ROTHAMSTED RESEARCH

Report for 1948

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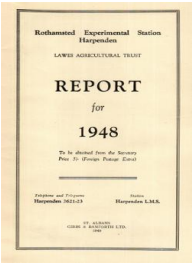

Physics Department

R. K. Schofield

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PHYSICS DEPARTMENT

By R. K. Schofield

Dr. R. K. Schofield was appointed head of the Physics Department in succession to Dr. B. A. Keen. Dr. E. W. Russell resigned his position on the staff on becoming Reader in Soil Science at Oxford in October, 1948. Dr. C. Dakshinamurti concluded his voluntary work and obtained the Ph.D. degree of London University. Mr. M. L. Puri continued as a voluntary worker throughout the year. Mr. H. C. Aslyng, having been awarded a scholarship by the British Council, commenced as a voluntary worker in October, 1948.

Field Work

Deep ploughing

The germination and early growth of sugar beet was slowed up by deep ploughing in the long-term six-course experiment at Rothamsted, and the same effect was observed at most of the outside centres in 1948. By midsummer this backward growth was no longer noticeable at Rothamsted, the yield of clean beet was only reduced from 16·3 to 15·2 tons per acre, although the yield of tops was increased. At the outside centres this early check did not affect the yield of beet.

The advantage apparently obtained in 1947 by deep incorporation of fertilizers was not seen in 1948. Dr. Russell has arranged further experiments to be run from Oxford to test the effectiveness of ploughing down part or all of the potash and phosphate given to sugar beet and to lucerne.

Deep ploughing appears to have increased the average yield of potatoes in 1948 from 15 tons per acre to 18 tons per acre on the plots of the six-course experiment at Rothamsted where potash was put in the bouts. A similar effect in the same sense is shown in each year since the experiment was started in 1944, particularly in 1946 when the increase was 1½ tons per acre. It is too early to pronounce on the statistical significance of these results. None of the outside experiments on potatoes showed any benefit from deep ploughing in 1948.

Residual effects on the yield of winter wheat in 1946 from the deep ploughing and subsoiling for the preceding potato crop were obtained on ten out of thirteen fields. Deep ploughing appeared to give an improvement of about 1 cwt. per acre and subsoiling about 2 cwt. per acre. No residual effects in corn crops were found in nine experiments in 1947, but they were again observed in two out of five experiments in 1948. Over this period deep ploughing for corn itself has given an increase of 1–2 cwt. per acre in four out of ten experiments.

Intertillage, ridging and straw mulching for potatoes

This experiment was carried out for the third time in 1948. This year, owing to the very rapid early growth made by the potatoes, it was not possible to make any appreciable distinction between the intensively and the lightly cultivated plots. The results were in

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accord with those of previous years inasmuch as earthing up had no effect on total yield, or on the yield of saleable ware. On the other hand, the straw mulch increased the yield of ware from 11¾ to 13½ tons per acre, the increase being statistically significant.

Agricultural Meteorology

Measurements of evaporation

Observations of evaporation from open water, bare soil and turf have been maintained. It is satisfactory to be able to report that the evaporation per unit area of the standard Meteorological Office open water tank, which measures 6 ft. square, is the same as from our circular 2 ft. 6 in. diameter tank. The observations indicate that to get reliable readings the reflection of light from the sides and bottom of the tank must be minimized by suitable treatment of the surface.

Drainage from sandy soil

During 1947 and 1948 one of the cylinders filled with sandy soil has been used as a bare soil drain gauge 6 ft. deep and there has always been some daily drainage from it, even during the dry weather of 1947 when the ordinary drain gauges (local clay soil undisturbed) gave no discharge over a period of four months. This slow drainage from sandy soil has an important bearing on the assessment of water use of plants by soil sampling methods.

Control of irrigation by calculation of soil moisture deficit from meteorological data

The department has shared in an irrigation experiment on Mr. F. Secrett's farm at Milford, Surrey. The crop was sugar beet and there were three main watering treatments: unirrigated control (O), full irrigation at Mr. Secrett's discretion (F), and restricted irrigation based on weather data (R). A small weather station was fitted up on the field, and from records sent weekly to Rothamsted the transpiration was estimated and the trend of the estimated soil moisture followed throughout the growing season. Soil samples were taken at the beginning of the experiment and at the time of the maximum deficit: the estimated deficit by sampling agreed very well with the estimate based on weather. Wet periods immediately followed two of the three irrigations, so there were no major differences in results from the three treatments. The yields of sugar (cwt. per acre) were: O, 65·6: R (2·6 inches irrigation) 66·8: F (4·7 inches irrigation) 64·1.

The experiment is to be repeated in 1949.

Advice and service

Advice has been given to the Rother and Jury's Gut Catchment Board on an irrigation scheme for Walland Marsh, their engineer's estimate of summer water requirements being based on Rothamsted work.

Experience in the interpretation of data obtained from drain gauges has been placed at the service of the Land Drainage Legislation Sub-Committee of the Central Advisory Water Committee through its Technical Panel of which Dr. Schofield and Dr. Penman are members.

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Hygrometry and wind recording

The faulty switches in the recording electrical resistance thermometers used in the new type of dew point recorder have been scrapped, and switches designed and made in the departmental workshop have been fitted. The records now being obtained appear to be trustworthy and will be critically examined when enough have accumulated.

The hair hygrometers at 40 ft. and 80 ft. on the tower have been replaced by wet and dry bulb continuously recording electrical resistance thermometers. Alongside the thermometer screen are run-of-the-wind cup anemometers also giving a continuous record at ground level.

Instrument hut

A wooden hut has been set up in the pit in the meteorological enclosure. It is not so high that it will interfere with air flow over the site, but does offer an opportunity of protecting the less robust equipment necessary for our work in agricultural meteorology.

Soil shrinkage gauges

During the year we have set up a set of soil shrinkage gauges designed by the Building Research Station. In shrinkable clay soils such as ours, removal of water by plants causes shrinkage and at least one third of this shrinkage must be vertical so that an indicator in the root layer of the soil will move down (on drying) or up (on re-wetting) relative to a deep reference level well below the effects of root action. Plates have been set at 9, 6, 4, 3, 2, 1, 0·5 and 0 ft. from the surface. From their relative vertical movements information about transpiration losses will be obtained.

Micro-meteorology

The new instrument for the study of micro-meteorology among potato plants has worked satisfactorily, and a description of it is being published. Results show that wind movement inside the crop is slight, there are no marked temperature gradients within the crop, and when the soil is wet the temperature is greater in the crop than on the open headland. Under the same wet conditions there is a marked water vapour pressure gradient inside the crop, the vapour pressures at equivalent heights being greater inside the denser crop.

LABORATORY WORK

Measurement of the volumes of solids, water and air in soil clods

In connection with investigation of soil structure, soil moisture and soil aeration, means are required for measuring rather precisely the volumes of water and air contained in the total volume of a mass of soil in its field condition. A method developed by Russell, though considerably better than earlier methods, has not been entirely satisfactory. In a number of instances the sum of the volumes of water, air and solids has apparently exceeded the total volume. Further study has shown that the method originally adopted for obtaining the water content is inaccurate. This source of error has been practically eliminated by the use of the Dean and Stark apparatus in which the water is distilled off in boiling toluene. Several minor modifications have also been

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introduced, the total effect of which is both to speed up the determinations and increase their precision. It is hoped that in its revised form the method will be a useful research tool.

Vapour pressure of aqueous solutions

Existing data from which the vapour pressures of aqueous solutions of non-volatile solutes can be computed are not entirely concordant. As an aid to the selection of the most probable values, use has been made of the quantity Ψ defined by the equation

$$\Psi = \frac{p}{p_0 - p} - \frac{55{\cdot}51}{\nu m}$$

in which

55·51 is the number of moles of water in 1,000 grm. of water

m ,, ,, ,, ,, ,, ,, solute ,, ,, ,, ,, ,,

ν ,, ,, ,, ,, ions into which the solute molecule dissociates ($\nu = 1$ for non-electrolytes)

p ,, ,, vapour pressure of the solution

p_0 ,, ,, vapour pressure of water at the same temperature.

The most reliable data for solutions of sodium chloride and potassium chloride have been used to trace the variation of $\psi\sqrt{m}$ with $\sqrt{m}$ for each salt at 25°C. The graphs start from the value 10·83, when $m = 0$ (the limit obtained by applying the Debye-Hückel theory) and curve gently all the way to the saturation points. By tabulating the values of $\psi\sqrt{m}$ to two decimal places, full justice can be done to all existing data. For lower vapour pressure, data for sulphuric acid solutions have been similarly treated.

Directly determined vapour pressures of solutions of non-electrolytes appear to be less accurate, and the most probable values are obtained by using the isopiestic method to find the concentration of a solution of one of the above electrolytes which has the same vapour pressure. Several sets of data are available for sucrose and one for urea and glycerol. Measurements were made on dextrose and levulose as part of a study of the vapour pressure of honey. A solution obeying Raoult's Law would have a zero value of ψ. For sucrose, dextrose, levulose and glycerol ψ is the negative at all concentrations for which it can be determined with certainty, whereas for urea it is positive. Recent theories have been examined in an attempt to predict the trends of ψ at concentrations too low for accurate experimental determination. ψ is nearest to zero for glycerol, and the smoothness of change of its ψ with concentration provides a further sensitive check on the accuracy of the data for the electrolytes used as isopiestic standards.

This work is being prepared for publication.

Thickness of water films

There is considerable divergence of opinion regarding the causes of water retention in soil, and in particular on the factors that determine the thickness of water films covering the surfaces of the solid particles. Kussakov in Moscow has used an optical method to measure films as thin as one tenth of a wave-length of light. The soundness of Kussakov's method was demonstrated by preliminary work carried out at Dr. Schofield's suggestion in the Department of Technical Optics of Imperial College, London. An

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attempt is being made at Rothamsted to photograph the Newton's rings obtained with water films on mica. Gouy's theory of the ionic distribution in the diffuse component of the electric double layer has been extended by Dr. Schofield in order to calculate the maximum thicknesses that would be possible if the films were stabilized solely by the presence of exchangeable cations. Most of Kussakov's results confirm this idea but a few give film thickness in excess of the calculated values. It is primarily to check these results that this work has been undertaken.

Thermodynamic potentials of soil constituents

Theoretical studies suggest that the physico-chemical environment of the roots of plants growing in soil may be better expressed in terms of the thermodynamic potentials of bases such as potash, lime and magnesia and of acids such as phosphoric acid than by finding the quantities of these substances that can be extracted from the soil by various means. In order to test the usefulness of this concept, methods for measuring these potentials are being worked out. These investigations are still at a preliminary stage.

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