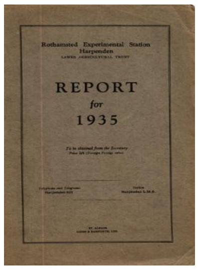
ROTHAMSTED RESEARCH

Report for 1935



Soil Micro-organisms

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Mr. Botelho da Costa, under the direction of Dr. Schofield, has used the improved freezing point technique mentioned in the last report to measure the *p*F of the water that remained in seven soils, of widely different character, when beans growing in them became "permanently wilted." The values so determined fell between *p*F 4.0 and *p*F 4.4, although the corresponding moisture contents ranged from 2.9 to 21.6 per cent. of dry soil. Taking the mean value of *p*F 4.2 and reading the corresponding moisture content from the curves plotted from the freezing point measurements, the values obtained differ on an average by only 0.7 per cent. from the moisture contents found in the wilting experiments. The greatest difference was only 1.2 per cent., which would be of small consequence in field measurements.

The moisture content of a soil at permanent wilting does not bear a constant ratio to the "moisture equivalent" determined in the Brigg-McLean centrifuge as these authors claimed. The freezing point determinations show why this is so. For a medium textured soil the "moisture equivalent" corresponds to about *p*F 2.9. This was confirmed by the freezing point measurements which showed that the curves connecting *p*F and moisture content differ in *shape* from soil to soil, and for the seven soils examined the ratio of the moisture content at *p*F 2.9 to that at *p*F 4.2, instead of being constant at 1.84, varied from 1.5 to 5.3.

By using the *p*F scale the results of measurements by direct suction, centrifuge, freezing point and evaporation into atmospheres of controlled humidity can be plotted on the same graph and curves connecting *p*F and moisture content can be traced from saturation (*p*F 0=1 centimetre suction) to oven dry (approximately *p*F 7). This work has brought into prominence the great importance of distinguishing between wetting and drying conditions. The suction needed to withdraw water from a moist soil is, in general, greater than that against which water will enter the soil at the same moisture contents. This fact, coupled with the slowness of wetting of clay by water at *p*F 3 or above, has been shown to account in a general way for the characteristic moisture distributions met with in the field.

SOIL MICRO-ORGANISMS

The growth of the plant, in nature is determined not only by chemical and physical soil factors but also by the soil micro-organisms, which are studied in the Micro-biological, Bacteriological and Fermentation Departments. The more these organisms are investigated, the more numerous they appear. Twenty-five years ago, the bacterial population in one gram of soil (about a salt-spoonful) would have been assessed at about 5 to 10 millions. It is now known that the figures are very much higher. A gram of field soil may contain several thousand million bacteria, many thousands of protozoa, millions of actinomycetes and fungi, in addition to an unknown number of eel-worms, besides other organisms not invariably found, either because they are not always present or because the technique is defective. The greater accuracy of modern bacterial counts is due to the method of counting bacterial cells in soil under

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the microscope which has been developed in the Bacteriology Department and now gives reliable quantitative results.

Three main groups of investigations are carried out :—

1. The decomposition of organic matter and its conversion into simpler substances. This is at the basis of the production of plant food in nature, but it has also many applications on the farm and in the countryside ; three of which are studied in detail :

(*a*) The decomposition of plant residues in the soil in relation to green manuring, ploughing-in of leys, residual values of farmyard manure.

(*b*) The conversion of straw and other plant residues into organic manure. This process has been taken up by Adco, Ltd., and developed by them into a workable process for making artificial farmyard manure. While English farmers do not make much use of it the method is used a great deal by gardeners and to a still greater extent by planters and growers overseas. Some 50,000 tons or more of manure are probably made annually through this one organisation and there is reason to believe that the total made in all countries by the process is not less than 200,000 tons annually.

(*c*) The biological purification of effluents from sugar beet and milk factories.

The last-named investigation is carried out in the Microbiological and Fermentation Departments under the ægis of the Department of Scientific and Industrial Research ; the work is done partly at Rothamsted and partly in the factory.

In the Bacteriological Department the interesting work on clover organisms continues, and it is shown that in the soils of certain hill districts there occur harmful strains which do not themselves benefit the clover plant, and which prevent most beneficial strains from forming nodules. A few beneficial strains, however, are able to overcome the harmful effects of the bad strains and enable the plant to make full normal growth. Experiments have been begun on the inoculation of these beneficial strains into soils containing the harmful ones, and the results are distinctly promising. The first essential is a survey of the hill districts to see how far these harmful strains are prevalent, and to what extent the highly efficient strains already isolated are able to act generally in overcoming their bad effects.

The process of infection has been studied in considerable detail. It is impeded by the presence of nitrates which not only reduce infection but also reduce the activity of nodules already formed. Part of the effect consists in checking the deformation of the root hairs which is an essential preliminary to infection : this, however, can be counteracted by adding dextrose. Such nodules as are formed in presence of nitrate are abnormal in several ways. The distal cap of the cells, normally thin-walled and actively dividing, develops much thickened cell walls and the cell-division soon ceases. The lateral endodermis and the cells surrounding the vascular strands become heavily suberised. These changes result in the central nodule tissue becoming enclosed in a layer of thick walled cells. This central tissue shows evident signs of starvation.