ROTHAMSTED RESEARCH

Report for 1934

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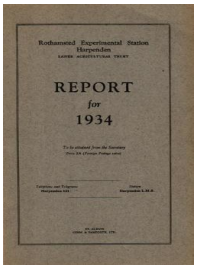

The Production of Crops

Rothamsted Research

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to the Mycologist, Mr. Geoffrey Samuel, who is studying plant diseases caused by soil fungi. Advantage is being taken of our new position as owners to plan out the land behind the laboratories for future development so as to avoid the congestion and inefficiency that always follows when development proceeds haphazard. A new wing is to be added so as to relieve the congestion in the older departments by setting up new biochemical and bacteriological laboratories. The James Mason bacteriological laboratory erected in 1906 has proved a remarkably fertile source of agricultural and scientific discovery, and its success has necessitated considerable enlargement. It is further proposed to extend the farm buildings and replace the present wooden piggeries and stores—erected in 1921 and 1922 from old Army huts—by modern brick buildings better suited for their purpose. Finally, it is intended to lay out the forecourt in front of the laboratories in accordance with the very dignified design of Mr. Walter Tapper, R.A. A sundial is being made by Sir Charles Vernon Boys. It is expected that these various developments will cost some £25,000 towards which we hope for substantial Government grants: a considerable sum, however, will still have to be raised from private donors and others.

THE PRODUCTION OF CROPS

The practical purpose of the experiments on crop production is to discover how crops may be raised in larger quantity per acre, at lower cost, and of better quality. In view of the great variety of conditions of soil and climate in Great Britain it would be of little use for us merely to achieve these ends on our own farm: the work has to be put on a much wider basis and it resolves itself into a series of investigations to discover the influence of soil, climate, manuring and cultivation on the yield, composition and quality of crops. Thanks to the generous collaboration of farmers in all parts of the country, and to the enlightened co-operation of some of the larger commercial and agricultural organisations, it has been possible to repeat typical experiments at a large number of outside centres: Mr. Garner has been, as before, in charge of this work. The new methods of field experiment designed at Rothamsted have proved exceedingly valuable and have given to the results a degree of trustworthiness that would otherwise have been quite unattainable. The investigation of the composition of the crops grown under these various conditions has thrown a vast amount of work on Dr. Crowther and the staff of the Chemical Department and explains the need for laboratory extensions. The study of crop quality, however, necessitates special procedure, as " quality " is an exceedingly elusive property which can in no case be defined with accuracy. The method adopted at Rothamsted is to produce a series of samples of known agricultural history, then submit them to expert buyers or users of the crop who grade them in classes. Efforts are then made to relate the grading to the chemical composition.

" Quality " is thus defined as " commercial desirability " : it has no necessary connection with nutritive value. So far we have failed to find any method whereby the nutritive value of the different grades of produce can be discovered, short of very elaborate and exceedingly difficult feeding tests on human beings which would be

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more appropriately carried out under medical supervision than by us. For the farmer commercial desirability is the important test : it is useless for him to produce something the market does not want. In point of fact the ordinary diet of the Englishman is so varied that variations in chemical composition of the raw materials supplied by the farmer are probably not very important ; attractiveness and palatability are, however, important, and on these points the expert buyer can advise.

The crops studied in detail have been barley, wheat, sugar beet and potatoes. A beginning has been made with grass and fodder crops : naturally by different methods because the feeding test can be applied to these.

Broadly speaking the results have been that " quality " is determined primarily by the general soil conditions and is not much affected by manuring, while quantity is largely determined by the manuring. Usually the highest crop obtainable by normal manuring is of as good quality as can be obtained on the farm : the scheme of manuring can therefore be drawn up chiefly with the view of securing quantity. The management of the crop, however, affects its quality, and serious losses may easily occur through avoidable causes.

Wheat. Work on the quality of wheat is done in association with the Research Institute of British Flour Millers, St. Albans. Certain physical properties of dough are so closely allied to the properties of clay that they are studied in the Physical Department, but the workers are in constant communication with those at St. Albans. The effect of manuring on the composition of the gran is not very marked. It would be impossible to find two more widely different treatments than on the Broadbalk unmanured and tihe Broadbalk fully manured plots, yet the Vitamin B content of the wheat grain was found to be the same for both by Dr. Leslie Harris of the Dunn Nutritional Laboratory, Cambridge.

Barley. In March, 1934, the investigations on malting barley which had been carried on since 1921 under the Research Scheme of the Institute of Brewing, were transferred to the School of Biochemistry and Brewing of the University of Birmingham, where malting and brewing investigations are more appropriately made ; this was done in March, 1934. The Director still remains Chairman of the Institute's Barley Committee so as to ensure continued close contact with the work. In October, 1934, a Conference was held at Rothamsted between the barley growers and the buyers, at which some 200 samples of malting barley were exhibited and discussed. 1934 was a bad season for malting barley, in contradistinction to 1933, when good samples were common.

The samples had been graded by experts, who then explained to the growers the reasons for the grading and the faults which had detracted from the value of otherwise satisfactory samples. Premature harvesting, faulty stacking, and wrong setting of the threshing machine had been responsible for a certain amount of low grading. The Conference served a very useful purpose and will be repeated in October, 1935.

Sugar Beet. A scheme was inaugurated in 1933 whereby Rothamsted carries out fertiliser experiments on commercial sugar beet farms in association with the Committee on Sugar Beet Research and

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Education set up by the beet sugar factories and the Ministry of Agriculture. These experiments were continued in 1934 and it is hoped to put the work on to a permanent basis ; if sugar beet is to be continued as an English crop the yields must be increased, and all experience shows that the surest way of doing this is by suitable cultivation and manuring. Hitherto the advice given to farmers has been based on Continental recommendations. It by no means follows, however, that a scheme which answers well in Czechoslovakia or in Holland will also answer in England and in point of fact our experiments do not in general support the recommendations made to farmers. Hitherto the experiments have not been sufficiently numerous to justify us either in condemning the old or in putting out new recommendations, but if the co-operation with the Factory Committee can be continued we hope to remedy this defect.

The average yield of sugar beet in England is only about 9 tons per acre, as shown by the following figures :

1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934
8.1	7.7	8.6	6.5	7.7	8.7	8.8	7.1	8.7	9.0	10.1(1)

This is considerably lower than on the Continent. Average yields for the last nine years (1925-1933) are in tons per acre :

Holland ..	13.4	France	10.8	Hungary ..	8.2
Denmark ..	11.9	Italy	10.6	Great Britain ..	8.2
Sweden	11.9	Czechoslovakia	10.0	Finland ..	7.5
Belgium ..	11.9	Austria ..	9.7	Roumania ..	6.9
Germany ..	11.5	Spain	8.8	Jugo-Slavia ..	6.3
Ireland ..	11.2	Poland ..	8.5	Bulgaria ..	6.3
				Turkey ..	4.3

(1) Provisional

The average yield on our experimental plots has been :

	Washed Roots, tons per acre.		Sugar, cwt. per acre.	
	1933	1934	1933	1934
Rothamsted (2)	6.5	14.0	21.0	47.6
Woburn (2)	9.2	18.4	32.4	63.8
Mean of outside Centres	11.5	13.5	37.5	47.6
Average for England	9.0	10.1	29.5	34.7

(2) Spacing Experiments

Our yields are therefore considerably above the average. None of these yields, however, except perhaps that at Woburn, is really satisfactory, and we ought to aim at crops of 18 to 20 tons per acre as the usual thing, and not as the exception.

How to secure it is not at all clear. In the 1934 experiments 27 different combinations of artificial fertilisers in dressings ranging up to 12½ cwt. per acre of the complete mixture were tested at 15 different centres, but the results were only small ; the effect of manures was on the average :

Mean yield per acre.		Increase in sugar in cwt. per acre for		
Washed Roots. tons.	Sugar. cwt.	4 cwt. sulphate of ammonia.	6 cwt. superphosphate	2½ cwt. Muriate of Potash.
13.47	47.6	+3.0	+0.9	+0.4

	Sulphate of Ammonia.			Superphosphate.			Muriate of Potash.		
Cwt. per acre	0	2	4	0	3	6	0	1½	2½
Roots, tons per acre	12.9	13.5	14.0	13.3	13.4	13.6	13.4	13.6	13.4
Tops, tons per acre	9.6	10.7	12.3	10.7	10.9	11.0	10.9	10.9	10.8
Sugar, per cent.	17.9	17.7	17.5	18.0	17.7	17.4	17.6	17.8	17.8
Sugar, cwt. per acre	46.0	47.8	49.0	48.1	47.5	47.2	45.0	48.4	49.4
Purity per cent.	88.9	88.3	88.0	88.4	88. 4	88.4	88.4	88.5	88.4

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Of these increases only that given by the sulphate of ammonia is of much significance. Nitrogenous manure almost always increased the tops, but it did not increase the roots to the same extent : it depressed the sugar content and the purity of the juice, but to a less degree. The gain in roots more than compensated the loss in sugar percentage, so that a net gain of 3 cwt. per acre of sugar was obtained on the average by the use of 4 cwt. sulphate of ammonia. The response differed at the different centres : at only half of them was it significant ; it amounted on the average to a gain of only 6 per cent ; the gain is, however, profitable, and the effect is greater than in 1933. The mineral fertilisers were almost ineffective : 6 cwt. per acre of superphosphate added on the average less than 1 cwt. sugar per acre : it gave significant increases at one or two centres only, the increase amounting to rather less than 3 cwt. sugar per acre. Potash was of no direct benefit ; indeed, at one centre it appeared to depress the yield of roots ; it tended slightly to raise the sugar content, especially when in combination with nitrogen.

It is difficult to understand why the potash and phosphate should have so little effect, and experiments are made both at Woburn and at Rothamsted to seek an explanation. It seems improbable that these yields are the highest possible, and the experiments should certainly be continued to find some way of inducing the crop to make bigger growth.

It may be that the ordinary way of adding these fertilisers is not very effective, and several experiments have been made to test other ways of incorporating them with the soil : the results, however, have been quite small ; the yields of washed roots were, in tons per acre :

	1931 Woburn	1933 Woburn	1933 Rothamsted	1933 Rothamsted	1934 Woburn	1934 Rothamsted
Usual harrowing ..	11.64	9.44	5.21	6.08	18.24	14.81
Special incorporation ..	10.56(1)	9.01(2)	6.51(3)	6.96(2)	18.52(2)	15.58(3)
No minerals	—	—	4.79	—	18.59	—

(1)' Simar " rotary cultivator ; (2)ploughed in ; (3)in subsoil.

The incorporation of the minerals has thus been without effect at Woburn though it appears to have been beneficial at Rothamsted. Nevertheless the subsoil plays a very important part. Experiments at Woburn showed that the sugar beet roots penetrate deeply into the soil. Apparatus was designed to trace the movement of the roots : before the season was over they were at least five feet down. At centres where, during the drought, there was much free subsoil water, the yields of tops were higher than the average, the purity of the juice was lower, and there were indications of a better response to phosphate.

It may be that application of the manures right alongside the seed would be more effective.

Experiments have been started at Rothamsted to test the effect of various cultivations, *e.g.*, rolling the seed bed on plots receiving farmyard manure and on those receiving artificials only. Heavy rolling was harmful and reduced the yield by 9 cwt. washed roots per acre, but sulphate of ammonia counteracted the bad effect to some extent.

Farmyard manure acted as if its nitrogen had less than half the

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effectiveness of that in sulphate of ammonia but as it did not depress the sugar percentage its production of sugar was better than that suggested by the yield of roots. Thus in a comparison between 10 tons of dung and 3 cwt. sulphate of ammonia the results were :

	Dung.	Sulphate of Ammonia.
Approximate quantity of nitrogen in manure, lb. per acre	150	70
Mean increase in yield of washed roots, tons ..	1.26	1.61
Mean increase in yield of tops, tons	2.08	4.60
Mean effect on percentage of sugar	−0.06%	−0.38%
Mean increase in sugar per acre, cwt.	4.1	4.4
Mean effect on plant numbers, thousands ..	+2.4	−1.6

The yield and sugar content of the roots depends upon the spacing but the effect varies with the season. In 1933 with a rather small crop, 10-inch spacing gave much higher yields and somewhat higher sugar content than 20-inch spacing : in 1934 there was very little difference, but at Rothamsted 20-inch spacing was somewhat the better and at Woburn 15-inch spacing : the 1934 results were :

Mean Effect of Spacing: 1934.

	Plant Number, Thousands per acre.		Washed Roots, Tons per acre.		Sugar, Cwt. per acre.	
	Rotham-sted	Woburn	Rotham-sted	Woburn	Rotham-sted	Woburn
20 in. rows	32.2	33.4	14.54	18.31	49.2	63.9
15 in. rows	42.5	42.9	13.68	19.17	47.0	66.0
10 in. rows	69.0	63.1	13.87	17.88	47.1	61.4

It is difficult to understand why the results in the two years should have been so different : the two seasons had a good deal in common.

Variations in soil conditions have a very great effect, however, on the yield of sugar beet : the results on different fields at Rothamsted and at Woburn have been in tons per acre :

	Rothamsted		Woburn	Woburn
	Long Hoos 6-course.	Pastures field.	6-course.	Butt Furlong.
1933 ..	2.13	6.52	9.15	—
	Long Hoos			
1934 ..	11.08	15.36	9.73	18.45

Potatoes. The manurial experiments on potatoes were continued at Rothamsted, Woburn, and at outside centres chiefly in the Fen district : some striking results were obtained. In one series of experiments three levels of manuring with artificial manures were tested in 27 different combinations : no dung was used as this is not generally available on the fen soils. The results were :

	Standard Error.	Sulphate of Ammonia cwt. per acre.			Superphosphate cwt. per acre.			Sulphate of Potash cwt. per acre.		
		None	2	4	None	4½	9	None	1½	3
Light peaty fen.										
Wissington ..	±0.386	8.25	9.07	9.18	6.99	9.67	9.83	6.04	9.58	10.88
Thorney ..	±0.560	6.79	7.62	9.10	7.59	7.66	8.26	6.79	8.13	8.59
Clay fen.										
March ..	±0.403	7.56	9.09	10.49	7.00	9.49	10.65	8.80	8.76	9.59
Little Downham	±0.205	12.89	14.94	16.04	11.73	15.50	16.64	14.18	14.85	14.84
Silt.										
Wisbech .. (early potatoes).	±0.138	5.98	7.11	7.15	6.49	6.76	6.98	6.68	6.74	6.83

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The effect of superphosphate is as marked as that of nitrogen and the response continues even to the larger dressing. On the light peaty fen, potash also produces a marked increase but on the clay fen its effect is less. The early potatoes on the silt soil at Wisbech were less responsive but still gave definite responses to superphosphate and sulphate of ammonia.

At one fen centre, Wimblington, March, on a light fen soil, the effect of adding dung was tested. Sulphate of potash gave marked responses even in the presence of dung; sulphate of ammonia was less effective. The dressing of 2¼ cwt. each of sulphate of ammonia and sulphate of potash with superphosphate proved nearly as effective as 8 tons of dung per acre. The increases were :

	Mean Effect.	Dung Absent.	Dung Present.
Sulphate of ammonia, 2¼ cwt.	0.56 tons	0.29	0.83
Sulphate of potash, 2¼ cwt.	3.80 ,,	4.93	2.68
Dung 8 tons	5.00 ,,	—	—
Standard errors	±0.177	±0.250	

The investigations on the quality of potatoes begun in 1929 in association with Messrs. Lyons have now been transferred almost entirely to their laboratories, but a few key determinations continue to be made here so as to facilitate linking up with their work.

MINOR ELEMENTS IN PLANT NUTRITION

The investigations on boron are still being continued by Dr. Brenchley and Miss Warington.

Manganese is needed by plants, though only in small amounts; in its absence they become liable to certain diseases such as grey speck disease of oats. Chemical examination shows that the determining soil factor is not the actual amount of manganese present, but the proportion that exists in the exchangeable form and the tenacity with which it is held.

Molybdenum salts have been found to cause symptoms that look very much like those of Virus disease. This observation is being followed up in the Plant Pathological and Botanical Departments. Mr. W. A. Roach at East Malling has shown that some fruit tree stocks can take up molybdenum from the soil and others cannot.

ORGANIC MANURES

(1) *The Use of Straw as Manure.*

With the increasing tendency to break away from fixed rotations the systematic return of the straw to the land in the form of farmyard manure is becoming more and more difficult and two alternative methods are being compared with farmyard manure at Rothamsted: in one the straw is rotted artificially before being applied; in the other it is ploughed direct into the land but artificials are added to furnish the necessary food for the micro-organisms effecting the decomposition. The effect is then observed in the year of application and in each of the four succeeding years. For each manure there are thus five plots under each crop in each year, one of which has received the manure during the year, another received it one year ago, while others had it two, three, and four years ago. The straw ploughed in with the appropriate artificials proved at least as useful as farmyard

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