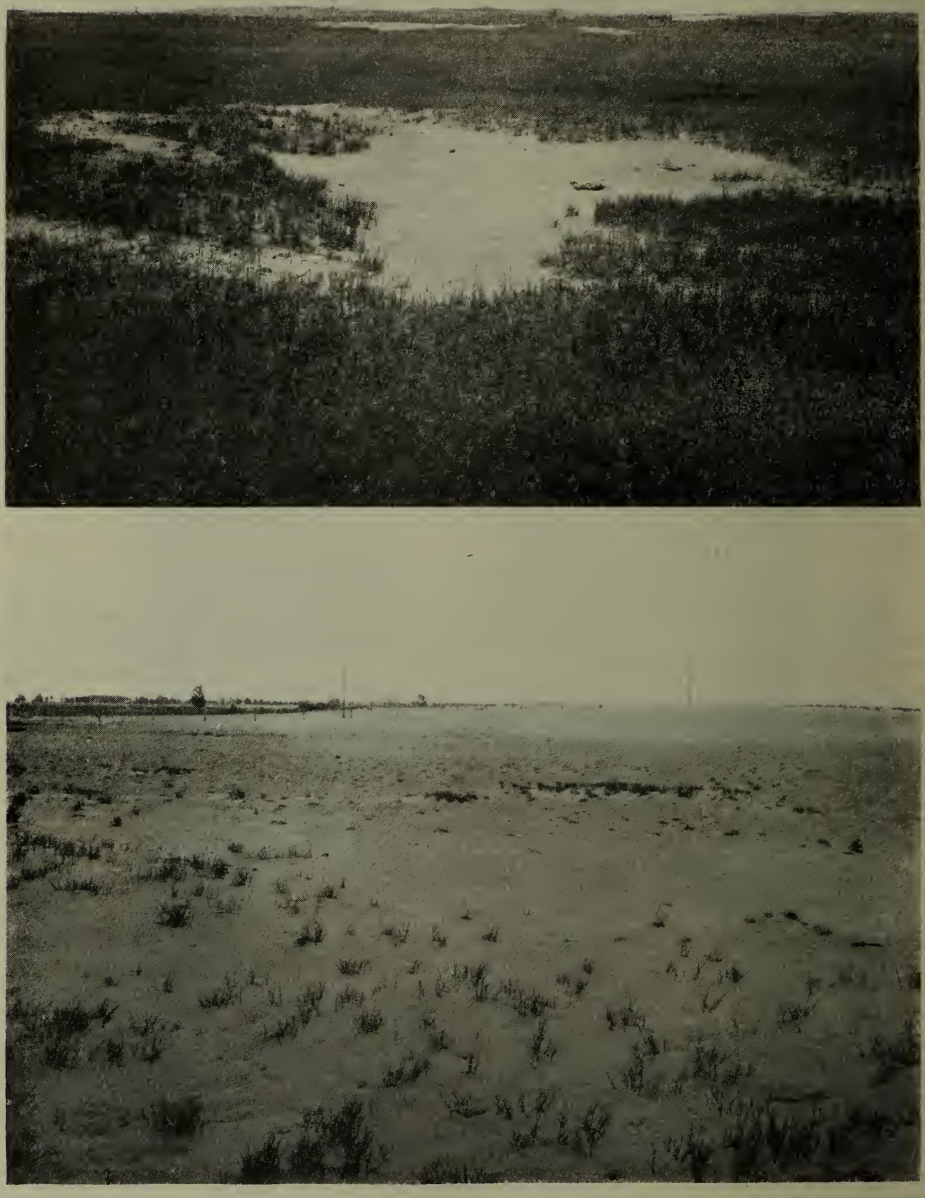
VALUE OF LIME ON SANDY SOILS

Soils of this type although not usually deficient in lime sometimes lack this constituent. A litmus-paper test (see page 60) and small-scale trials with different rates of application of ground limestone may be undertaken to determine whether or not the soil is acid and to find out if crops respond to additions of lime. One ton of ground limestone per acre every three or four years will usually be sufficient for soils which are acid in character. Lime should be applied after ploughing and worked in with disc or harrow.

CROPPING METHODS FOR DRIFTING SAND

It is advisable to keep sandy soils, especially those which have a tendency to drift, covered with a crop at all times. Short rotations such as potatoes followed by fall rye seeded down in the spring to clover, tends to fulfil this requirement. Where large areas of light sand are devoted to farm crops it may sometimes be wise to grow these crops in long narrow strips or lands, fifteen to twenty rods in width, alternating grain and grass crops with cultivated ones. In order to check the winds most effectively these strips should run at right angles to the direction of the prevailing winds. The use of brush, manure, coarse hay and corn stalks are used with some success as a temporary means of protection for cereal and other crops being produced on sandy soils which drift readily.

Around the margins of spots of blow-sand, the growing of such crops as fall and spring rye, sweet clover and corn will help to prevent these areas from being a nuisance to crops on the surrounding land. If sweet clover grows successfully it should be allowed to reseed itself and in time the blow-spot, if not too large, may become at least partially covered with sweet clover plants.



Unless corrected by proper methods small blow-spots on sandy soils will gradually develop into large barren areas.

For drifting sands a plant known as sea-sand reed or beach grass (*Ammophylla arenaria*) has been used with considerable success in Michigan. It is valuable because of its root-stock growth, which enables it to grow up through rapidly accumulating sand. When the sand has been fairly well controlled there are two other grasses, namely, rattail and wild rye, which have been found useful. The seed of these plants is, unfortunately, exceedingly scarce.

There are many areas of blow-sand which may never be fit for anything but the production of trees. It may be necessary even in the establishing of desirable types of trees to first plant quick-growing kinds, establish beach grass or use other measures to control the sand until the young permanent trees can secure a proper foothold.

TILLAGE METHODS FOR SANDY SOILS

There appears to be little difference in crop yields from different methods of ploughing sandy soils. They are usually ploughed five to six inches in depth. Fall ploughing is generally recommended for cereals because there is less likelihood of delayed seeding. If spring ploughing can be done early, however, good yields of cereals may be expected. Fall ploughing should be left as rough as possible. Late summer ploughing and frequent working until late fall is desirable when couch grass or other weeds are plentiful. It is not difficult to prepare a seed-bed on sandy soils with a disc and drag-harrow. If the land is to be seeded down to a hay crop it may be desirable to compact the soil by rolling before seeding. For crops other than cereals, fall or early spring ploughing may be practised. If the soil is liable to drift, the land should be spring-ploughed and implements which fine the surface soil should be used with caution. The sowing of small seeds should be somewhat deeper on sand than on other soils.

MANURE AND FERTILIZERS FOR SANDY SOILS

Farm manure is probably the most beneficial and most generally used fertilizer for sandy soils. It supplies all three of the essential elements of fertility most deficient in ordinary soils, namely nitrogen, phosphorus and potash, and in addition provides organic matter which is liable to be lacking. When manure is available for the application of frequent light dressings, commercial fertilizers are not required except in special cases.

In the absence of manure for corn, roots, potatoes or other cultivated crops, a mixture of 75 pounds of nitrate of soda, 250 pounds of superphosphate and 75 pounds of muriate of potash (or 300 pounds of a 4-10-8 manufacturer's mixed fertilizer) broadcast on the land and thoroughly disked in just before planting would constitute a fertilizer dressing of value. For potatoes, which are so extensively grown on sandy soils, commercial fertilizer dressings are sometimes used in amounts much larger than that just suggested, as much as 1,500 pounds per acre not infrequently being used in the Maritime Province for this crop. In conjunction with manure, 200 to 400 pounds of superphosphate may be utilized with profit for potatoes. For cereal crops, especially wheat and barley, 200 pounds of superphosphate per acre may be applied and satisfactory returns usually secured. For cereal crops which are not seeded down and for row or cultivated crops, fertilizer applied in ordinary amounts in the drill or row by modern fertilizer attachments to the seeding or planting machines is likely to give a larger increase in yield than are broadcast application of fertilizer. For clover meadows, 200 pounds of superphosphate and 50 pounds of muriate of potash might be applied early in the spring just as growth is commencing. Alfalfa, especially when growing on soils rather deficient in fertility, would also be benefited by a similar dressing. For timothy meadows 75 to 100 pounds per acre of nitrate of soda may be applied in the early spring.

CROPS FOR SANDY SOILS

Potatoes, turnips, field beans, soy beans (southern Ontario principally), fall and spring rye, oats, vetches, red clover, sweet clover and alfalfa are crops suitable for sandy soils. If the sand is of such a nature that ordinary farm crops fail to make a stand, or if the initial outlay to bring them under cultivation would be too high, the growth of native grasses, where some covering is essential, may be encouraged by light dressings of manure or fertilizers. Even weeds are better than no covering at all, when the drifting sand is menacing other crops.

LEGUMES ESPECIALLY DESIRABLE ON SANDY SOILS

Leguminous crops such as alfalfa, sweet clover and red clover are always desirable crops for sandy soils, but frequently a good stand is not obtainable because the seeds will not germinate due to the lack of moisture, or, because of absence of protection, the plants are cut off when the soil begins to blow. If alfalfa can once be established it should be left down as long as it gives profitable returns. When it can be grown it is a most desirable crop for sand. Alfalfa does not, however, grow successfully if the soil is acid, and liming may be necessary. If sweet clover is to be grown, lime is even more essential than for alfalfa. Red clover may grow successfully without additions of lime, while alsike is grown extensively where soils are acid, but the latter crop is more particularly of value on low land. Inoculation of sweet clover and alfalfa seed with nitro-culture may be of considerable benefit in securing a stand, especially where the crop has not been grown before. A light dressing of manure, preferably rotted manure, before ploughing will aid materially in getting legumes started. In nearly all cases a nurse-crop of grain, sown at the usual rate or a little less than the usual rate, may be used.

SPECIAL METHODS OF ESTABLISHING LEGUMES ON VERY LIGHT SANDY SOIL

On very light sand which dries out excessively or blows very readily, where the ordinary method of seeding down with a nurse-crop has failed, the use of special methods may be necessary to secure a crop. If a light nurse-crop is used it should be cut when it is 8 inches in height and the cuttings left in the field. If a second growth of grain appears it should be cut just as it begins to head out and again the clippings should be left in the field. In places where the methods suggested have proven unsatisfactory because of dry conditions, alfalfa or other legumes may be seeded without a nurse-crop in late May or June on rye, oats or even on corn stubble after it has been lightly disked so that it may be in a condition to readily absorb rainfall. The seed should be sown with a drill to a depth of between one and two inches. The stubble present on the field will protect the young seedlings from wind and will not utilize moisture as would a nurse-crop. Applying manure to prevent soil blowing after alfalfa or clovers have been sown may not always give good results in locations exposed to considerable winds, as the soil may drift and form wreaths or banks around the pieces of manure deep enough to bury the young plants. Sowing of alfalfa or clover seed on newly turned sod has been practised with good success when all other methods of seeding have failed. For satisfactory results with this method of preparing land, good ploughing of the sod must be done or else grass will grow up which may crowd out the young seedlings. There must be a complete severance of all the sod from the soil immediately beneath it. When this is done and the upturned surface properly worked down with disc and drag-harrow there is little fear of interference from grass, little or no soil drifting, and no serious competition from weeds the first season. If couch grass is present the sowing of seed on freshly turned sod could not, of course, be practised. A dressing of fertilizer before sowing may assist in securing a catch.

Conditions may vary greatly even in sandy areas and where one practice may not give good results, another may be very successful. Trials may be necessary, therefore, before it can be determined what practices or cultural methods are most suitable to any particular soil or set of conditions. Where, after repeated attempts, crops of any kind cannot be established, reforestation with desirable trees would be advisable.

MANAGEMENT OF PEAT AND MUCK SOILS

Peat and muck soils consist largely of partially decayed moss, grass, swamp sedge, flags and similar plants. For many years plants of these kinds have grown and died where they stood, and in some places their decaying remains have been accumulating for centuries. The terms peat, muck, marsh, moor, bog, swamp and moss, all refer to these soils, if they may be called soils, which are very high in their percentage of organic matter. According to general usage the term " peat soil " covers all classes of these soils, regardless of their percentage of organic matter. Peat is considered technically, however, to mean all soils having over 50 per cent of organic matter, while muck soils are those which have from 15 to 50 per cent of organic matter. Muck soils, therefore, contain a much higher percentage of mineral matter than peat soils. In Canada it is estimated there are approximately 22,000,000 acres of peat soils.

Probably the most extensive experimental work with the cropping of peat soils is that which has been conducted in Germany, Austria and Sweden. There, land is valuable and the extensive peat lands have been farmed for a great many years.

Peat and muck soils vary greatly in composition. There are grass-peats and moss-peats, deep and shallow peats, poorly decomposed peats and well-decomposed peats, peats with clay subsoils and with sandy subsoils, lime-deficient peats and peats rich in lime. All of these soils cannot be handled in a similar manner. Peat and muck soils are almost universally well provided with moisture and the presence of this moisture has prevented the entrance of air, retarded the rate of oxidation and largely checked the decomposition of the vegetable matter of the soil.

The value of this land will depend largely upon its proximity to a good market for agricultural products, its state of decomposition, the nature of the subsoil and the possibility of drainage.

DRAINAGE

The reclamation of this type of land depends first upon drainage. Before installing a system of drainage, which is the first and most expensive of the operations necessary in the bringing of muck and peat soils into a state of high production, one should determine if by so doing the expenditure involved will give profitable returns. If the land can be used for the production of truck crops such as celery, onions and lettuce, drainage is usually essential and profitable. For general farm crops the establishment of drains may prove quite profitable when the peat or muck layer is not more than 3 feet in depth, when it is fairly well decomposed, and when lime is available at a reasonable price, if the soil is deficient in this material. It need hardly be pointed out that in all cases of drainage a good outlet is essential. If a drainage outlet cannot be secured, if the peat is very deep and poorly decomposed, or if covered with a growth of small trees requiring considerable expense for removal or in too dangerous a situation to be burned off, it is doubtful if it would be profitable to establish an extensive drainage system. Drainage would also be questionable if the top soil is underlaid with hard-pan or quicksand, or if it already produces a fair crop of wild grasses and even when drained, because of the distance the land

is from market, would not be very much increased in value. For muck and peat land that can be worked sufficiently without drainage to produce fair crops of acid-tolerant meadow and pasture plants, the expense of a drainage system may also be unwarranted.

In peat and muck soils underlaid with clay, which are usually very suitable soils to drain, tiles should be placed 2, 3, 4 or even 5 feet from the surface, depending upon the depth of the surface soil, and into the clay subsoil at least a few inches. The distance apart of the underdrains may be 200 to 300 feet at first and the land put in hay for two or three years. At the end of that period another line of tiles may be put between those first laid and cultivated and cereal crops grown, because these crops require a lower water-table than grass crops. Instead of the tile, open ditches about ten or twelve rods apart may be used at first and the tile installed later as suggested. The use of open drains may be necessary if the surface soil is very deep, as the tile drains placed in peat or muck will not retain their alignment because of rapid and uneven settling of this surface layer. Newly cleaned land which has never been cropped before when it is first put down to hay will settle usually from 25 to 50 per cent. Where conditions demand the putting of tile into the peat or muck layer, and the expense is warranted, boards placed beneath the tile will help to keep them in alignment. If the clay subsoil is near enough to the surface to be touched with an ordinary plough, or a subsoil-plough it should be mixed with the top soil and usually a very rich soil will result which may be tile-drained immediately at intervals of about 100 feet, and hay, cereal or cultivated crops grown at once. Clay tile is almost always preferable for draining peat and muck because it is not corroded by the acids present in such soils. If tile is expensive and cedar is cheap, triangular or box drains of cedar may be used instead of tile.

For peat and muck with sand subsoils open drains are essential for three years at least, and unless the crops grown are of considerable value, it is doubtful if tiling would even then be profitable. Open drains should be from 4 to 8 feet deep or even deeper, depending on the depth of the peat or muck. The distance apart of the open drains may be at first 500 to 600 feet and the land put into meadows or pasture. After settling, drains may be placed 250 to 300 feet apart. If the peat is well decomposed and is to be used for high-priced crops, open drains, or in some instances, tile drains may be placed closer than 250 feet and it may not in all cases be necessary to put the land down first into meadow or pasture. Deep open drains 500 to 1,000 feet apart may, in some low-priced locations, permit the establishment of meadows and pastures, sometimes even without additions of fertilizers or lime. For very large areas of peat or muck land, open drains as much as one-half a mile apart have been used. These drains have been constructed about 8 feet deep, 6 feet wide at the bottom and 22 feet wide at the top. Co-operative work between a number of farmers may be necessary in the draining of extensive swamp lands. Because of the great variety of peat and muck soils it is difficult to recommend any particular method or system of drainage. Opinions vary greatly especially as to the best distance at which to place open and tile drains. Each case of drainage must be dealt with individually, taking into consideration such factors as the area and value of the land, the decomposition of the surface soil and the kind of subsoil. It is almost essential to obtain the recommendations and services of a qualified engineer before commencing the drainage of any considerable area of land. Most of the provincial departments of agriculture offer some assistance to farmers in this respect.

On otherwise productive upland fields there may be found small areas of mucky land into which the surplus water drains from the surrounding higher levels, keeping these areas so water-logged that they will not produce a crop.

The establishment of open drains is, in most cases, the first essential step in the draining of peat and muck soils.

If tile are laid around these mucky spots just outside of their margins all the seepage water from the uplands may be carried away by a main drain and the mucky spots will become productive.

The reason for placing tile and open drains at a greater distance apart in peat and muck than is customary in other types of soil is because, if placed too close, the surface soil will dry out too quickly, necessitating considerable water to again put it in condition for plant growth. When drainage systems are established in localities where the rainfall is liable to fall below the requirements of the crops during part of the summer, stops of some kind are placed in the lateral tiles to hold back the water from draining away in the dry seasons in order that the water-table may be kept from 2 to 3 feet from the surface. In open drainage systems, sods are frequently thrown into the lateral drains near their outlets and tramped down to prevent the escape of the water and to keep the water table high. In dry summers careful watch must be kept and precautions of this kind always taken.

BURNING OF PEAT LAND

The burning of peat land is now not generally recommended, as uneven burning is likely to occur and there is a grave danger of removing so much of the top soil that the infertile subsoil will be exposed. Burning, however, may be resorted to if the peat is very deep and little decomposed and if there is no danger of fire spreading. If an unproductive layer of peat covers a rich subsoil or if other methods of bringing deep, poorly decomposed peat into a productive condition require the expenditure of too much time and money, burning may be practised. Sometimes, too, rough land may be levelled by burning, in which case knolls and hillocks should be first dug up and dried.

Burning of peat land was practised in the seventeenth century in Germany. The method followed was to burn an area and grow crops as long as profitable production continued, then another area was burned and cropped, followed by another area, and so on. Finally the farmer came back to the first area and burned off another layer. In the burning of peat considerable phosphorous, some potash and lime are liberated for plant use. The continuation of this practice, however, results in the complete depletion of the peat soil, leaving nothing but the unproductive subsoil. At the present time in European countries burning is little carried on and in some districts is prohibited because of the nuisance from smoke. The burning of shrubs, small trees and other materials, frequently necessary in the clearing of land, should not be confused with the burning of peat soils, as these practices are distinctly different and conducted for entirely different reasons.

USE OF LIME

Although the fact is perhaps contrary to the general opinion, lime is not needed on all the peat and muck soils of Ontario. This has been shown by surveys conducted by the Ontario Agricultural College. There are, however, in Ontario many lime-deficient soils to which one, two or even more tons of ground limestone per acre applied at intervals of 4 or 5 years may be necessary to produce profitable crops. It is quite likely, too, that many of the soils of a mucky or peaty type found in the provinces east of Ontario are also acid in character and will respond to dressings of ground limestone. In certain districts where liming is expensive, the installing of a drainage system and the growing of acid-tolerant meadow and pasture plants such as timothy, alsike clover, red top and meadow fescue may be more profitable than buying lime for the production of other crops. Where doubt is entertained as to the necessity of liming, a test may be made with blue litmus paper which may be procured from any drug store. The

paper should be kept in a clean, dry, preferably wide-mouthed, well-corked bottle. When cutting off a strip of litmus paper for use, a pair of forceps or scissors should be used as the paper is sensitive and the fingers may cause it to redden. If carefully carried out the following test, to determine the acidity of the soil, is fairly reliable:

Take up, by means of a spade or trowel, a little of the surface soil from, say, half a dozen places on the area to be examined and mix well; do not touch the soil with the hands. Take a small quantity of the sample, say a few ounces, put it in a clean cup or tumbler, pour on a little boiled water and stir with a clean piece of stick or spoon until a pasty mass is obtained. Into this "mud" press, by means of a small stick or the back of a knife, a strip of blue litmus paper for about one-half to two-thirds of its length. If, on drawing out the paper, at the end of fifteen minutes, the part in contact with the soil has turned red, then the soil is acid.

If the paper reddens but slightly, no lime may be needed for ordinary farm crop production, or, it may be that only a small amount, perhaps half a ton or less per acre, may be sufficient to correct the small amount of acidity present. The amount of limestone required can be best ascertained, probably, by small-scale trials, beginning at the rate of one-half a ton per acre and increasing the rates by one-half a ton up to three tons per acre.

CULTIVATION OF PEAT AND MUCK

The breaking of peat and muck soils should for best results be done in the summer or fall with a wide plough. Ploughs 16 to 24 inches in width with a long mould board and a rolling coulter are extensively used in Europe and in the United States. Ploughing about 6 inches deep appears to give the best results. The furrow slice should be turned flat. It is usually desirable to plough these soils only when they are in sod, as the more compact they can be kept the more they will produce.

A very important implement used in the handling of muck and peat soil is a heavy roller. This implement is said by many authorities to be indispensable in the production of crops on these soils. A heavy roller is generally used immediately after ploughing. In the preparation of a seed-bed the disc harrow is used. It should be weighted if a heavy roller is not available. The drag-harrow should follow the disc to fine the surface and then the roller should be used before and usually, also, after sowing. Frequent rollings are beneficial in particular to new meadows. The best time to roll meadows is when they are moderately moist, when the impress of a heavy footprint will remain distinct for some time. They should not, however, be rolled when wet as the tramping of the horses will make undesirable holes. On meadows and pastures the first rolling should be in the spring soon after the grass and clover have begun to grow. The last rolling should be in the fall, after the last mowing of the meadows or at the end of the pasture season. An additional rolling after the first crop of hay has been removed from meadows, and about the middle of the summer on pastures, has been found to increase the yields. Heavy muck-rollers, usually constructed of concrete, should exert a pressure of not less than 1,600 pounds per yard of length. A five-foot roller 30 inches in diameter would weigh almost 1,800 pounds and require 3 or 4 horses to handle it. The tramping of pasturing animals is also beneficial in compacting peat and muck soils.

Marsh lands which are merely wet clay lands containing considerable well decomposed organic matter, are sometimes too compact or "tight," and on these, rolling is not beneficial and fall ploughing should be left rough over the winter to secure the beneficial action of the frost.

MANURE AND FERTILIZERS FOR PEAT AND MUCK

In almost every instance where light dressings of manure have been applied, beneficial results have been secured. Strawy manure while not as generally used as rotted manure may, however, be utilized because straw contains a high percentage of potash. Even if fertilizers are used, an occasional light dressing of manure has proven beneficial. In addition to the content of plant food, the bacteria in manure is beneficial to muck and peat because these soils are frequently lacking in desirable organisms. For land which has been burned too much, applications of manure are almost essential.

With few exceptions, peat and muck soils are deficient in potash. Where clay subsoils are found, especially those underlying a shallow depth of peat, the surface soil may be sufficiently supplied with potash for crop production. Where there is a seepage of water from upland soil rich in potash to mucky lowlands, potash may be found in fairly considerable amounts. Peat and muck soils well supplied with potash are, however, very rare. Manure supplies potash, but where all the manure is required for the upland soils of any farm it should be used there, and commercial fertilizers used on the peat and muck areas. One hundred to 250 pounds of muriate or sulphate of potash per acre may be broadcast on these soils and harrowed in before sowing or planting a crop, or this fertilizer may be applied as a top dressing in the early spring to meadow and pasture lands. Even 50 to 75 pounds of potash fertilizers will give good returns.

In many cases applications of 200 to 400 pounds per acre of superphosphate have given good results, especially when combined with fertilizers carrying potash. Superphosphate alone or when mixed with muriate or sulphate of potash should be applied at the time and in the manner suggested for the application of potash alone.

For truck crops, especially in the early stages of cropping of peat and muck soils, commercial fertilizers containing nitrogen may give profitable response. For general farm crops, however, it is not a common, and seldom a profitable, practice, to apply commercial fertilizers which are used for their nitrogen content alone, as these soils are extremely rich in organic nitrogen although they may not be well supplied with soluble nitrates. After drainage, however, aeration takes place, and after liming, where this is necessary, an environment is created suitable for the growth of nitrifying bacteria which change the nitrogen into nitrates, in which form it is utilized by most plants.

OTHER MUCK SOIL PROBLEMS

The producers of truck crops on muck soils have some additional problems to which they must give attention. The danger of frost is one of importance. On spring nights the atmosphere which does not reach the frost point over upland soils may, over low-lying, peat and muck lands, become so cold as to destroy certain tender plants. The reason for this is that the heavier cold air settles in the lower levels and when there is little movement of the air it remains there. Moreover, muck and peat soils being very open in texture, lose heat more rapidly than other soils and as they act as a kind of insulating material they prevent the upward movement of heat from the subsoil as is the case in other ordinary types of soil. In dry summers it may be necessary for the production of truck crops to establish overhead or sub-irrigation systems to provide water for crop production. Windstorms, too, are sometimes a menace, particularly to the production of intensive crops. Provision may have to be made sometimes for wind-breaks such as trees, shrubs and bush fruits, or at intervals across the fields for strips of rye, sweet clover, corn in single rows or other crops which grow to a considerable height in order to prevent losses where wind is excessive.

Where land is valuable and intensive crop production profitable, the application of 2, 3, or more inches of clay to the surface muck soil may result in an economic increase in crop yields.

CROPS FOR PEAT AND MUCK

Of the field crops produced on these soils, meadows and pastures cover the largest area. They require the least expenditure of all the crops in labour and money, and even with a small amount of drainage and with fairly acid soil conditions such crops as timothy, alsike clover and red top, meadow fescue and orchard grass yield, in most cases, fairly good crops of hay and pasture. Rye, wheat, barley or early oats appear to be better nurse-crops for clovers and grasses than late oats. Corn, mangels, flax, potatoes, and sweet clover have also been grown with success on these soils, but for the most of these crops drainage must be adequate and with the exception of potatoes, the largest crop yields will usually be obtained when the soil is not acid.

MANAGEMENT OF HILLSIDES AND ROLLING LAND

Surface erosion is an important cause of soil deterioration where the topography of the land is rolling and the rainfall is abundant. Erosion as it occurs under farm conditions is very largely a transfer of the surface soil from the hillsides to lower levels.

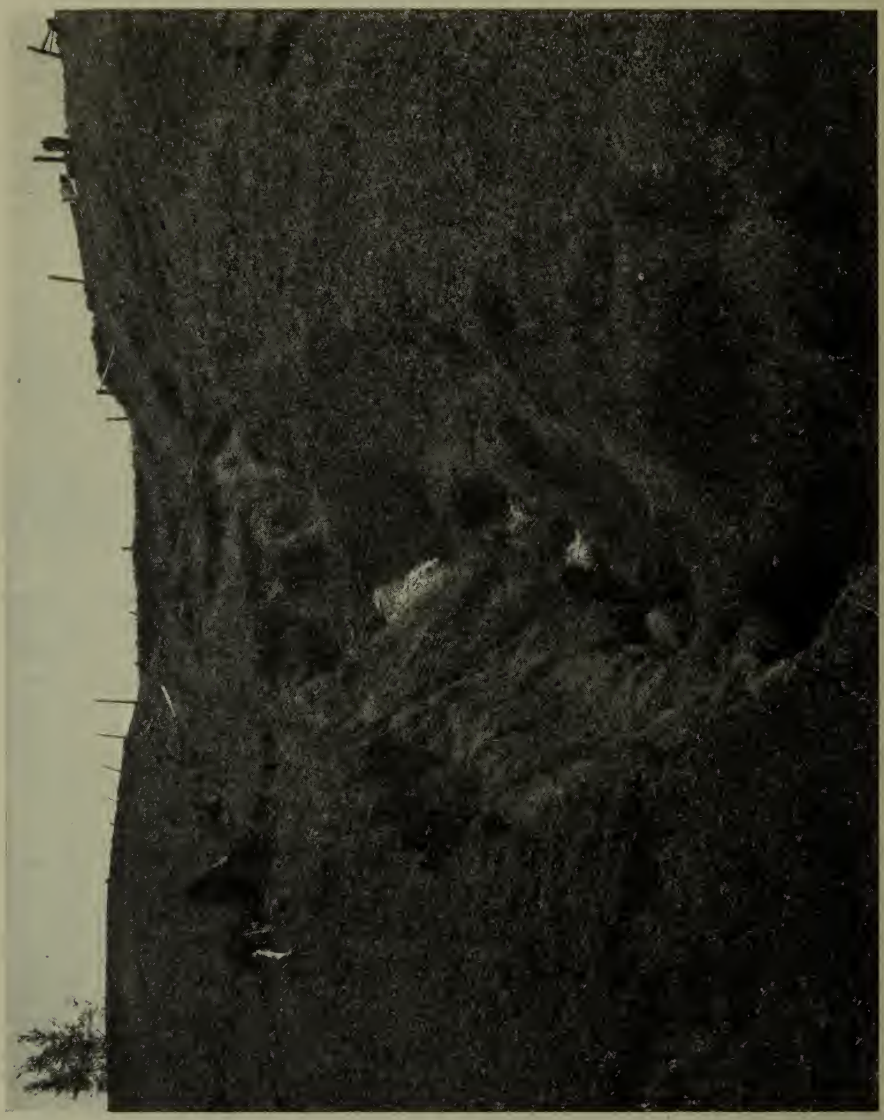
In the management of rolling land and particularly hillsides, to prevent erosion, rotations should be used which will keep the land covered with a growing crop practically all the time. The frequent use of clover and grass crops will aid materially in establishing such a cropping system. Very steep slopes should, wherever possible, be kept in permanent meadow and pasture crops.

Ploughing, when necessary, should never be done up and down, but always across, the slopes, and planting should be done in the same manner. The soil should be kept well supplied with a large amount of decaying vegetable matter. Shallow channels having a slight grade, seeded to grass in the bottom may sometimes be used to carry off excessive rainfall. These are practices which will be of value in the successful management of hillsides which cannot be kept permanently in grass.

WHY SOD CROPS ARE DESIRABLE

The outstanding advantage of sod crops in preventing erosion has been demonstrated at the Missouri Agricultural Experiment Station where the average rainfall resembles that of Eastern Canada. The results of six years' experimental work show that the surface of a loam soil on a slope averaging 3·68 feet in 100 feet under different cropping systems would be carried away by erosion in greatly varying lengths of time. If the rainfall were to continue to be the same as that received during the progress of the experiment, the seven inches of surface soil would be removed at the following rates: blue grass sod in 3,547 years; rotation of corn, wheat and clover in 437 years; wheat annually in 150 years; corn annually in 56 years.

Sod crops absorb large quantities of rainfall, the stubble and organic materials lying on the top of the ground very greatly restrict the flow of water down the slope which gives it more time to be absorbed, and the fine roots of the grasses and legumes bind the soil particles together. The deep roots of alfalfa and sweet clover which extend into the subsoil make vertical passages for water, allowing more rapid percolation of rainfall than would be provided by the more shallow-rooted hay and pasture crops. Care should be taken that the grasses on hillsides are never pastured too heavily, especially on western slopes which dry and burn out more quickly than they do on eastern slopes.



Owners of hilly land should adopt methods to prevent the formation and enlargement of gullies.

TILLAGE METHODS FOR HILLSIDES

When contour-ploughing is followed, the water running across the furrows meets with more obstructions and greater resistance than in running with the furrows and hence more absorption takes place. This reduction in the rate and amount of run-off prevents to a considerable extent the carrying down from the slopes of the fertile surface soil. Ploughing to a depth of seven or eight inches provides a deeper layer of loose soil than more shallow ploughing and is, therefore, generally recommended as it is believed somewhat more rainfall will be absorbed and the amount of run-off will be reduced.

A hillside plough with a mouldboard which can be quickly changed from one side to the other is a good implement to use if much hillside land is to be ploughed. The use of this type of plough will permit the turning of each furrow down hill. Where fall, winter or early spring erosion takes place, fall ploughing is not desirable. Planting as well as ploughing should be done across the slope as each row retards the movement of water down the slope, permitting greater absorption.

DRAINAGE OF HILLSIDES

Where the land is not permanently in grass, and erosion is liable to occur, shallow surface ditches with very slight fall, sometimes grassed in the bottom, may be run across the slope to conduct the water along the hillside to well-grassed, or otherwise well-protected main ditches extending up and down the slope. When this land is ploughed, the shallow, grassed drains should be skipped; this practice is called skip-ploughing. On springy hillsides where the surface soil remains saturated and will not absorb rainfall, tile drains are sometimes used to remove the excess moisture and permit earlier seeding and to prevent erosion which would occur if the rainfall ran off the surface.

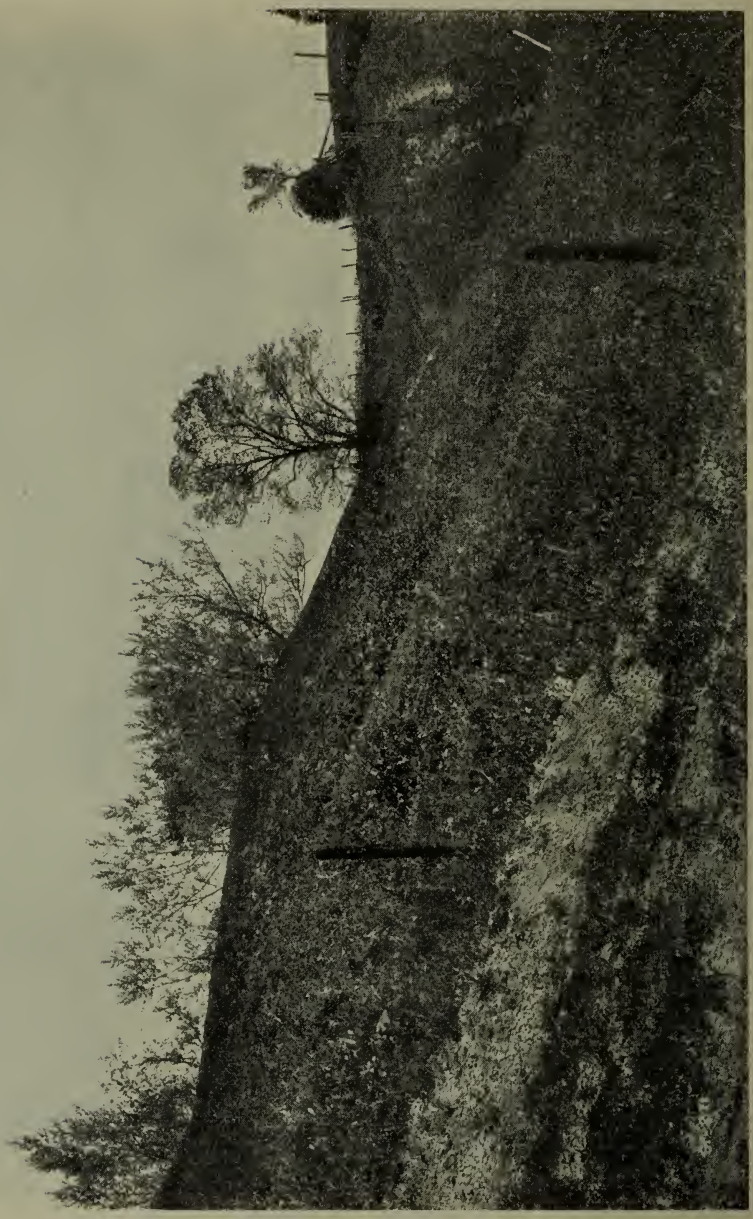
GULLIES

The owner of rolling or hilly land must be constantly on the lookout for new gullies, and must use every means for preventing their enlargement. Shallow ditches which tend to form gullies should be seeded to grass and kept sodded until such time as the drains become filled with sediment, when they may be cropped, but they should be seeded down again if there is a danger of a gully forming. Timothy, red top and Kentucky blue grass are good grasses for drains. The seed of Kentucky blue grass is usually more expensive than red top or timothy.

The most elaborate method of preventing erosion is by the use of terraces which are sometimes necessary on steep hillsides where the rainfall is particularly heavy. Terracing is the laying off of the hillside into a series of more or less level ridges or benches at regular intervals from the top to the foot of the slope.

CROPS FOR HILLSIDES AND ROLLING LANDS

Permanent pastures are extensively grown on rolling lands. Canada blue grass, red top, Kentucky blue grass and white clover are useful for this purpose. The first-mentioned grass is of particular value where the soil tends to dry out in summer. The common mixture of red clover, alsike and timothy may be sown for hay and the timothy left down for a number of years. Alfalfa is an excellent crop for hillsides and is to be desired over other hay crops where it will grow successfully. In order to receive a good stand of this permanent hay crop liming may be necessary on some soils. Oats, rye, wheat, and corn are crops frequently grown with success on rolling lands, but these crops are not as effective in controlling erosion as hay and pasture crops.



Where possible, hillsides should be kept in permanent meadows or pastures.

MANURE AND FERTILIZERS FOR HILLSIDES AND ROLLING LANDS

If satisfactory crop yields are to be secured, farm manure must be applied at seasons when it can be ploughed under before any loss of fertility takes place or applications of commercial fertilizers must be made if manure is not available. Fall and winter applications of manure are not desirable because of the great loss of fertility which is liable to occur from spring runoff. Meadow crops will usually respond to the application of commercial fertilizers after the spring freshets are over. A mixture of 50 pounds of nitrate of soda and 200 pounds of superphosphate and 25 pounds of muriate of potash would constitute a fair dressing. Top dressings of manure in early spring would also be of value for permanent grass. For acid soils one ton of ground limestone per acre may be used with profit.

CROP ROTATIONS AND SOIL MANAGEMENT FOR EASTERN CANADA

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