ROTHAMSTED RESEARCH

Report for 1930

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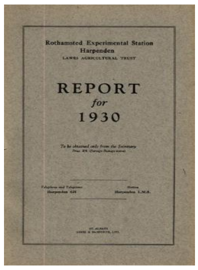

Composition of the Soil : Soil Analysis

Rothamsted Research

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THE UTILISATION OF RESULTS OF AGRICULTURAL EXPERIMENTS

Agricultural problems rarely present clear cut simple issues; they are usually complicated by a number of factors, some of which are themselves highly complex; in experimental work there is always, therefore, an element of doubt whether the result is obtained because of the treatment or in spite of it. Experimenters in the past have got round the difficulty by repeating the experiment a number of times, and if they frequently obtain the same result they have felt justified in attributing it to the treatment and not to some other and unknown cause. In the original Rothamsted experiments Lawes and Gilbert repeated their field trials for twenty years before publishing much about them; they then could speak with considerable certainty.

It is not practicable in modern conditions to use this long time method, and another was introduced at Rothamsted in 1919. Mathematicians have developed methods for studying figures and tracing any relationships that may exist between one set of observations and another; the result can be expressed as the odds in favour of one result being related to another. Dr. R. A. Fisher was appointed to apply these methods at Rothamsted, and he has designed arrangements for field experiments which allow of the valid calculation of the odds in favour of the result being due to the treatment and not to chance. These field methods have been in use for several years, and have proved easily workable and a great advance on the old ones.

Dr. Fisher has also improved the methods for studying masses of data such as agricultural experimental farms and stations have accumulated. It is now possible, for example, to trace the effect of rain week by week, on crops grown under different manurial or cultural conditions, and so to learn definitely how crops and manures behave in different seasons. Great masses of data that have accumulated at the various experimental farms in the country, and have not hitherto been used, can now be examined with a high degree of assurance that any information concealed therein will soon be discovered. In recent years Dr. Fisher has developed a new method, the Analysis of Variance, which is of special value in agricultural and biological research. It is used at Rothamsted for the most diverse purposes; in the bacteriological work for the study of the hourly fluctuations of the numbers of bacteria in the soil, in the entomological department for studying bees and other insects, in the field work for assessing the trustworthiness of the results, and in the chemical department for extracting information from the masses of figures accumulated by a succession of industrious analysts.

THE COMPOSITION OF THE SOIL: SOIL ANALYSIS

For many years past, chemists have been analysing soils, and the work has now been systematised by the setting up of soil surveys in different parts of the country. Great quantities of analytical data have accumulated which, however, are difficult to interpret by the older methods. Statistical methods have been used by Dr. Crowther, and he has extracted from the figures some highly interesting and valuable results. He has begun on the many analyses of clay fraction of the soil that have been made. The molecular ratio of silica to alumina (SiO_2/Al_2O_3) has been recognised as an important soil character, but it varies a good deal from soil to soil with little or no apparent regularity. Dr. Crowther now shows that the ratio is determined partly by the geological history of the parent material of the soil, and partly by the rainfall and temperature conditions under which it now stands, and further, he has been able to assess the relative effects of these different factors. As the rainfall increases the clay becomes less siliceous (*i.e.*, the ratio SiO_2/Al_2O_3 decreases) ; as temperature increases the clay becomes more siliceous (*i.e.*, the ratio SiO_2/Al_2O_3 increases) ; in the clays examined a rise of 1°F had about the same effect as a reduction by 1 inch of the annual rainfall, when both temperature and rainfall increase the composition remains constant if 1°F rise of temperature is accompanied by 1 inch (more accurately 0.97 inches) of rain. This close connection between rainfall and low temperature arises because the effective agent is not the amount of rain, but the quantity of water leaching through the soil, and this falls off as the temperature rises because a larger proportion evaporates. The relation of rainfall and temperature with the amount of drainage through the Rothamsted drain gauge is almost identical with that of rainfall and temperature with the SiO_2/Al_2O_3 ratio.

The ratio also depends on the geological history of the soil. Soils which have been little disturbed during their lifetime, *e.g.*, soils derived from igneous rocks which have not been moved far have a low SiO_2/Al_2O_3 ratio ; soils that have been much reworked (*e.g.*, the soils of the south east of England) have a high SiO_2/Al_2O_3 ratio. Much reworking in water therefore has the opposite effect from high rainfall ; apparently silica is returned to the clay during this process.

Dr. Crowther has further studied the relationship between soil type and climate. Rainfall is the more important factor in dry conditions, and temperature the more important in humid conditions. The difference between the various soils in the highly leached group, with the exception of the extreme podsol, does not lie in the alumino-silicates of their clay fraction, but in the distribution of the iron oxide in the various layers of the soil ; in high temperature weathering this is deposited near to the surface giving red soils, in low temperature its solution or suspension is more stable and is leached down to lower depths.

This work is being continued and will, it is hoped, systematise and make useful a large mass of data which at present has little value.

Another important contribution from the chemical department has cleared up some difficult problems in connection with compensation for unexhausted value of lime. Estimates so far made of the time that lime might be expected to last in the soil do not agree well. Dr. Crowther now finds that the rate of loss of lime and the extent of the loss depend not only on the amount of leaching, but also on the amount of exchangeable calcium in the soil ; if this is high the whole of the added lime is soon lost ; if it is low the lime remains in the soil and is a permanent improvement. A uniform scale of compensation which takes no account of this soil character therefore operates unfairly, and a better one could now be drawn up.

Considerable progress has now been made with the solution of the difficult green manuring problem at Woburn. The tares and mustard ploughed into the soil, decompose with formation of nitrate, which is rapidly washed out, especially from the tares, leaving only little for the wheat, and in consequence it starves for want of nitrogen.

THE COMPOSITION OF CROPS

Dr. Bishop's work on the composition of barley grain, carried out under the Institute of Brewing scheme, shows that the composition and amounts of the various proteins in the grain depend only on the total amount of nitrogen present, and not at all on how it got there—whether as the result of manuring, of soil properties, or weather conditions. The simplest connection is shown by hordein ; all varieties of two rowed barleys so far examined contain the same amount of hordein for any given total weight of nitrogen per grain ; for a nitrogen percentage N in the dry matter the weight of hordein in the dry matter of 1,000 grains of barley is : $0.089+0.422\ N+0.0727\ N^2$ grams.

The other nitrogen compounds, the salt soluble compounds and the glutelin differ in their proportions according to the variety. In the fully mature grain these proportions depend only on the total nitrogen content and the variety ; they are independent of soil, season and manuring.

Dr. Bishop further shows how from a knowledge of the percentage of nitrogen in the barley grain, and of the thousand corn weight, it is possible to calculate the amount of malt extract obtainable after malting, a figure of great importance to maltsters. He has constructed a slide rule which shows this figure at a glance, and thus furnishes information which hitherto could be obtained only after a long, difficult and expensive analysis. Another simple calculation shows also from the barley figures the diastatic power to be expected in the malt cured at any given temperature ; the closeness of agreement between the values expected and those found can be used as a measure of the efficiency of the malting process. The equations are for Plumage-Archer barleys :—

(1) For extract, E :
$E=110.1-11.2N + 0.18G.$

(2) For diastatic power, D.P. :
$D.P.=29N + 0.4\ G-21.$

(3) For permanently soluble nitrogen :
$P.S.N.=0.33\ N.$

Where

N is the total nitrogen percentage on dry barley.

G the dry weight in grams of 1,000 grains.

The D.P. is given for a " kilning temperature " of 180°F.*

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* For full accounts of this work see:

Proteins—

Journ. Inst. Brewing, Vol. 34, p. 101, 1928.
" " " Vol. 35, p. 316 and 323, 1929.
" " " Vol. 36, p. 336, 1930.

Prediction Methods—

Extract. Ibid. Vol. 36, p. 421, 1930.

The papers relating to permanently soluble nitrogen and diastatic power are in preparation.

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