ROTHAMSTED RESEARCH

Report for 1927-28

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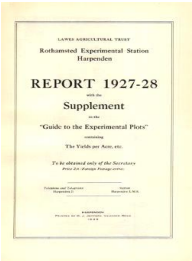

Soil Cultivation

Rothamsted Research

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Sodium Silicate. Sodium silicate has long been shown to benefit the barley crop at Rothamsted: evidence is now obtained that this is due to an action in the soil enabling the plant to take up more phosphate, rather than an action in the plant enabling it to use phosphate better, as was previously supposed.

Elements needed only in small amounts. The necessity of boron and of manganese in small amounts has already been demonstrated in earlier reports. Recently, R. V. Allison, in Florida, obtained striking crop increases by the use of copper sulphate on certain Florida "muck" soils, which apparently resemble some of our fen and peat soils. Dr. Brenchley has made trials on a number of crops on these soils, but found no response to copper sulphate: there seems, therefore, no likelihood of it proving useful here.

SOIL CULTIVATION.

The experiments on soil cultivation follow three general lines. Measurements are taken in the field of the draught or drawbar pull of the implement and of the effect it has had on the soil. Laboratory experiments are made to study the physical properties of the soil, including stickiness, tilth, its relations to water, air and temperature, and so to explain the field observations. Finally, field experiments are made to test other and simpler methods of achieving the same results as present-day cultivation methods.

Earlier work had shown that heavy dressings of chalk, such as were formerly given in Hertfordshire, markedly reduced the drawbar pull necessary to get a plough through the soil. The smaller dressings now customary have been tried during the past three years: five tons per acre of finely divided chalk and 30 cwt. per acre burnt lime; but at Rothamsted neither caused any appreciable reduction in drawbar pull, though another property was affected, as shown later.

Among the attempts to simplify cultivation, the rotary cultivator is one of the more promising: it achieves in one operation what the usual implements do in two or three, and thus offers the possibility of reduction in cost. It proved better in 1926 than either the ordinary ridge or flat cultivation for swedes during the first part of their growth, but not afterwards; the rotary cultivated plots then "capped" or hardened considerably; ordinary cultivation methods were used for the succeeding barley in 1927, but the effect of the 1926 rotary cultivation was still visible and was entirely beneficial—a residual effect that was not expected and cannot yet be explained. The values for yields were:—

Barley, 1927.	Former rotary-Cultivation.	Horse Cultivated.	Horse Ploughed.	General Mean.	Standard Error.
Grain.					
Per cent. ...	117.0	91.0	92.0	100.0	4.89
Bushels ...	27.8	21.6	21.9	23.8	1.16
Straw.					
Per cent. ...	111.1	95.3	93.6	100.0	2.35
Bushels ...	21.7	18.6	18.3	19.5	0.46

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In 1928, swedes were again grown, but on different land: this time, however, rotary cultivation caused no " capping " and no difference in growth, as compared with ordinary cultivation. This variation of result with season was expected, and is being studied: the bad effect in the summer and autumn of 1926 is not easily understood. The rotary cultivator produced in each year as nearly as can be measured the same degree of disintegration of the soil as ordinary cultivation, except when the soil was in an unkind or difficult condition for cultivation: in this case rotary cultivation was less effective than the ridging plough. The experiments further showed the value of the ridging plough in breaking up an unkindly soil.

The purposes of cultivation are threefold: (1) the formation of tilth, (2) the conservation of moisture, (3) the suppression of weeds. It is not agreed how closely (2) and (3) are linked, but it is certain that weed suppression is an important function, and this has been studied by Dr. Brenchley and Miss Warington on the permanent plots of both Woburn and Rothamsted. One of the chief factors is the time the weed seeds can live in the ground. Cultivation encourages the germination of Black bent (*Alopecurus agrestis*). Poppy (chiefly *Papaver rhoeas*), however, survives much longer in the soil: its seeds are still germinating in a sample of Broadbalk soil taken in 1925 and continuously cultivated ever since in a glasshouse, where contamination is reduced to a minimum. The seedlings are removed as they appear, so that no fresh seeds reach the soil, yet already the number of plants appearing has been at the rate of 33 millions per acre on the plot receiving no nitrogen and up to 205 millions per acre on one of the completely manured plots.

The principles of cultivation: the meaning of tilth.

A great deal about cultivation must remain obscure until we know what it does to the soil and how it does it. The science of cultivation is only in its infancy, and is far behind the science of manuring; advice can be given only empirically and tentatively. The subject is, however, steadily being developed by Dr. Keen and his staff, Dr. Schofield, Mr. Scott-Blair and Mr. Cashen. The mechanical principles involve the movements of layers of soil against and over each other and against the metal surface of the implement. Special methods have been designed for working these out: measurements are made of the Static Rigidity, *i.e.*, the energy required to cause a soil paste just to flow; and of the viscosity (more strictly pseudo-viscosity) of the paste once it has begun to flow. The measurements of static rigidity are closely related to the observed Draw Bar Pull, but represent only one group of the factors involved, *e.g.*, a dressing of one ton per acre of slaked lime reduces the static rigidity, but not the dynamometer values.

" Single value " soil constants. The only method at present available for the physical specification of a soil is mechanical analysis, but this is tedious, and the results have only a qualitative value. Attempts have been made from time to time to develop other simple measurements of some single property (or group of properties) easily expressed by a figure, and thus serving as " single-value " soil constants. The subject has now been

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re-opened at Rothamsted. The " sticky point " (*i.e.*, the moisture content at which a plastic mass of soil and water is just about to become sticky) is promising. It is closely correlated with the loss on ignition which may be taken as an approximate measure of the amount of the organic and the inorganic colloids : it is not, however, correlated with the percentage of clay. The amount of moisture in air dry soil is correlated with the percentage of clay, but not with the loss on ignition, *i.e.*, not with the total colloids : this moisture is therefore presumably held in the minute interstices between the small particles. On the other hand, the clay and the sticky point, and the ignition loss and the air dry moisture content, are significantly correlated. These results indicate two ways in which the water is held in the soil. The organic and the inorganic colloids control the sticky point, while the minute interstices between the small particles control the air dry moisture content. Confirmation has been obtained by repeating the measurements after treating the soil with hydrogen peroxide to remove the non-structural organic matter. The two values are therefore of help as a means of soil specification, and an extended co-operative comparison of them for many different soil types has been agreed to by the International Society of Soil Science. This work will be controlled from Rothamsted.

THE CONSTITUENTS OF THE SOIL.

The Organic Matter.

For some years past the chemical changes occurring during the decomposition of plant residues in the soil, and especially those concerned in the formation of humus, have been studied by Mr. H. J. Page and his staff, G. V. Jacks, C. E. Marshall, C. W. B. Arnold and others.

Lignin is the main, though not the only source of humus, but the plant residues apparently humify as a whole.

Humus is very complex in composition, and its effects in the soil are not yet fully known. There is an important difference between the humus of the soil and that of leaf mould and peat : while all three kinds of humus yield up ferric iron after hydrolysis with acid in boiling solution, soil humus gives ferrous iron also.

Now iron may play an important part in the oxidation processes in the soil : for example, the artificial production of humic acid from lignin by atmospheric oxidation in strongly alkaline solution takes place only in the presence of organically combined iron.

The clay and the reaction of the soil.

The reaction of the soil is closely associated with the amount of the bases, particularly calcium, that can be replaced by other bases when the soil is mixed with a salt solution. Much work is being done on the amounts of these replaceable bases in the Woburn soils.

The exchangeable calcium is greatly reduced by sulphate of ammonia, and slightly increased by nitrate of soda, superphosphate and farmyard manure. The exchangeable potassium is very low : it is hardly affected by nitrate of soda or sulphate of ammonia in spite of the fact that this reduces the calcium, but

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