SOME OF THE PROPERTIES OF SOILS

(By C.O. Williams. B.Sc., A.R.CS., Chemist, Schl. of Agriculture, Cedara).

In my lecture last year, to the Congress, on the Manuring of Cane Lands it was emphasised that the fertility of a soil does not depend alone on an adequate supply of available plant food being present, but that there are a great many other factors governing the fertility of a soil. A farmer is too often ready to jump to the conclusion when his crops are poor that the soil requires some form of artificial fertiliser, and that if he can only get his soil analysed and find out which constituent is deficient he has only to apply that constituent in comparatively small amounts in order to bring up the soil to the required degree of fertility.

I am not decrying the practice of requesting the chemist to conduct an analysis of the soil, for often that is of very great value in assisting the agriculturist to diagnose the complaint the soil suffers from, but one should not imagine that the analysis of a soil alone is always sufficient to give a clue as to what treatment the soil requires to restore it to normal health. In this lecture it is proposed to carry out a few experiments illustrating some of the properties of soils upon which their fertility depend, in addition to their chemical composition.

Need for an adequate supply of water—The soil is composed of grains of matter of various sizes packed more or less closely together, and the spaces between are occupied partly by air and partly by water, with a film of water round each particle. This water has dissolved a large number of different substances from the mineral and organic matter of the soil, and this solution enters the plant through the roots, so that the plant obtains its food from the soil only when it is in solution in the water. The soil solution is very weak so the plant has to take in a large quantity of water in order to obtain an adequate amount of the dissolved mineral matter necessary for its growth and well being, and the excess of water is transpired through the leaves into the atmosphere. It will be readily seen that there must always be a plentiful supply of water round the roots of the plant, and the water in the soil must be free to move in all directions, from the region where it may be present in excess to where there is a deficiency of it.

Percolation of water and water capacity of the soil—The pores of a soil should only be partly filled with water for air is also necessary in the soil consequently the excess of the water that falls as rain should be free to move down through the soil. If the particles of the soil are comparatively coarse and far apart an excessive amount of the rain water will percolate downwards leaving an insufficient amount in the pores of the soil for the needs of the plant. On the contrary, if the size of the particles is very small and they are very close together there will be too great a friction offered to the passage of the water downwards, with the consequence that the pores of the surface soil will become completely filled with water and remain so for some time after a heavy shower of rain. These two extreme types of soils (sandy and clayey soils) are thus defective from this point of view, for a soil should be able to retain a fair amount of the rain water in its pores and still allow the excess to percolate down fairly readily, as is the case with a good loam.

The first experiment consists of two long glass funnels of the same size, in one of which there is a sandy soil and in the other a clay soil, both dry and filled up to the same height. Equal quantities of water are poured slowly on their surfaces, and it is seen that the water percolates very quickly through the sandy soil and it retains a much smaller proportion of the water.

Capillarity—You are all acquainted with the way water clings as a film round any object such as a stone or a clean sheet of glass that has been immersed in it and taken out again, but if such objects are plunged into mercury they are not wetted at all by it. In the first case there is an attraction between the water and the stone or the glass, whereas there is actually a repulsion between mercury and them when brought into close contact. This phenomenon explains why water rises in narrow glass tubes above the surface of the water outside, and why the water creeps up a porous material like a piece of chalk or a length of cotton wick. It also explains why it clings round each particle of a soil and fills the minute nooks and crannies between the particles in spite of the fact that the force of gravity may try to pull it down to as low a level as possible in the subsoil. This force is usually termed capillarity and the water held by it round each particle in the form of a film is known as capillary moisture. If the films of capillary moisture are thicker in one portion of the soil than in another there is a tendency for the water to creep from where the films are thickest to where they are thinnest so as to make the thickness of the films of moisture uniform throughout. Now, the particles of soil or rocks

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deep down in the crust in contact with the underground supply of water are saturated with water, but the water round each particle of soil near the surface gets evaporated away by the heat of the sun or is used up by the roots of the plants, so there will be a creeping up of the superfluous water from the wetter regions below to the drier regions above.

If the soil is very coarse in texture there is very little obstruction to the passage of the capillary moisture, but on the other hand the particles of soil are not in sufficiently close contact for the force of capillarity to act efficiently; the consequence is that in such a soil the water may rise quickly at first by capillarity but not to a great height. In a very fine-textured soil the particles are so close together that the movement of the capillary water is very much impeded, and although ultimately it may rise to a very great height it will take a long time to do it.

The second experiment consists of three long glass tubes standing in a tray of water, one filled with a very sandy soil, the second with a fairly heavy loam, and the third with a clayey soil. The bottom ends of all these tubes were immersed in the tray of water at the same time, and the height to which the water has risen at certain fixed intervals of time has been noted. The figures confirm the explanation just given of the behaviour of the capillary water in different types of soils. In another tube there is a layer of an inch or two of finely cut vegetable matter half way up the column of soil, and it will be noticed that the capillary water has risen in the soil up to the bottom of the layer of vegetable matter but cannot rise any higher, for as already explained in order that capillary movement of water may take place in the soil the particles should be in close contact. A layer of dry vegetable matter just below the surface of the soil will break the continuity of the soil particles so that the capillary rise of water will cease at that spot. If a crop is sown or planted in a soil with such a layer of dry vegetable matter below the surface it will be unable to secure sufficient moisture from the lower soil in its early stages of growth, and if the season is dry the young crop will suffer greatly from the lack of moisture. It is therefore undesirable to plough under a large amount of dry coarse organic matter into the soil just before planting, but it should be given time to decompose into fine humus and become more or less incorporated with the soil. A layer of such dry vegetable matter on the surface, however, will act as a mulch to conserve the moisture in the soil underneath.

Retention of soluble substances by soils—In the third experiment a solution of superphosphate in water is allowed to percolate down through columns of two different types of soils: (1) a very sandy, and (2) a fairly close-textured soil. By testing equal volumes of the original solution and of the two percolates for phosphate it is seen that the close-textured soil has retained all the phosphate that was in the solution originally, and even the sandy soil has retained a fair amount.

If the experiment is repeated with nitrate of soda instead of superphosphate it will be seen that there is very little nitrate retained by any of the different types of soils. A soil is capable of absorbing from solution a large number of chemical substances, and when such substances are applied to the surface soil they are not readily washed down by the rain into the subsoil below and thence to the underground drainage.

Of the usual fertilising constituents the phosphates. potash, ammonia, and organic compounds are retained very tenaciously by the soil, but the nitrates are washed down very readily. Consequently, any of the ordinary fertilisers applied to the soil and not used by the crop during the first season are still largely available in the soil for the following season, except the nitrate. Such a fertiliser as nitrate of soda should therefore be applied in small quantities at a time, as the crop needs it, and preferably as a top dressing.

Effect of certain substances on flocculation of clay.—In this experiment a little clay is rubbed up with distilled water in order to break down the small aggregations or granules so that the minute individual particles are now free and not sticking to one another: this process is known as "puddling." More water is added and the turbid liquid is poured into a number of vessels of the same size. Into one vessel there is added a few drops of the clear solution obtained from shaking up superphosphate in distilled water and filtering; into the second vessel there is added a little lime water, and to the third a solution of sodium carbonate (washing soda), while a fourth has nothing added to it. It will be noticed that the first vessel clarifies very quickly, the second takes a little longer time, whereas the third vessel remains turbid even for a longer period than the last one.

An acid or a salt of an acid nature (such as gypsum, alum, or superphosphate) has the property of causing the very minute particles of clay to aggregate together so that they are now heavy enough to fall very readily through the water, leaving it clear. Contrariwise, an alkaline substance (such as carbonate of soda) will break down such aggregations if they are already formed and will therefore prevent any clarification of the water taking place.

In a soil the minute particles of clay tend to make it very plastic (or sticky) and impervious to water, so a clay soil is very difficult to work, sets very hard in dry weather and becomes waterlogged in the wet season. If these excessively small particles are flocculated (i. e., aggregated into comparatively large-sized groups) the soil becomes more granular or crumbly, is easier to work, and allows of a freer movement of the water to take place in it. This

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beneficial effect may be brought about by adding lime, either in the form of burnt lime (after being water slaked) or as carbonate of lime (ground limestone). Fertilisers of an acid nature, such as superphosphate and gypsum, tend to bring the same beneficial change about, but nitrate of soda leaves a residue of soda in the soil which is harmful to the texture of the clay. Alkaline soils containing appreciable proportions of sodium carbonate (black alkali) are notoriously bad in texture if there is a fair amount of clay present, for the presence of this alkaline material prevents the flocculation or aggregation of the minute particles taking place.

Other means of improving the texture of clay soils is to plough them up early and expose them to the action of frost, or to the alternate heating and cooling, wetting and drying that the surface soil would thus undergo. Working such soils when wet is fatal for the clay material is thus puddled.

Testing for acidity and alkalinity in soils—Lay strips of blue and of red litmus paper on the bottom of a shallow vessel like a large watch glass, or a small clock glass, or a small bowl, and pour in a fair amount of the fine soil to well cover the papers. Thoroughly moisten the soil by pouring in some distilled water (or freshly boiled, clean rain water) carefully down the sides of the vessel, and leave for about a quarter of an hour. Then carefully remove the soil and note any permanent change in colour of the strips after allowing them to dry. Should the soil be of an acid nature the blue litmus will be turned red, but an alkaline soil will turn the red litmus blue. If the soil is neutral there will be very little change in the colour of either of the papers. When carrying out this test prevent contamination of the fingers and of the vessel as much as possible, and the experiment should be carried out where there are no acid or ammonia fumes.

It may be pointed out, however, that the litmus test is not a very satisfactory one, and great caution must be observed in connection with it. It does not always follow that because the soil solution will turn blue litmus more or less red in colour it will be an economical proposition to lime that land. Sourness or acidity arises from various causes and liming is not always desirable. Some crops thrive in a soil with a slight acidity, though many crops do best in a neutral soil, while a few will even flourish in a soil that is rather alkaline.

Sugar cane is a crop that does not seem to have a marked predilection either way, so farmers should ascertain first of all, by experimenting on a few plots, whether their particular soil does give increased yields by liming. Of course, liming has other reasons in its favour besides correction of acidity, which were pointed out in my previous lecture, and one beneficial effect was also pointed out in the last experiment.

I have only attempted, in the short time at my disposal, to illustrate a few of the properties of the soil that are useful for the farmer to know, but it is hoped that it has been sufficient to create interest in the subject and to enable him to understand better a few of the many problems that he has to deal with in the cultivation and treatment of the many types of soils he often meets with on his farm.

SOIL FERTILITY

(Paper By M. EDELMAN, C.D.A., Lecturer in Agriculture, Cedara.)

It is not intended to discuss soil fertility from every point of view in this paper, as Mr. Williams has already dealt with the properties of the soil, and Mr. Staples' paper on "How Plants Feed and Grow" has furnished us with a further supply of information relating to the soil. The main object of this lecture is to try and drive home first what soil fertility means to the crop, and second its significance to the farmer.

The fundamental principles underlying soil fertility are the same for sugar cane as for any other crop, and, of the many factors that control farming today, four are outstanding, and these go to decide the value of any farm; they are:—

1. Climatic Conditions.
2. Labour Supply.
3. Distance of Farm from Nearest Railway.
4. The Soil.

The climate is left to nature to decide; the labour supply remains more or less constant in respective areas; in most cases the distance from the nearest railway station cannot be altered but when the soil is considered it is left to the farmer to get the best out of it, or left to the native to get the worst out of it. Other things then being equal, the farmer is dependent on his soil for profitable yields. A fer-