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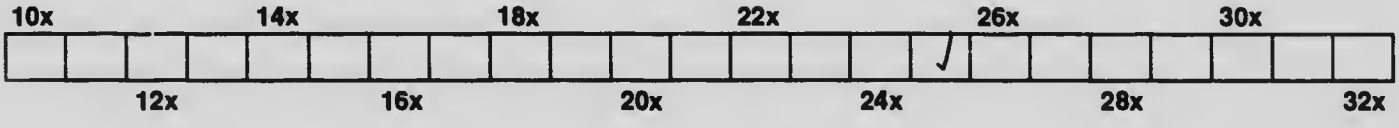

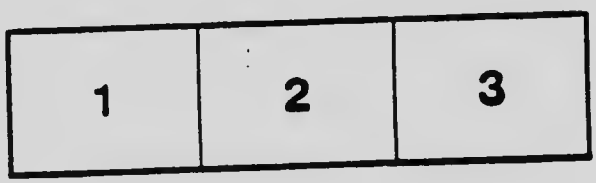

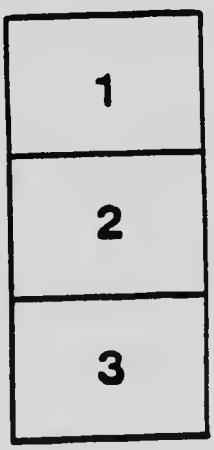

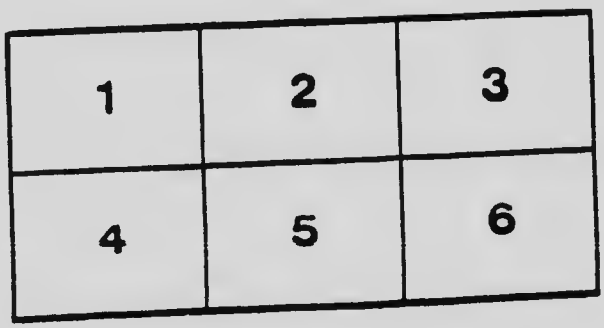

CROP ROTATION AND SOIL CULTIVATION

A PAPER

READ BY

J. H. GRISDALE, B. AGR.

Director, Dominion Experimental Farms

BEFORE THE

STANDING COMMITTEE OF THE SENATE

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CROP ROTATION AND SOIL CULTIVATION.

BY

J. H. Grisdale, B. Agr.

Director Dominion Experimental Farms

The aim of every farmer should be to produce as large crops at as low cost as possible, while at the same time increasing the crop producing powers of his farm. Crop returns depend upon two things: Soil and soil management.

SOME SOIL FUNCTIONS.

The soil is the medium in which the roots of every crop live from seed sowing to harvest. The soil is likewise the source or rather the storage room for plant food. Crop returns depend to some extent upon the character of the soil, but more largely upon the handling of that soil previous to seeding, and, in the case of certain crops, to its management during the growing season.

FOOD REQUIREMENTS OF FARM CROPS.

Crops have different requirements as to plant food; some, as for instance roots, mange crops, require large quantities of readily available food suitable for the production of root, stem and leaf. Other crops, such as cereals or grain crops, will do with less readily available plant food, suitable for root, stem and leaf production, but need a proportionately greater supply of such plant food, or such elements, as enter into the composition and are necessary for the development of large quantities of seed, be this seed oats, barley, wheat or any other grain.

Crop Residues.

All crops when harvested leave behind them in the soil or on the surface thereof greater or lesser quantities of vegetable matter, such as roots, bits of stems, leaves, etc. The residues from crops such as potatoes, roots, corn and cereals are very small, in fact negligible, so far as they are likely to exert any influence upon the fertility or the physical condition of the soil in succeeding years. Certain other crops, however, such as pasture, sod, timothy hay, alfalfa and clovers, leave as residues large quantities of vegetable matter in the form of roots and stubble, and these residual substances

on being buried, or mixed with the surface soil, break down and have a very appreciable effect upon both the physical condition and the fertility or plant food content of the soil.

Good Physical Condition.

Crop returns depend very largely upon the physical condition, that is, upon the friability and fineness, upon the firmness and moisture-containing powers of the soil, as well as upon the supply of plant food contained. The physical condition of a soil depends to a very large extent upon residues left by recently grown crops. Crop residues when breaking down or decaying form humus, the most important of all the various elements entering into the make up or composition of any surface soil. Soils rich in humus and at the same time in good physical condition are likely to give large returns in the way of root, leaf and stem, whatever the crop grown. Soils from which some part of the humus has been removed, that is utilized, or which are more solid and firmly packed, seem better fitted for the production of plant seeds or grain.

Crops Needed by the Farmer.

Farmers in Canada require to grow some crops likely to give profitable returns in the form of seeds, that is, grain crops. At the same time they need large quantities of forage, that is, such crops as yield rough feed suitable for live stock must be grown, for instance, clover, timothy, roots and corn for ensilage.

Effects of Certain Crops on Succeeding Crops.

Clover or pasture sods, when turned under, leave the soil in most excellent condition for the production of forage crops, such as roots and corn. Soils which have been occupied by roots or corn have lost by the end of the season a considerable proportion of the humus they contained at seeding time. They are, however, compacted and in most excellent shape for growing grain. The grain crops grown upon fields which have been under some hoed crop the previous year are likely to give large yields of seed with a comparatively small proportion of straw, the ideal condition for most profitable returns.

It is evident, therefore, that each crop affects the condition of the soil in its own peculiar way, and that the condition in which a soil finds itself, after having borne a certain crop, is nearly always the condition best suited for the production of some other crop.

Having observed the peculiarities of crops as to food requirements, conditions of growth and residual effects upon the soil, it is evident that it should be possible to work out a succession of crops where the soil condition after each would be such as best suited the growth of the next. Arranging crops in this way is called 'Rotation of Crops."

ROTATION OF CROPS.

Rotation of crops means the following of one crop with another in a regular and ever recurring or repeated succession. Rotation comes from the word 'rotare,' mean-

ing 'to turn round,' hence a rotation might possibly include only two crops, as for instance, hay and grain alternately for a long period of time. Generally speaking, however, a longer rotation, that is a succession of crops including a greater diversity, is meant when one uses the term rotation.

Crop Rotations for Eastern Canada.

As rotations possible in eastern Canada, and as rotations likely to give satisfactory results, I might mention the following:—

'A.'—Two year rotation = Grain—hay.
'B.'—Three year rotation = Grain—hay—hay or pasture.
'C.'—Three year rotation = Hoed crop—grain—hay.
'D.'—Four year rotation = Hoed crop—grain—hay or pasture—hay or pasture.
'E.'—Five year rotation = Hoed crop—grain—hay—grain—hay or pasture.
'F.'—Five year rotation = Hoed crop—grain—hay—pasture—grain.
'G.'—Six year rotation = Hoed crop—grain—grain—hay—hay or pasture—pasture.

Some Remarks on Rotations.

Rotation 'A,' that is the two year rotation:—

First year—grain, seeded down 10 lbs. red clover, 6 lbs. timothy per acre. Second year—hay, followed again by grain, is one that might be adopted on a stock farm where the area of arable land was limited and where it was considered impossible to grow hoed crops to any large extent. It is, however, not quite what might be called a practical sort of rotation, and its use could be recommended only under very exceptional conditions.

Rotation 'B,' of three years' duration, is one much better suited than rotation 'A' for the farmer who cannot, on account of the character of his land, or who does not care for some other reason to grow any considerable area of roots, or other hoed crop. This rotation:—

First year—grain seeded down with 10 lbs. red clover, 2 lbs. alsike and 12 lbs. timothy per acre. Second year—timothy or pasture, will provide a large quantity of forage and at the same time do much toward building up or improving the soil on the farm. On a 100-acre farm in Ontario on which this rotation was used for six years, the crop producing powers of the soil were practically doubled, and in this particular case very little barnyard manure was used.

Rotation 'C,' of three years' duration:—

First year—hoed crop; followed by second year—grain, seeded down with clover and timothy, say 10 lbs. red clover, 2 lbs. alsike and 6 lbs. timothy per acre. Third year—hay or pasture, is a rotation likely to give very large returns in the way of crop produced and net profit per acre. It is a rotation peculiarly well fitted for certain districts in eastern Canada, where farms usually include considerable areas of rough land fit for posture, but not available for crop production. On such farms, the division of the arable land into three equal or nearly equal areas and the following thereon of the rotation described, will enable the farmer to carry a much larger number of cattle,

and will insure his getting much bigger returns than where a longer rotation is followed and a relatively smaller proportion of the arable land given over to the production of forage crops such as corn, roots and clover hay. On the Experimental Farm, Ottawa, this rotation has proven to be by much the most profitable of all rotations tried.

Rotation 'D,' a four year rotation, including:—

First year—hoed crop; followed by second year—grain, seeded down with, say, 10 lbs. red clover, 2 lbs. alsike, 12 lbs. timothy per acre. Third year—hay or pasture. Fourth year—hay or pasture.

This rotation recommends itself for use on farms where most of the land is arable and where provision has to be made for pasturing, to some extent at least, on arable land. It has the advantage of sod being turned down once in four years, of clover occupying the land, to a greater or lesser extent, three years out of four, and of being under pasture to some extent the third or fourth year. This rotation would probably suit a light, sandy soil, even better than rotation 'C', since rotation 'C' in the case of light, sandy soils would probably have a tendency to open up or loosen the soil too much.

Rotation 'E,' of five years' duration, as follows:—

First year—hoed crop. Second year—grain, seeded down with 10 lbs. red clover, 2 lbs. alsike and 6 lbs. timothy per acre. Third year—hay, land ploughed in fall. Fourth year—grain, seeded down with 10 lbs. red clover, 2 lbs. alsike and 6 lbs. timothy per acre. Fifth year—hay or pasture, land to be left unploughed till the following spring, manure to be applied during the winter and turned under with a shallow furrow for corn production the sixth year, or the first year of the new cycle of rotation. Such parts of the hoed crop field as it is desired to devote to roots or potatoes should be ploughed in late summer the year previous. Immediately after ploughing the land should be rolled, disc harrowed and worked down to insure rotting of the sod. Short manure or rotted manure should be applied during the fall or winter and worked in on the surface preparatory to growing roots or corn next year. This rotation does not allow for the production of timothy hay, but provides a very large supply of clover hay suitable for most live stock, and is certain to give large grain crops, both after corn and after the clover. The crop coming after clover is likely to be something heavier in the straw, but on a stock farm (the kind of farm for which such a rotation is fitted) an extra amount of straw is always valuable. This rotation, since it allows for growing grain on two-fifths of the whole area, may recommend itself to such farmers as desire to grow all the grain feed they require on their farms.

Rotation 'F' is similar to rotation 'E' It, however, allows for the production of some timothy hay. It is as follows:—

First year—hoed crop. Second year—grain, seeded down 10 lbs. red clover, 2 lbs. alsike and 12 lbs. timothy per acre. Third year—clover hay or pasture. Fourth year—timothy hay or pasture, the land under timothy hay or in pasture to be ploughed in August with a shallow furrow, rolled, disced and harrowed to insure breaking down or rotting of the sod, and harrowed at intervals during the fall to destroy weeds and get the soil into good working condition. In early October this land should be ploughed again with a slightly deeper furrow, or else ridged up with a double mouldboard plough and left for the winter.

Fifth year—grain, seeded down 10 to 12 lbs. red clover per acre. This clover is allowed to grow all fall, manure applied during the winter and the whole mass of clover and manure turned down in May for corn or roots. This rotation, while not yielding quite as large a proportion of forage as rotation 'C' or rotation 'D,' has the advantage of allowing the farmer to grow more grain, and so providing for almost all his feeds on the home farm. It is a rotation that can be safely recommended to any farmer interested in dairying or beef production in eastern Canada.

Rotation 'G' is of six years' duration, and might be of various forms. The form given above:—

First year—hoed crop; second year—grain; third year—grain; fourth year—hay; fifth year—hay or pasture; sixth year—pasture, is probably not the best arrangements of crops, but it is the rotation most commonly followed in many parts of Canada. It has the disadvantage of trying to grow two grain crops in succession. Were it modified to read: First year—hoed crop; second year—grain; third year—hay; fourth year—hay; fifth year—pasture; sixth year—grain, it would be likely to prove more satisfactory, both as a rotation for producing large quantities of forage and as a rotation for keeping the farm in good condition.

Some Reasons for Adoption of a Rotation.

Any one of these rotations carefully followed and the cultural operations connected therewith performed at the right time and in the right way would be sure to increase tremendously the crop production of any given farm, and at the same time increase but slightly, if at all, the cost of production. In addition to the increased returns and lower cost of production per unit of crop, the following advantages might be anticipated from the introduction of a rotation into the farming operations of the average eastern Canada farmer:—

1. The cost of fencing on farms where live stock are kept could be materially reduced, since it would be necessary to fence off only three, four or five fields instead of fifteen or twenty as is very commonly the case. Farmers of course do not always fence off each small field, still, where fields are not fenced, the disadvantage of being unable to pasture any given area when conditions were such as to invite such treatment, and the trouble of driving cattle across unfenced fields to reach other fields, would more than make up for the extra cost incurred in the construction of suitable fences. The introduction of a rotation including a few properly fenced fields would do away with all trouble in this respect.

2. All cultural operations of one kind would be in one field, thus lowering the cost by reducing the travelling necessary from one small plot to another. All corn or hoed crops would be together, all grain crops in one group, and all hay crops in another, hence much time would be saved, and so cost of production lowered.

3. Larger machinery could be used. Where fields are few they are sure to be larger, and larger fields can always be handled more cheaply with large machinery.

4. Every field would receive its fair proportion of barnyard manure, and receive this manure at regular intervals. In this way every part of the farm would be kept in good tilth, and the whole farm kept up to its highest producing possibilities. As operations are usually conducted on farms where no rotation is practised, certain fields

adjacent to the farm buildings or supposedly possessing some peculiar soil characteristics are usually favoured to the disadvantage of the rest of the farm. Many farms include small areas upon which practically all the manure is lavished each year, greatly to the detriment of the rest of the farm, and much to the disadvantage of the owner. The influence of a rotation in improving conditions in this respect can hardly be overestimated.

5. Considerably less labour is required to keep fields in good condition where a rotation is followed. While it might be claimed that ploughing a field every third or fourth year would involve a large amount of labour, it can be stated on the other hand that performing these cultural operations more frequently permits of their being performed much more easily year by year. At the same time, if careful record be kept of the amount of labour upon a field where no rotation is followed, it will probably be found that practically just as many hours of horse labour or man labour have been spent as where under a short rotation.

6. Fields under long rotations or no rotations are almost certain to become infested to a greater or less extent with weeds. Fields under a short rotation are practically always clean, provided of course that the cultural operations are properly performed. The value of the rotation in helping eradicate all injurious plant life is a point the importance of which cannot be too much impressed upon our farmers in eastern Canada to-day, where weeds are so exceedingly prevalent, as is well known to be the case.

Many other minor points might be cited in favour of the introduction of a rotation. The above should, however, suffice to indicate its value on the farm. The rotation, as I have attempted to demonstrate, is important, but no rotation can make up for poor cultivation or faulty soil treatment. So I propose to devote the rest of this paper to a consideration of some of the more important conditions of plant growth and the different cultural operations as affecting the same.

SOIL CULTIVATION.

The requirements of rapid plant growth are: 1. Moisture. 2. Warmth. 3. Plant food.

MOISTURE.

The moisture supply depends primarily on precipitation. Precipitation, or rainfall, is, however, not controllable. It is necessary, therefore, to so handle soils as to enable them to conserve or retain the moisture received until required for crop production.

Drainage a Factor in Moisture Conservation

Several factors influence moisture conservation in soils. Of these various factors, good drainage is probably the most important. Well drained soils are free from the danger of baking or puddling, that is, they are friable and loose on the surface, so preventing evaporation. Well drained soils being free from hydrostatic or free water to a considerable depth are in shape to absorb rain as it falls and preserve it in the form of capillary or hygroscopic water. It is only as capillary or hygroscopic water

that moisture can be retained for any length of time in the soil in dry weather, hence good drainage is an absolute necessity where moisture conservation is a matter of importance, just as it is an indispensable condition where seasons are short or rainfall very great in order to carry off the surplus water and allow air to enter the earth to reach plant roots and raise the soil temperature.

Ploughing and Cultivating as Methods of Controlling Soil Moisture.

Shallow ploughing and deep cultivation are, after drainage, probably the most important influences making for moisture conservation. Shallow ploughing by keeping the humus near the surface greatly increases the moisture holding power of that, the most important soil layer. Deep cultivation by stirring the lower stratum of soil helps disintegrate the stiff and probably waterlogged upper subsoil, and so very greatly increases the amount of capillary water readily available near the surface layer for crop requirements.

Surface Cultivation Conserves Moisture.

No matter what the condition of the surface soil and upper subsoil as influenced by ploughing and subsoil stirring, no matter how well drained the lower subsoil, if no precaution be taken to prevent evaporation, a very large amount of moisture is sure to be carried off from the surface by every faintest breeze and weakest sun ray. To prevent this, the maintenance of a soil mulch on such surfaces as are exposed to the moving air or direct sunshine is a necessary precaution. A soil mulch may be made by means of a light harrow. Sometimes, too, it may be made by a roller. The roller has usually just the opposite effect; under certain conditions, however, it is of value in this connection. To illustrate, it often happens that two or three weeks after seeding, before the grain is up high enough to protect the soil surface from winds and sunlight, a crust forms and moisture evaporation goes on apace. Going over such a field with a light roller breaks the crust and forms a soil mulch which effectually stops the loss.

Humus Conserves Moisture.

Humus absorbs and retains moisture much more readily than any other constituent of the soil. Hence one of the best methods of improving the moisture storing and moisture conserving powers of a soil is to increase its humus content. This may be done by the frequent turning under of sod and by the use of barnyard manure.

WARMTH.

For plants to grow rapidly, warmth as well as moisture is an absolutely necessary condition.

Drainage Warms Soils.

Drainage was shown to be probably the most important factor in making for moisture conservation. Drainage as an influence affecting soil temperature is of even greater importance. Undrained soils are always cool, usually too cold to favour plant

growth, save in the case of certain species accustomed to such peculiar conditions. Practically all cultivated plants require warm soils. Drainage will warm the soil by carrying off surplus moisture and enabling air to enter.

Soil Mulch Affects Soil Temperature.

Once a crust has formed on the surface of the soil, water escapes rapidly through the pores, evaporating as it passes off. The change from liquid to gaseous form means the absorption of large quantities of heat by the escaping water, and in this way much heat is taken out of the soil. Thus in spring, when heat is of such paramount importance, it not infrequently happens that a field lying under a bright sun is going down in temperature rather than rising, for the reason that much moisture is escaping from the surface by evaporation. To prevent this and stop the cooling-off process, all that is necessary is a cut with a common harrow, that is, a mulch should be formed.

Humus Warms the Soil.

After drainage and the soil mulch, the colour of the soil is an important factor affecting soil temperature. Dark soils absorb heat readily and rapidly. Humus has the effect of darkening soils, hence the increasing of the humus content of a soil is an important and practical method of raising the temperature of a soil that, due to its colour, might otherwise be slow in warming up.

PLANT FOOD.

The supply of plant food in a soil is very commonly supposed to be the measure of its crop producing powers. Such, however, is not exactly the case. Even the most barren soils, so far as plant food is concerned, may in a few years be made to produce most excellent crops provided the other conditions of plant growth be right. Any soil to which humus can be added at not too great expense will shortly be found to yield profitable crop returns.

Commercial fertilizers might be of some value in building up a worn-out or barren soil, in as much as they will supply more or less immediately available plant food, and in the case of certain fertilizers being used, such as land plaster, lime or ashes, will do something toward rendering available such plant food as may be already in the soil. They will also correct any acidity in the soil, and in the case of ashes and lime will do something to improve the physical condition.

Humus, however, is the material required to get the soil in good crop producing shape. The farmer's aim should be, therefore, not to find out by chemical analysis what elements of plant food appear to be lacking in whole or in part, but rather to improve the physical condition of his soil by adding humus, draining properly and performing the necessary cultural operations in the right way, at the right time.

CULTURAL OPERATIONS AND IMPLEMENTS.

The following notes on cultural operations and implements will probably serve to supplement the preceding paragraphs on crop rotation and soil cultivation.

Ploughing.

Ploughing is admittedly the foundation operation in all crop production effort. Ploughing has been performed with many different kinds of plough and in many different styles. No definite rule can be laid down as to the best method of ploughing. A safe rule, however, is to plough only when the soil is in shape, that is when not too wet; this rule, of course, applying to heavy soils only. Ploughing deeply in autumn, turning an upstanding furrow, and ploughing shallow in spring, turning a low-lying or flat furrow, is another general rule, and is applicable to a greater variety of soils than the first. Ploughing should, in my opinion, be done whenever possible with the two-furrow gang plough, using four, or at least three horses. In this way, the cost of the operation is materially reduced.

Disc ploughs recently put on the market afford a means of performing this operation at times and under conditions where it would probably be impossible for the common mouldboard plough to operate, as for instance, ploughing heavy clay lands when hard and dry. They are also useful in burying manure, grass or weeds and in exposing heavy soils to the action of the frost, since they leave a very rough surface exposed to the air.

Subsoil ploughing is a cultural operation very seldom practised, and one that should be more frequently performed by the farmer, and serves, as indicated in preceding paragraphs, to open up the upper subsoil and so increase the water containing capacity of the root-holding soil strata. The subsoil plough may to a certain extent be replaced by what is known as the subsoil hook, a cheap, light affair, that can be readily attached to the beam of any plough and passing over between the handles, do a good job in the way of stirring to a depth of three or four inches, the upper subsoil.

Harrowing.

A great variety of implements have been devised and put on the market wherewith to perform the operation commonly known as harrowing. Of all these implements, the disc harrow is probably the most generally useful and the most effective in the work of preparing soil for seed after it has been ploughed. The larger the disc and the more acute the angle at which it is set in operation, the more effectively will it work. To insure good work, however, with a large sharp-set disc, rolling is necessary in order to crush the soil down that it may remain in place when being carved by the disc.

A new disc harrow, known as the Double Cutaway, has recently made its appearance, and has proven to be a most excellent implement. It consists of two disc harrows, one in front of the other, cutting, the one with an inthrow and the other with an outthrow; the discs are so placed as to prevent their running in the same track, hence a much more thorough cutting up of the surface soil is insured. Considerably more power is necessary to operate this disc than in the case of a single disc. It is, however, an implement capable of materially reducing the cost of preparing the soil for seed after the land is ploughed.

The spring tooth harrow is an implement that cannot be too strongly condemned, where used, as is commonly the case, on sod land or on rough hard land. This implement tears up the sods, exposes the grass and leaves an exceedingly rough surface, very certain to give poor results in crop production.

Harrowing is an operation usually very badly performed, and an operation that is almost always ended up sometime before it should be on any given area. Good ploughing is a necessary condition of the best crop results, but thorough harrowing is an indispensable condition of profitable crop returns from any field. Thorough harrowing does not necessarily mean three or four or ten different harrowings, but it means such treatment as leaves the surface of the seed bed smooth and friable, and leaves the bottom of the seed bed firm and solid. Until these two conditions are fulfilled the harrow should not stop.

Where sod land is being prepared for any crop, possibly the best treatment would be about as follows: Roll with a heavy roller, disc harrow lengthwise and crosswise or on the bias; roll again, disc harrow once more, and then smooth harrow with a common spike-toothed harrow. If, however, it is found that the land is not yet in perfect tilth, then it might be necessary to repeat the disc harrowing and the rolling. In any case, seed should not be sown until the soil is in perfect shape for crop production. It is usually safe to harrow again after conditions seem nearly perfect for seeding.

The spike-toothed harrow may often be run over the land when the average farmer would consider it utter folly to use it at all, for instance, in the corn field a few days after sowing or planting the corn, and in the same field a few days after the corn is up. Harrowing the field at such times is almost certain to materially help the crop.

Where large areas of corn are grown, an implement likely to prove a considerable value is what is known as the slant-tooth or tilting harrow. This enables one to control the depth to which the harrow shall sink in the soil, and so permit of harrowing the corn or potatoes at times and under conditions when the common spike-toothed harrow might do some small amount of damage.

Seeding.

Seeding is now rarely done by hand. It is, however, in too many districts still done broadcast, that is, what are known as broadcast seeders are used. Such seeders are not nearly so satisfactory as drill seeders. Much of the seed is insufficiently covered, while another part is buried too deeply. Consequently it comes up unevenly, grows unevenly, ripens unevenly, and there is thus considerable loss at harvesting, to say nothing of the seed lost by being buried too deeply or by being insufficiently covered.

The hoe drill and the single disc are the best seeders, and of these, I believe the single disc to be the better. Here, as in the case of the plough and the harrow, as large an implement as possible should be selected, since such implements aid materially in reducing the cost of production.

The Roller.

The roller is commonly looked upon as the implement wherewith to give the finishing touch. It is just at this point, however, that the greatest danger lies. It is as an operation after seeding that rolling is, on the average, of least value. There are, of course, conditions when it is advisable to roll after seeding, but the true value of this

implement lies in its usefulness as a means of preparing the land preparatory to seeding, as already mentioned in connection with harrowing. The use of the roller in preparing sod land for grain or corn is much to be commended, and it is here that this implement is of the greatest value to the farmer. In certain soils, as for instance, mucky or peaty soils, it is often advisable to roll once or twice before seeding, and two or more times after seeding; this more particularly, if the land is to be seeded down to grass or clover, at the same time as sown to grain.

No land should be rolled after seeding if the surface is at all damp. The surface should be allowed to dry a few days before the roller is put on. Rolling in this way a few days or even two or three weeks after the grain is up, breaks the crust, forms a mulch, and so helps to conserve moisture, as already mentioned in a preceding paragraph.

On light dry soils, rolling is an essential operation after seeding to insure quick germination of both grain and grass seeds. Here again, however, it is often advisable to roll a second time two or three weeks after the grain is up. This helps firm the soil and breaks the crust as before stated.