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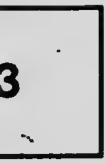
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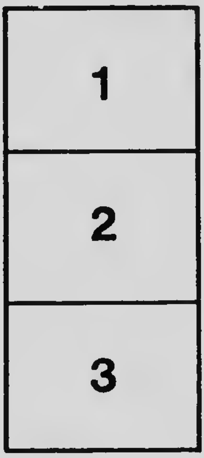
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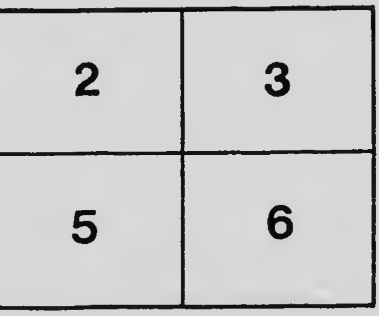
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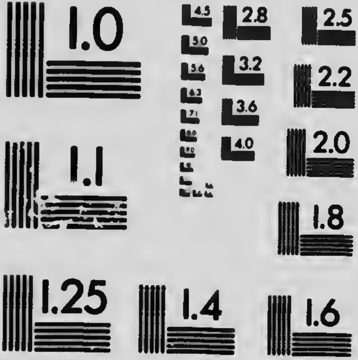

EXHIBITION CIRCULAR No. 27.

DOMINION OF CANADA.

DEPARTMENT OF AGRICULTURE.

EXPERIMENTAL FARMS.

DIVISION OF CHEMISTRY.

J. H. GRISDALE, B. Agr., Director.

FRANK T. SHUTT, M.A., Dominion Chemist.

THE FARMER AS A MANUFACTURER.

BY

A. T. STUART, B.A., Assistant Chemist.

Part II.—Soils: their origin and nature.
Fertility: its maintenance and increase.

HOW SOILS ARE FORMED.

The earliest surface of the world was composed of solid rock, like granite, which had cooled down from a molten state. Now, these rocks are nothing more than innumerable small pieces of mineral cemented together. The other type of rocks (marble, limestone, sandstone, &c.,) were formed later.

Soils are formed by the decay and crumbling of these rocks. The small pieces of mineral become separate and cover the surface. Then plant life began to develop. The vegetable organic matter (humus) resulting from the gradual decay of plants together with the small pieces of minerals give us our soils of to-day.

MINERALS IN SOILS.

If a soil be sorted out and the humus separated we can actually see, by means of the microscope, the great variety of small pieces of minerals. It is upon these minerals the plants must ultimately depend for their supply of mineral matter.

The plant requires a considerable variety of mineral matter but luckily in farming it is found that of this only Phosphoric acid, Potash and Lime run short. Of course, in addition to this we must consider the supply of nitrogen in the soil, as described before.

THE PHYSICS OF SOILS.

In general the constituents of soils are:—

1. *Clay*—The particles of which are extremely small; they measure $\frac{1}{25000}$ inch. Its plasticity and adhesiveness hold the particles of sand and these help to form soils of good tilth. The extreme fineness serves to hold moisture and gases and solutions of plant food.

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2. *Sand, Silt and Dust*—Or ground up rock form the greater part of soil. These particles, varying greatly in size, are much larger than those of clay. They help to make a soil porous and mellow.

3. *Humus.*—Vegetable matter from the decay of plants.

These particles can be sorted out, counted and measured. In size they vary from $\frac{1}{25}$ inch to $\frac{1}{25000}$ of an inch, and the number in 1 gram of soil (an amount which may be held on the end of a penknife) may vary from 1,000,000 to 100,000,000,000,000. If the total surfaces of these small particles be added together it will measure from 20 square feet to 3 acres for each pound of soil.

This may seem unnecessary detail, but it must be realized that upon these conditions depend the whole possibilities of agriculture. In a soil suitably moist for crop growth each particle is closely surrounded by a thin film of water from which the plant must take its living. The larger particles here and there keep open the soil passages so that air, water and roots can pass along.

It is the variations in kinds and amounts of these particles that make all the different kinds of soil. Weights may thus vary from 30 to 110 lbs. per cubic foot and the air spaces from an extremely small amount 25 or 50 per cent of the total, as in well tilled soils where large crumbs are formed (good tilth).

THE LIFE OF THE SOIL.

The differences between soil and subsoil lie in the predominance of roots and decayed residues of plants near the surface. Here also is more exposure to air, heat and cold, light and life. Living with and upon the decayed vegetation are myriad forms of bacteria. Their number may run to 15,000,000 in 1 gram of soil. Then there are moulds and fungus growths and ferments; many of these minute forms of life do a most valuable work in preparing food for farm crops.

Of the utmost importance among all this low order of vegetable or animal life is the fact that certain bacteria are active in absorbing nitrogen from the air. These live chiefly on the roots of leguminous crops (clover, alfalfa, peas, beans, &c.) and the good farmer takes advantage of them to enrich the soil. There are many other beneficial agents at work, amongst which are the earth worms. When all is added together this work greatly exceeds the sum total of all human endeavour.

MOVEMENT OF SOIL WATER.

There are two main movements of water, up and down. After a rain there is a great rush of water downwards, with which is carried the finer particles of clay and plant food in solution. On the other hand, in dry weather water has a tendency to climb up through the small spaces and evaporate at the surface. In so doing it carries up much material which is soluble in water which sometimes deposits at the surface, and this explains why in dry regions (as in parts of Western Canada) alkali lands are formed. In such places there is not enough rain to wash the alkali down and away into the rivers and oceans where all such material collects to form the salt sea.

In order to grow, plants require from 200 to 1,000 times their dried weight of water. This very large amount is taken up by the roots, evaporates from the leaves and totals hundreds of tons per acre each year. In the soil, water may be classified as follows:—

1. That which is absorbed from air.
2. That which is suspended between particles (film water).
3. That which sinks down and runs away.

Upon No. 2, the plants depend for supplies.

REGULATING AND CONSERVING FILM WATER.

1. Loosening the surface allows rain to soak in.

2. Under-drains help to increase water-holding capacity of soil by keeping clay loose and porous. Likewise they carry off excess of free water which drowns the roots of crops.

3. Irrigation.

4. Loose surface tilth with close texture below allow water to climb up to roots but not to the surface to evaporate.

5. Weeds are a heavy drain on soil water supply.

PLANT FOOD IN SOILS.

A moment's reflection will convince one that the roots of plants cannot assimilate a solid piece of soil. The root hairs, which take in the food supplies, are like small paper bags. Everything entering the roots must pass through these cell walls so that it is clear that plants can only drink in their food, which must be absorbed from its solution in water.

In the soil, plant food may be said to exist in three conditions. A very little is already dissolved in water, some of it can be fairly easily dissolved and may be called available and lastly there is the big reserve, practically insoluble, in the form of particles of rock and minerals and decayed plants. Nature thus holds large stores, but doles out gradually the requirements. If the available forms of plant food be drawn upon too fast we see crops becoming less and less.

MAINTAINING FERTILITY.

It is evident that the farmer must exercise extreme care if he would keep his soil in the highest condition of productiveness. The soil is the real guardian of the farmer's capital and the security is absolute. Try as he may he cannot 'break the bank.' He may bring about temporary derangement and dividends may for a while be suspended, but invariably, under better management, prosperity can be restored and perhaps even larger profits than ever secured. However, if the farmer is a good banker he will not draw upon his accounts faster than he makes deposits, but will gradually build up wealth upon which he may draw more and more interest. He is at once the proprietor and patron of nature's bank.

The ledger account he keeps may be headed 'Fertility.' His deposits (the Dr. side) consist of what fertility he adds to the land—by raising clover and other legumes and in the return of all manure. His withdrawals (the Cr. side) consist in what he removes from the land and sells off the farm—butter, cattle, grain, or occurs through loss in handling manure, &c. The net loss, may be kept very low, even nil, by selling small bulk (concentrated) products at high prices, *e.g.*, butter, milk, eggs, poultry, wool, pork, beef, mutton, fruits, vegetables, as against selling bulky products at low prices (hay and grain). The figures are startling (see circular, 'The Balance of Fertility'). A 160-acre farm in one case may lose no fertility or even gain a considerable amount, while in the other the annual loss of plant food may reach 15,000 lbs. per year of nitrogen, phosphoric acid and potash.

FERTILIZERS.

It is often profitable and sometimes very profitable to apply also forms of plant food other than those produced on the farm. These may be used without disturbing the ordinary methods. The use of fertilizers calls for considerable care and it is just as easy to contract large losses from their misuse as it is to obtain large profits from their right use. However, the fact that frequently profits may be doubled by their employment shows their possibilities. The nature and composition of fertilizers is a subject well worthy of the farmer's careful study. No farmer should employ fertilizers unless he has proven by experiment that by them he makes a profit.

It is usually much cheaper to buy the materials and mix them at home than to purchase a ready-made fertilizer. A summary of the results of some 10,000 fertilizer experiments in the United States has been made and it seems possible to draw a few general conclusions therefrom which might be of value. Of course it must be remarked that these conclusions are not true in each and every individual case.

1. That it is generally much more profitable to use complete fertilizers, *i.e.*, those containing all three elements—nitrogen, phosphoric acid and potash.

2. That moderate applications only are advisable—say from 300 to 500 lbs. per acre.

3. That increased yields may follow the use of fertilizers on many classes of soils, even those considered rich.

It is usually easy to obtain considerable profits on such crops as potatoes, while fertilizers for such crops as grain, hay and corn require very careful study. The safest practice seems to be to fertilize the money crops in the rotation, allowing the other crops to benefit by the residues.

SOURCES OF PLANT FOOD.

Nitrogen—*Manure, clover,* tankage, nitrate of soda, sulphate of ammonia.

Phosphoric acid—*Manure,* acid phosphate, basic slag, bone.

Potash—*Manure,* sulphate of potash, muriate or potash and wood ashes.

The importance of *manure* in farm economy is now realized. It is the inevitable by-product of the properly conducted farm, just as bran and shorts and tankage are the by-products of manufacture. It is a surety that the manufacturer exacts full value from his by-products. Why not the farmer, the manufacturer of protein, fat and carbohydrates?

In order to establish a proper treatment and care of the land the crops are 'rotated.' In this way all parts of the farm get an equal chance. This also serves to produce the different kinds and amounts of crops as required for feeding, allows for proper manuring and cultivation, for alternation of crops with deep and shallow root systems, for using preceding crop residues, gathering nitrogen from the air, distributing farm labour, controlling weeds, &c., &c., &c.

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