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Rothamsted Report for 1946

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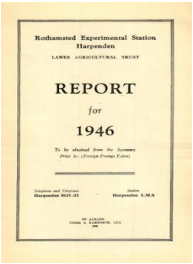

Physics Department

R. K. Schofield

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DEPARTMENT OF PHYSICS

By R. K. Schofield

Staff

During the year Dr. Keen was seconded on two occasions for duties overseas. At the invitation of the Palestine Government he visited Palestine to report on agricultural policy and on soil conservation, and to formulate proposals for the administrative organisation needed (1). Later in the year, at the request of the British Government, he went to West Africa as Chairman of a Government mission to inquire into the production of vegetable oil and oil seeds (2).

In Dr. Keen's absence Dr. Schofield acted as head of the department. Dr. Antonio Teixeira returned to Portugal in August, 1946, having obtained the Ph.D. degree. Mr. Oscar Talibuddin has worked throughout the year as a voluntary worker.

Field work

Deep ploughing experiments

This series of field experiments has been continued for a second year in an enlarged form. Fifteen centres were started in the autumn of 1944 and a further 15 in the autumn of 1945. The ploughing and cultivation treatments compared were shallow ploughing, about 7–9 in., with and without subsoiling to about 13–15 in., and deep ploughing, about 13–15 in., with and without subsoiling to 18–20 in. In addition on some fields an extra treatment, ploughing to 11–12 in., was also added. Of the fifteen experiments started in the autumn of 1944 fourteen were cropped with potatoes, and at harvest it was found that depth of ploughing, or the presence or absence of subsoiling, had no effect on the yields taken as a whole. In detail, deep ploughing had not depressed the yield on any field appreciably, whatever the subsoil, provided an adequate supply of fertiliser was given, and it probably increased it on one very badly drained field.

Fourteen of these fields went into corn in 1945–46, having received shallow cultivations only after the potatoes. Since the harvest was very difficult, yields could only be determined on ten of these fields, and the results were that the yield of winter wheat was between 1–2 cwt. higher on land ploughed to 12 in. or over, or subsoiled to 12 in. or over for the potato crop, and this effect was usually more noticeable on the heavier lands.

Nine of the fields of the second series were in potatoes in 1946, having received the same ploughing and subsoiling treatments in the autumn of 1945 as the first series received in 1944. The results were also the same: no matter what the subsoil, the potato yields were independent of depth of ploughing. Four of the fields were in sugar beet. They received the same ploughing treatments as the potatoes, but in three of them an additional comparison was made between ploughing the mineral fertiliser down with putting it

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in the seed-bed. The results were that yields were not affected by any of the ploughing treatments, but it is just possible they were slightly increased by ploughing in the fertiliser.

Arrangements were made during the summer for a third series to start in the autumn of 1946.

Effect of cultivation on the root development of the crop and on the physical properties of the soil

The comparisons of root systems, soil moisture and air contents under different methods of cultivation were again made at several centres. Some time had, however, to be spent in finding a quicker and more reliable method of determining air contents than that previously used. The results were similar to those of the previous year and the methods employed did not show that any of these properties was appreciably affected by the different cultivation treatments.

The tendency noted on a few fields in the spring of 1945 for root penetration to occur more rapidly on the deep than on the shallow ploughed plots did not persist into the summer, nor was it observed again in 1946.

An experiment was carried out on Great Knott, Rothamsted, on the effects of depth of cultivation between the rows of potatoes; the effects of earthing up or not earthing up; and of straw mulching between the rows. The total crop yield and percentage ware showed no significant differences under the different treatments.

The crop was sampled at harvest and the ware sorted to determine the incidence of greening, blight, scurf and scab. The extent of the last three of these troubles was independent of cultivation treatment. The amount of greening was reduced appreciably by earthing up, but was as high under the straw mulch as on the plots that were not earthed up. It is intended, however, to repeat the experiment on similar lines in 1947.

Evaporation and transpiration

The third summer of experiments round the pit in the meteorological enclosure has not added much to existing knowledge because of the unfavourable weather (see p. 25). It was hoped that with a water table maintained at 36 in. below a turf surface some evidence of root range might be obtained, but there was always sufficient rain to ensure that the grass was never short of water whatever the depth of the water table. The experiment has given a convincing demonstration of the lack of any precise meaning in "transpiration ratio". Of three turf surfaces, two date from the spring of 1944 and have been unfertilised, and the third dates from the spring of 1945 and was given a heavy dressing of ammonium phosphate. Transpiration from all three during the summer of 1946 was, very nearly, the same: the crop yields were 29 and 28½ cwt. per acre for the unfertilised, and 71 cwt. per acre for the fertilised surface. With other evidence the present indication is that transpiration from grass under British conditions is largely a weather phenomenon, though it can be limited by the physical conditions in the soil, and that growth, although dependent upon the weather, is not dependent in the same way and is more directly related to soil fertility.

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A report on the experiments has been submitted to the Meteorological Office, whose requirements largely determined the form the work took, and this report will probably be used by the Meteorological Research Committee in planning future work on evaporation in the British Isles. Even in advance of publication the experimental results have aroused interest: at the John Innes Horticultural Institution Mr. Lawrence has attempted to base an irrigation experiment on them; some of the conclusions have been incorporated into Ministry Bulletin No. 138 on "Irrigation", and advice has been given to the Rother Catchment Board on the irrigation of the Romney Marshes in summer.

The preparation of the report showed some of the points at which increased precision of measurement is desirable. During the period under review apparatus has been designed and set up to give a continuous record of dewpoint: examination of its efficiency is not yet complete.

During the winter of 1945–46 part of the apparatus round the pit was used for an investigation into ice formation below a bituminous carpet, on behalf of the Soil Stabilisation Panel of the Institute of Petroleum. The experiment showed that with a water table at 2 feet below the surface no surface damage resulted, but a water table at 10 in. produced heaving and fracture of the bituminous carpet during frosty periods, due to the accumulation of ice immediately below it. The experiment, apart from its direct result, is of interest in connexion with water movement in soils due to temperature gradients, and the effectiveness of frost action in producing good tilth in autumn-ploughed land.

Observations on slow drainage from soil

In order to determine the amount of water removed from soil by plant roots it is necessary to know how much water has been lost by drainage from the root zone during the same period. Observations during rainless periods in late autumn and early spring, when plant roots are inactive, have shown that the suction continues to rise over a considerable period of time Quantitative interpretation of these results is, however, complicated by the fact that a change in temperature can cause a change in suction.

Laboratory work

Physico-chemical studies on clay

Previous work had shown that a true picture of the electric charges carried by clay particles and their variation with pH cannot be obtained in acid conditions unless great care is taken to remove soluble aluminium by repeated washing. To facilitate this process repeated washing with a solution of acid ammonium oxalate was tried. It was then noticed that under the influence of sunlight this solution is capable of dissolving practically all the iron which gives colour to the Rothamsted subsoil. It was found that the nearly white residue carries substantially all the negative charges detectable in the raw subsoil and that these negative charges do not change in amount with pH within the range 2·5 to 5. Above pH 5 the negative charges increase: this must be due to the dissociation of hydrions. At pH 2 there is evidence of damage to the clay.

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It has further been found that the oxalate-treated clay carries no positive charges that can retain chloride ions. This result shows that in the Rothamsted subsoil the positive charges are not on the surface of the clay mineral proper, but are carried by the material consisting mainly of hydrous ferric oxide which is soluble in acid ammonium oxalate under the influence of sunlight.

Negative adsorption in jute

Very careful measurements have been made of the increase in chloride concentration which occurs when solutions of alkali chlorides are shaken up with dry jute. The results can be expressed as the volume, V, of water apparently taken up per 100 grams of jute. Taking the ideal system consisting of two parallel charged surfaces separated by a film of solution, it can be seen that V should approach a limiting value for very low salt concentration and should be inversely proportional to the square root of the salt concentration at higher concentrations, the proportionality factor giving a measure of the surface area. The cellulosic material, of which jute and similar fibres are built, has a porous structure. From the values of V obtained at pH 1·3 when almost all the carboxyl groups are —COOH groups, it can be seen that about 11 c.c. of water is taken up into pores so fine that chloride ions are excluded (presumably by their size). At pH 6 there is in addition a repulsion of chloride ions by the negatively charged carboxyl groups. V then exceeds the value at pH 1·3 by an amount which follows closely the expected change with salt concentration. It is deduced that there are passages through the fibre substance averaging 5 mμ to 10 mμ in width the total internal surface being 1 to 2 $\times$ 10^8 cm^2., or about 4 acres per 100 grams of dry matter.

Ionic forces in thick films of liquid between charged surfaces

We still know very little about the forces that operate between clay particles through the water films that separate them. A theoretical discussion of the osmotic activity of exchangeable ions in a water film separating two charged surfaces shows that a small repulsive force operates, which varies inversely as the square of the distance separating the surfaces when this is of the order of 100 mμ. The equation obtained also applies to the film held on a single charged surface, and receives considerable support from optical measurements of film thickness made by Deryagin and Kussakov (5). The extension of the theory to thinner films presents considerable difficulties.

Vapour pressure of sugar solutions

The work on the vapour pressure of sugar solutions was continued: following an examination of the published data relating to the isopiestic method of comparing solutions, the work was extended to include glycerol, which it was hoped would prove a suitable standard material for vapour-pressure determinations in general, since glycerol is miscible with water in all proportions and the deviations from ideal behaviour are comparatively small.

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