Rothamsted Report for 1938

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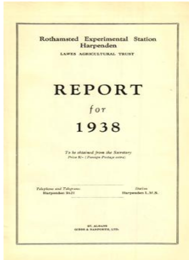
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The Soil

Rothamsted Research

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Mustard was again ineffective, but tares gave a significant increase of 1.4 tons per acre. The kale crop was followed by barley, which gave a significant residual response to tares of 2.2 cwt. per acre.

THE SOIL

One of the oldest problems in agricultural chemistry is to attempt a forecast of the effects of fertilizers on crops, this being done on the basis of chemical analysis. It was at one time thought that the problem was quite simple, and that a chemical analysis of the soil would readily show its response to fertilizers. Actual trial has proved that this view is wrong; no method of analysis yet tested accurately forecasts the effects of fertilizers: the soil is too complex to allow the problem to be solved in an easy way. Fortunately the liming problem is less difficult. Various methods are in use for estimating chemically how much lime is needed, and one of the most popular was devised at Rothamsted, but results are by no means clear cut and much further investigation is needed before they can be regarded as satisfactory.

The whole subject is under investigation in the Chemical Department.

The field experiments furnish numerous samples of soils which vary in their responses to potassic and phosphatic fertilizers, and these soils are examined chemically to find out how their composition is related to the fertilizer results.

Certain rapid methods for approximate analysis of soil have been examined and their possibilities noted, and a rapid pot culture method of soil analysis is also being studied in the hope of evolving something that will combine the advantages of the Neubauer and the Mitscherlich methods with certain other advantages. Now that the new chemical wing is built it is hoped to set up a spectrograph which would, of course, greatly facilitate the whole of this work and make possible rapid surveys that might prove of the utmost value.

Phosphorus compounds in soil.—The phosphorus compounds of the soil have also been studied in the Chemical Department. This subject is of particular importance at the present time because our field experiments indicate that, of the phosphate added as fertilizer, only about 25 per cent. is recovered in the crop in ordinary circumstances: the rest remains in the soil, but it is, so far as we can discover, in a form in which plants cannot easily take it up. On our present evidence the soil is a poor store house for fertilizers.

In the Rothamsted soils much of the phosphorus is present as iron phosphate even in neutral soils and those heavily dunged. Fenland soils are remarkable in their phosphate relationships and these are being studied in detail. A large part of their phosphate seems to be there in combination with iron and aluminium. The organic phosphorus compounds in soil appear to be relatively inert.

Manganese deficiencies in soils.—Three main types of soil are liable to manganese deficiency as shown by characteristic crop troubles.

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(1) Neutral or alkaline soils, notably recently limed reclaimed heath soils, which do not contain manganese minerals. These are liable to " Grey Speck " of oats.

(2) Alkaline fen soils: these are liable to " Speckled Yellows " of sugar beet.

(3) Heavily alkaline marsh soils, even if they contain manganese minerals: these are liable to " Marsh Spot " in seed peas.

All three diseases have been remedied by suitable applications of manganese sulphate. It should be noted that they can all be brought on by over-liming, and it is not difficult for a farmer to injure his crops by putting on more lime than the crop really needs.

Cobalt deficiencies in soils.—Both in Australia and in New Zealand animals grazing on certain pastures have suffered from a disease traced to cobalt deficiency. In the Chemical Department it has been shown that pastures in the Dartmoor area are also deficient in cobalt; the sheep there suffer from a disease similar to that in New Zealand. The remedy is to give a cobalt lick, but it is clearly desirable to make a survey of other hill or moorland grazings.

Soil Minerals.—Farmers recognise many different types of soil, and soil surveyors make maps showing their distribution in particular areas. But in order to understand them properly it is necessary to find out exactly how they differ, and investigations both of the organic and of the inorganic constituents have long been in hand. X-ray analysis is now used in the Chemical Department for the identification of the minerals in the various soil fractions and examinations made this year have included soils from India (in collaboration with Dr. A. Muir and A. D. Desai of the Macaulay Institute), from the United States Bureau of Chemistry, from Malaya and from the Malvern Hills. Special attention has been devoted to the clay fraction as being one of the most characteristic and at the same time most difficult to investigate. It is being studied in the Chemical Department by X-ray methods, and in the Physics Department by other physico-chemical and physical methods. Each set of methods reveals something about its constitution. The clay fraction is not homogeneous, but its special properties are largely due to certain components now under investigation. They are very complex, and their smallest particles are shown by X-ray analysis to consist of a lattice structure in which layers of silicon and oxygen atoms alternate sandwich-like with layers of aluminium and oxygen atoms arranged systematically. The particles are electrically charged and hence have associated with them various ions, of which the most important from the point of view of soil fertility are calcium, and in our conditions, hydrogen and potassium, but in arid conditions sodium and magnesium. These cations are replaceable by others: the " souring " of soil is caused by the replacement of calcium by hydrogen; conversely the " sweetening " of the soil by liming is due to the replacement of hydrogen by calcium. The electric charges appear to originate in three ways. Some are due to isomorphous replacements within the crystal lattice and are permanent in the sense that they are not influenced by the hydrogen ion concentration of the medium in which the clay is suspended, although this determines whether they are balanced by $H+$ ions or metallic cations. The other two kinds of electrical charges are associated

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with the surface of the clay particles when suspended in a solution of an electrolyte. One is associated with acidic " spots " where negative charges develop at high pH values of the medium through dissociation of the H+ ions which probably come from hydroxyl groups attached to silicon atoms at the corners and edges of the crystals. The other of these two kinds of charges is associated with basic " spots " which become positively charged at low pH values of the medium through combination with H+ ions : the chemistry of this process is not known, but it may involve an interaction with an aluminium-oxygen group. These basic " spots " occur on many of the common subsoil clays and indeed in some instances, a striking example of which was a red clay from Natal, they are so numerous that they exceed the permanent negative charges. In such cases by regulating the degree of acidity the number of positive charges can be made equal to the number of negative charges and the clay then carries no nett charge : it becomes incapable of retaining exchangeable ions, e.g. it cannot, like a fertile clay, hold calcium, magnesium and potassium and supply them to the growing plants.

The recognition of clays that can thus become uncharged at only a moderate degree ot acidity (pH 5) is obviously of considerable agricultural importance. The defect can to some extent be remedied by the addition of humic material which at this pH is negatively charged, and in such soils it is essential to maintain the supplies of organic matter.

These basic spots do not occur on all clays : montmorillonite and kaolinite seem to be free from them.

Soil surveyors use the colour of the soil as one of its properties for classification, but the estimation of soil colours is very vague. Dr. Schofield has devised an instrument for exactly measuring colour, and this has been taken over by Tintometer Ltd. for exploitation on a commercial scale. The instrument should prove of great value to a wide range of workers.

Water supply to plants.—The water supply to plants is at least as important as the food supply, and it is well known that different soils show remarkably wide variations in their power of holding water : some retain a large part so firmly that plants cannot get it, others hold the water with much less tenacity. A method of measuring the intensity with which soils hold water has been worked out in the Physics Department and is being developed for wider use. The underlying conception of water suction is being applied to a study of the pore size distribution in soils.

CROPS AND MICRO-ORGANISMS

For many years the Bacteriology Department has been engaged on a study of the organisms associated with leguminous plants and one of the best known results has been the working out of a method of inoculating lucerne seed before sowing : this is now generally adopted by farmers.

Investigation showed that clover nodule bacteria are very widely distributed throughout the country, but that some of their strains or varieties are much less efficient than others. One of the poorest, found on the Welsh hills, has been studied in some detail.