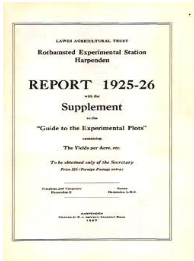
ROTHAMSTED RESEARCH

Report 1925-26 With the Supplement to the Guide to the Experimental Plots


LAWES AGRICULTURAL TRUST
Rothamsted Experimental Station
Harpenden
REPORT 1925-26
with the
Supplement
to the
"Guide to the Experimental Plots"
The Yields per Acre, etc.

Cultivation Studies

Rothamsted Research

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Less Tolerant.	More Tolerant.
Red Clover.	Cabbage and kale.
Foxtail (*Alopecurus pratensis*).	Lupins.
Barley.	Alsyke.
Peas, beans and vetches.	Swedes.
Wheat	Oats.
Mangolds.	Cocksfoot.
Mustard.	Potatoes.
Rye Grass.	Rye.
White Clover.	Sweet Vernal Grass. (*Anthoxanthum*).
	Sheep's Fescue.
	Yorkshire Fog (*Holcus lanatus*).
	Sorrel (*Rumex acetosa*).
	Rhubarb.

The practical outcome of this work is that it enables the expert to advise the farmer :

1. Whether his soil reaction is suited to a particular crop and if not how much lime should be added to make it suitable;

2. What crops can be grown on the soil as it is or as it would become with small and inexpensive additions of lime.

CULTIVATION.

The greatest single item of cost in arable husbandry is the cultivation of the land, and this has been so fully developed as an art by farmers and implement makers that little further development can be expected on empirical lines. Few cultivation experiments have been made and farmers visiting experimental farms are rarely shown anything bearing on the subject. The reason is that no underlying science of cultivation has yet been developed corresponding with the science of manuring, nor could it have been done until the physical properties of the soil were better understood. In recent years important advances have been made in the Soil Physics Department under Dr. Keen, and the extension of the work to cultivation problems has followed automatically.

The work falls into two chief divisions : investigations and comparisons of cultivation processes ; and studies to ascertain how cultivation affects the soil. In both divisions detailed examination is made whenever possible of the growth and final yield of the crop.

During the past year three different methods of producing a seed-bed for roots (swedes) have been compared : rotary cultivation, on the ridge, and on the flat. Soil measurements made immediately before and during the operations showed that the main result of rotary cultivation was to produce a much softer tilth, which was well loosened or puffed up by the action of the tines. The percentage of finest soil crumbs was no greater than on the ridged plots, and but little greater than with the flat cultivation, but there was a marked reduction in the percentage of the large lumps of soil. These differences were reflected in the earlier germination and better first growth on the rotary cultivation plots. Later on the deep uniform tilth proved detrimental, for the soil hardened, or " panned " to a greater depth than on the other

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plots. Growth was checked, and well before harvest it was obvious that the yield from the rotary cultivation plots would fall greatly behind the others. These main comparisons have been supplemented by many soil, plant and meteorological measurements; the full interpretation must be deferred until several years' data have been obtained. Broadly speaking, the effects of cultivation are three :—formation of tilth, control of air and water supply to the roots, and suppression of weeds. The weed problem is very important in normal years, and when opportunities for cultivation are restricted by wet and mild winters, it becomes exceedingly acute, especially on heavy land. The number of weed seeds capable of development in these conditions is very large; it becomes enormous on certain of our experimental plots where wheat is grown year after year, and opportunities for adequate cultivation are restricted. Dr. Brenchley estimates that one of our fields contains in places no fewer than 100 million good poppy seeds per acre, to say nothing of other kinds of weeds. Fortunately, young plants are as a rule easily killed by appropriate cultivation, and this is one of the chief benefits it confers on the land.

The study of the cultivation processes is much facilitated by measuring the resistance offered by the soil to the passage of the implement : this is done by means of a dynamometer inserted in the hitch between the implement and the tractive force. The records are of direct use in comparing the working efficiency of different implements, provided the heterogeneity of the soil itself is previously ascertained and allowed for. The records are also of further value after analysis in the laboratory, in ascertaining the part played by soil cohesion and plasticity, surface friction, etc.

The dynamometer measurements thus form an essential connecting link between field and laboratory studies, and it is necessary that the instrument itself should be as reliable as possible. Much time has been given to the development of a new design, and an instrument has now been evolved which has satisfactorily passed severe and extended tests. It has been built up partly from stock-pattern apparatus already on the market, while the remaining portions were developed in our own workshop, thus avoiding the costly process of empirical trial and adjustment. The instrument is very light and convenient in use, and as the record is obtained on a moving celluloid strip, it is grease and weather proof. Every range in draught from a few pounds to several tons can be recorded. The apparatus has been placed on the market by the Cambridge Instrument Company.

The heterogeneity of soil that may appear quite uniform to the eye is brought out by the " isodyne " maps of the field, all points having the same soil resistance being joined by a smooth continuous line. These maps, which resemble the familiar contour maps, are readily constructed in the laboratory from the dynamometer results. (See 1923-24 Report, p. 29.) The annual tests of the past five years on Broadbalk gave strong evidence that the distribution of the soil heterogeneity across an area remained sensibly constant from year to year, *i.e.*, the isodyne maps for successive years are all much the same. In the past season a crucial test of this constancy has been made on another

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field, in which every factor—except the soil itself—was changed from the previous years' tests : the new dynamometer was used instead of the old one, quite different ploughs were employed, horses were substituted for the tractor, with a corresponding reduction in speed, the direction of ploughing was across the field and not along it, and the season was spring instead of autumn. In spite of these very different experimental conditions, the two isodyne maps were similar.

Although the distribution of the differences in soil resistance from place to place remains unaltered, the average absolute values differ from year to year. The full reasons for this have still to be found. Moisture content has little effect, and laboratory investigations show that the changes in the colloidal condition of the clay from one season to another, are most likely to be responsible. These are, to some extent, under the farmer's control. Additions of farmyard manure or of chalk reduce the drawbar pull considerably, so much indeed as to effect very appreciable reductions in the cost of the operation. Some of our results have been given in previous Reports ; recently further investigations of the effect of chalk have been made. In these experiments the soil had been chalked in 1912 at the rate of 15 tons per acre by the old Hertfordshire method. The isodyne map of the field shown in Figure I is

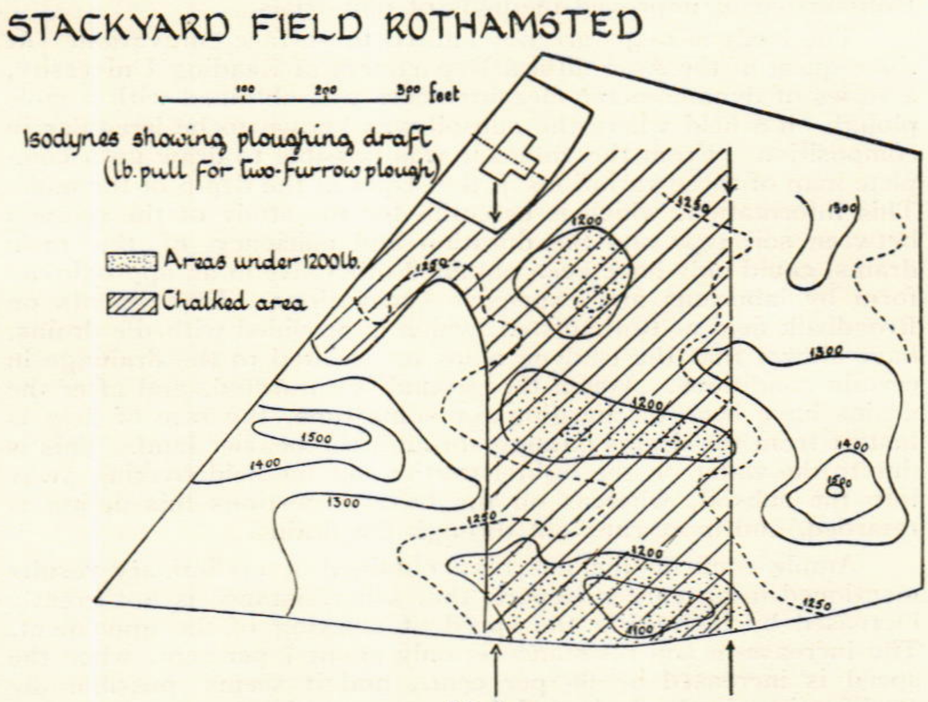

Fig. I

obtained from the 1925 ploughing results. It will be seen how persistent is the advantage, the resistance on the chalked area being much below that of the flanking unchalked strips. The method is feasible only on soils overlying the chalk, and in any case, the first cost is now too heavy. Farmers are therefore more and more relying upon purchased lime or ground limestone, both of which are applied in much smaller quantities. While these

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modern dressings correct sourness, it is not known how far they help to reduce the labour of cultivation. Experiments will be made this year with the aid of grants from some of the associations of limestone firms.

The dynamometer measurements have other applications in addition to the uses detailed above. They constitute at present the best single value specifying the condition of the soil in the field; no other analytical method yet devised could give such detailed data without a prohibitive expenditure of time and energy.

The condition of the soil as reflected by the isodyne maps is closely related to the early stages of plant growth. The number of wheat plants surviving the winter, and the percentage of tillering, are found to be greatest on the areas of low drawbar pull. The isodyne maps do not represent the variations in final yields of wheat, however, as the fewer survivors on the heavier land have a better chance of development, and may ultimately make up in numbers of mature ears what was lost in number of plants. On the other hand, the yield of swedes does appear to be related to the distribution of the isodynes. Although this work is still in its early stages, and the degree to which the relationships are altered by seasonal factors has still to be ascertained the results have already been of value in the development at Rothamsted of improved methods of plot trials.

The isodyne maps are not limited to surface cultivation. At the request of the Agricultural Department of Reading University, a series of dynamometer measurements was obtained with a mole plough on a field where the subsoil was known to be irregular in composition. From the values it was possible to draw up a complete map of these variations in the strata at the depth of the mole. This information, which is essential for the study of the relation between soil type and the duration and efficiency of the mole drains, could only have been obtained otherwise in an approximate form by laborious and expensive excavations. Experiments on Broadbalk field at Rothamsted, which is provided with tile drains, have shown that the isodyne maps are related to the drainage in certain conditions. When the ground is saturated, and after the drains have been discharging for some time, the rate of flow is fastest from the drains passing through the heavier land. This is due to the water on the lighter portions of the field soaking away into the subsoil, whereas on the heavier portions this action is retarded, and more runs out through the drains.

Ample confirmation has been obtained of preliminary results mentioned in an earlier Report, that soil resistance is not greatly increased by increasing the speed of working of the implement. The increase in soil resistance is only about 7 per cent. when the speed is increased by 60 per cent., and it seems possible by modifications in the design of the tractor and implements to hasten considerably the work of cultivation, thereby saving money, time and much future trouble, especially in difficult seasons.

Laboratory experiments show that the drawbar pull is not a simple quantity, but is made up of a number of factors which must be analysed before the field results can be interpreted. Three factors have been studied in detail by Dr. Haines: the friction between the surface of the implement and the soil, the cohesion of

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the soil and its plasticity. These are all much affected by water content, but in different ways; the cohesion decreases but the friction increases as the water increases; the effects just about balance, so that the drawbar pull, the sum of all of them, alters but little.

This analysis is being continued in order to insure a better understanding of the field experiments.

The work on soil cultivation is beginning to afford a physical explanation of the "condition" of the land—a term much used by farmers. It has also aroused much interest among the implement manufacturers, who are endeavouring, through their Association, to find part of the necessary funds to ensure the continuation and adequate development of this subject at Rothamsted.

GENERAL SOIL PHYSICS.

Much of the work in the Soil Physics Department is necessarily concerned with the general development of Soil Physics, the science that underlies soil management and explains the air, temperature and water relationships of soils.

Many attempts have been made to find means of expressing the highly complex water relationships. They appear to be best expressed by such properties as cohesion, plasticity and shrinkage, which show variations at moisture contents where plant growth is satisfactory; the vapour pressure method that at first sight seems more promising, is not so satisfactory since the values are still at their maximum when the moisture content is well below the minimum for plant life.

The vapour pressure curves, however, promise to be important in soil physics; they show typical hysteresis effects associated with colloids, and they are markedly affected by treating the soil with agents known to disintegrate the aggregates characteristic of good tilth. They are also of use in the search for a " single value " measurement for classifying soils—a long sought end—to which much attention has been given in the Physics Department.

Hitherto it has been difficult to decide what property, or combination of properties, the " single values " proposed really measure. Many of them have been tested on some forty different types of soil. The air-dry moisture content, or, more accurately, the moisture content at 50 per cent. relative humidity, as given by the vapour pressure curve, was found to be controlled mainly by the percentage of clay in the soil; while the " sticky point " (the water content of a plastic mass of soil when it first ceases to adhere to the fingers) is controlled by the material lost on ignition of the soil, i.e., the organic matter and water of constitution in the clay. These discoveries have greatly simplified the problem of " single value " classification.

The cohesion of soil presents an interesting problem. The work of Atterberg, in Sweden, appeared to show that, although the cohesion decreased with increasing moisture content, the curve connecting the values was broken into two distinct portions.

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