ROTHAMSTED RESEARCH

Rothamsted Report for 1932

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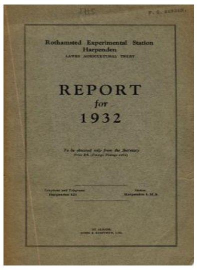

Field Experiments

Rothamsted Research

Rothamsted Research (1933) *Field Experiments ;* Rothamsted Report For 1932, pp 21 - 30 **- DOI: https://doi.org/10.23637/ERADOC-1-64**

Arable.

Classical experiments.	29½
Other permanent experiments.	15½
Temporary experiments. ..	11
Non-experimental.	68

Permanent Grass.

Classical experiments	7
Other Grass.	165
Used for buildings, roads and other purposes	26
Total	322

During the past five years under H. G. Miller's management there has been a marked improvement in the general appearance of the farm, and in the condition both of the arable and the grass land. Although they are only four or five years old, the new grass fields have already attained a high degree of productiveness, largely as the result of proper grazing and feeding of meal or cake.

The great expansion in the field experimental work is shown by the growth in the number of plots ; they were as follows :

1911-12.	1921-22.	1931-32.
250	638	1,408

In addition there are considerable numbers at Woburn and at the outside centres.

STATISTICAL CONTROL OF THE EXPERIMENTS

During its fourteen years of existence the Statistical Department under Dr. R. A. Fisher has had as its chief function the giving of assistance to other departments in the design of experiments and the interpretation of results. Its influence has not only permeated the whole Institution, but has spread far beyond, so that a constant stream of workers from other institutions come here to study the methods and to seek advice about applying them to their problems.

It is perhaps in the field work that the influence of the Department has been most profoundly felt. Three difficulties had always been serious and apparently insuperable : the irregularities of the land on which the experimental plots were set out ; the large experimental error attaching to the results ; and the fact that the magnitude of the error was unknown. Dr. Fisher has been able to devise experimental methods which are free from these difficulties and yet are practicable ; and these methods are now used not only in all the new work at Rothamsted and at Woburn, but in a large number of other field investigations at home and overseas. Several important agricultural colleges and departments now include courses on statistical methods.

Contrary to the earlier belief, it is found that a complex experiment involving a number of questions, gives better results than a single experiment involving one question only : a modern field experiment may include 80, 100 or even more plots. Much theoretical work has had to be done on the principles of experimental design and on the significance of results, as well as on such details as the proper procedure to be adopted when, as occasionally happens, one or more plots in a large set is for some reason spoiled.

Considerable work has been done in tracing relations between crop data and weather conditions. The results are of great scientific interest and of considerable potential value, for they open up the possibility of forecasting yield and quality of crop some long time before the crop is ready for harvesting.

THE MANURING OF CROPS

The new complex field experiments are more laborious and costly to carry out than the old ones, but they give more precise information about fertilisers. Much of this has been embodied in a volume published by the Ministry of Agriculture, entitled *Artificial Fertilisers*. The demand for information on this subject is so great that the first edition was rapidly exhausted, and a second edition has now been prepared.

There is no doubt that farmers, by more judicious use of fertilisers, could obtain larger yields without incurring appreciably more expenditure than they do at present.

SUGAR BEET

A serious effort is being made to improve the position in regard to sugar beet. The present average yield of about 8.5 tons per acre is unnecessarily low, and unless it is improved the industry can hardly survive. Hitherto it has been impossible to make adequate investigations into the manuring and cultivation of sugar beet ; the first stages of a scheme have now, however, been worked out jointly with the factory representatives, and it is hoped that this may be put on a permanent basis.

A usual yield of sugar from sugar beet is 1-1½ tons per acre. On the other hand, a usual crop of mangolds (25 tons per acre) contains 2 tons of sugar per acre, and it is quite easy to push up the yield so as to produce 3 tons of sugar per acre. Seeing that the sugar beet is supposed to be a better source of supply than the mangold, it looks as if there is still plenty of scope for improvement.

At present, unfortunately, we have no indication as to which way the improvement is likely to come. Few trustworthy experiments have been made, and the method adopted till recently of bringing foreign experts over to teach our farmers the Continental cultivations has only limited value because of the wide difference between Continental and British conditions. Straightforward manurial experiments do not get us very far ; indeed, in a number of tests last year the standard dressings based on the earlier guidance did not prove very effective. Sugar beet does not respond in the same way as mangolds to manure ; we still have to discover the proper way of treating the crop so as to get the best results. Some points have already emerged. Nitrogenous manures increase the weight of leaves, a valuable consideration for the stockman, but they do not correspondingly increase the weight of the roots, and they decrease the percentage of sugar, but increase the total weight per acre. Phosphates have less effect than one might expect. Potassic fertilisers are less effective than on mangolds. Salt is beneficial. The effect of fertilisers is summarised in Table I, which includes all the experiments made at Rothamsted, Woburn and the outside centres during the seven years 1926-1932.

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TABLE I.—Effect of fertilisers on yield of Sugar Beet : all Centres, 1926-1932.

Nutrient.	Number of Experiments.	Number of Significant Increases.	Number of Significant Decreases.	Per cent. of Experiments Increases.	Per cent. of Experiments Decreases.
Nitrogen—Roots	42	26	0	62	0
Tops	37	27	0	73	0
Sugar %	30	1	17	3	57
Potash—Roots ..	28	11	1	39	4
Tops ..	26	5	0	19	0
Sugar %	24	5	0	21	0
Phosphate—					
Roots ..	19	3	0	16	0
Tops ..	17	1	0	6	0
Sugar % ..	16	0	0	0	0
Salt—Roots ..	9	5	0	55	0
Tops ..	6	3	0	50	0
Sugar % ..	9	2	0	22	0

Average response to fertilisers

	Per cwt. N (as S/A)	Per cwt. P_2O_5 (as super)	Per cwt. K_2O (as muriate)	Salt (per cwt. Cl)
Roots (washed) tons per acre	+2.31	+0.46	+0.51	+0.59
Sugar percentage	−0.56	+0.12	+0.14	+0.22
Total Sugar cwt. per acre ..	+6.9	+1.3	+2.0	+2.6

All the responses are small, showing that the factors we at present control do not play the chief part in determining the crop. This was well brought out in the Rothamsted experiments in 1932, one of which was made in Long Hoos and one in Great Knott field ; both yielded almost exactly the same weight of tops, yet the crop in Great Knott gave nearly double the yield of roots obtained in Long Hoos. The averages for all the plots were :

	Rothamsted. Long Hoos.	*Rothamsted.* Gt. Knott.	*Woburn.* Stackyard.	*Woburn.* Butt Close.
Tops, tons per acre	14.9	14.6	6.33	15.8
Roots, washed, tons per acre	7.2	13.5	6.08	11.9
Roots, per ton of tops ..	0.48	0.92	0.96	0.75
Date of sowing	May 19th	May 19th	May 10th	May 6-12th
Response per cwt. Nitrogen				
Roots, tons ..	−2.01	1.97	−2.04	1.63
Tops, tons ..	0.22	4.84	−3.01	5.58

The two fields are not far apart, and Great Knott is not noticeably better than Long Hoos ; indeed, if there is a difference it is rather the other way ; the same seed was used, and it was sown the same day in both fields ; yet the one crop is the average which we recognise as below what is permanently possible for a successful industry, and the other represents a level that would bring a profit both to the farmer and the factory even if the subsidy should disappear. An attack of wireworm in Long Hoos, necessitating late patching, may account for much of the difference.

At Woburn the results are very similar excepting that the weight of tops on Stackyard is only 6.3 tons per acre ; the two fields are further apart and the soils differ, but we are unable to say what should be done to Stackyard to make it give the same yield of sugar beet as Butt Close.

Where to look for the difference we frankly do not know. Both experiments included a number of variants, but none caused any more than minor differences. In Long Hoos and in Stackyard the manurial dressings per acre are the same ; they varied in the different plots between 0 and 0.6 cwt. nitrogen, 0 and 1.0 cwt. K_2O and 0 and 0.6 cwt. P_2O_5 : 13 different combinations were tried, but all without effect. In Great Knott and in Butt Close the treatment is also the same ; the experiment consists in variations in time of applying the nitrogenous and the other manures, and also variations in the intensity of cultivation. The nitrogenous manures were effective in raising yields, but it was immaterial whether the manures were applied at sowing or three weeks beforehand, or whether half the nitrogen was kept back till the time of singling, though in this case the weight of tops suffered. Intensive cultivation —hoeing every 10 days between the rows—so far from benefiting the crop, reduced the weight both of roots and of leaves, the roots being reduced 1.2 tons and the tops 2.5 tons per acre. No more cultivation was needed beyond that required for keeping down the weeds. Clearly some new kind of experiment is needed different from the old fertiliser trial, and new methods are now being tried at Rothamsted, which if we can obtain the funds to continue them, will, we hope, prove more successful.

One cause of low yields stands out clearly : sugar beet will not tolerate soil acidity. On acid soils the yields are low, and they are raised by the use of calcium carbonate. A spectacular increase was obtained at Tunstall, and one that is perhaps more normal at St. Albans.

	No Chalk	*Chalk, per acre.*				
		1 ton.	2 tons.	3 tons.	4 tons.	S.E.
Tunstall—						
Roots, tons per acre	1.82	12.61	14.30	14.27	14.74	0.432
Tops, tons per acre	1.44	11.79	12.01	13.50	13.32	0.557
Sugar, per cent. . .	18.74	18.72	18.84	18.65	18.79	0.114

	No Chalk.			*Chalk.*	
	No Phosphate	Basic Slag	Super-phosphate	Super-phosphate	S.E.
St. Albans—					
Roots, tons per acre	5.25	6.58	6.68	8.94	0.571
Tops, tons per acre	6.34	7.53	7.67	10.19	0.614

In spite of the acidity of the soil, basic slag was no better than superphosphate, and it was much inferior to superphosphate *plus* chalk.

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TABLE II.—Yield of Potatoes in Tons per acre.

		Sulphate of Ammonia None.	Sulphate of Ammonia Increase with.	Sulphate of Ammonia Quantity of fertiliser used. cwt.	Sulphate of Potash None.	Sulphate of Potash Increase with.	Sulphate of Potash Quantity of fertiliser used. cwt.	Superphosphate None.	Superphosphate Increase with.	Superphosphate Quantity of fertiliser used. cwt.
Potton (earlies) ..	Sand .. (Nitrate of Soda)	5.07	**1.20**	2½	5.56	0.21	2	5.67	0.0	3
Wisbech	Silt ..	11.90	**0.53**	2	12.19	−0.27	2			
			−0.75	4		−0.03	4			
Stanford ..	Gravel ..	11.89	**0.61**	1½	12.26	0.12	1½	12.32	0.14	3
			0.28	3		0.15	3			
Little Downham	Sand ..	7.26	**1.61**	3	3.95	**4.11**	3	5.88	0.26	4
	Fen ..	9.29	**2.07**	2	10.32	0.02	2	8.37	**2.19**	5
									1.49	10
March	Fen ..	3.96	**0.60**	2	4.02	**0.48**	2	3.60	**1.92**	2
Kingennie.. ..	Loam ..	13.58	**0.37**	1						
			0.45	2						
			0.20	3						
Owmby Cliff ..	Limestone				3.79	**1.82**	1			
						0.77	2			
						−0.35	3			

The figures in heavy type are significant. In cases where two or more levels of a fertiliser were applied, the second increment of yield shown is the additional increment given by the heavier dressing as compared with the lighter.

Dung has been given at Potton, Wisbech and Stanford, but not at the other centres.

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POTATOES

In the experiments at Rothamsted, Woburn and the outside centres up to the present good results have commonly been obtained with a mixture corresponding to 1 N : 1.5 P_2O_5 : 2.5 K_2O with increased phosphate where the soil is known to be deficient in this substance. In the 1932 experiments at the outside centres the most general response was, as usual, to nitrogen. The average increase in yield given by 1 cwt. sulphate of ammonia was 0.35 tons potatoes per acre, *i.e.* 1 ton of additional potatoes was obtained by an expenditure of 19/- on sulphate of ammonia. All the soils tested, even the fen soils, responded. Most of them responded also to potash ; indeed, on the sandy soil at Stanford nitrogen acted only when potash also was given. The response to phosphate was less general, but it was well marked on the fen soils when, indeed, responses were obtained up to 10 cwt. super per acre, and nitrogen was more effective when phosphate was applied as well. (Table II.)

FODDER CROPS

Fodder mixtures of oats and vetches. The results in 1932 confirm those of previous years that the nitrogenous manure favours the oats and depresses the vetches. The relations are shown in Fig. 1 ; the full details are given on pp. 148-149.

The total nitrogen content of the crop is not appreciably altered by the application of nitrogen. The total dry matter reaches a maximum with a seeding rate of 110 lb. oats and 90 lb. vetches per acre where no nitrogen is given, and with a mixture somewhat richer in oats when nitrogen is given. The total nitrogen content is a maximum with a mixture of 50 lb. oats and 150 lb. vetches per acre irrespective of whether nitrogen is given or not.

Kale. Our experience with kale is very promising. The crop is hardy, easy to grow, convenient in use and much liked by stock ; its leaves are rich in protein, and its yield is easily increased by nitrogenous manuring. On the light soil at Woburn we have been able to push the yields up to 28 tons per acre, and even higher yields may be possible (Fig. 2) ; indeed, kale appears to be one of the most suitable crops for converting cheap fertilisers into animal food.

Thinning and cultivating beyond what is necessary for keeping down weeds were not only unnecessary, but reduced the yield about 2 tons per acre. The results were :

	Unthinned	*Thinned*
Number of plants per acre, about	55,000	14,500
Yield, tons per acre :		
Ordinary cultivation .	27.65	25.18
Intensive cultivation .	25.51	23.63

Samples of the crop were taken each month from November to March : analysis showed that the content of nitrogen increased up to mid-January ; there was no gain in dry matter after mid-November, but also there was no loss. After February both dry matter and nitrogen fell off as the result of the withering of some of the leaves. (Table III.)

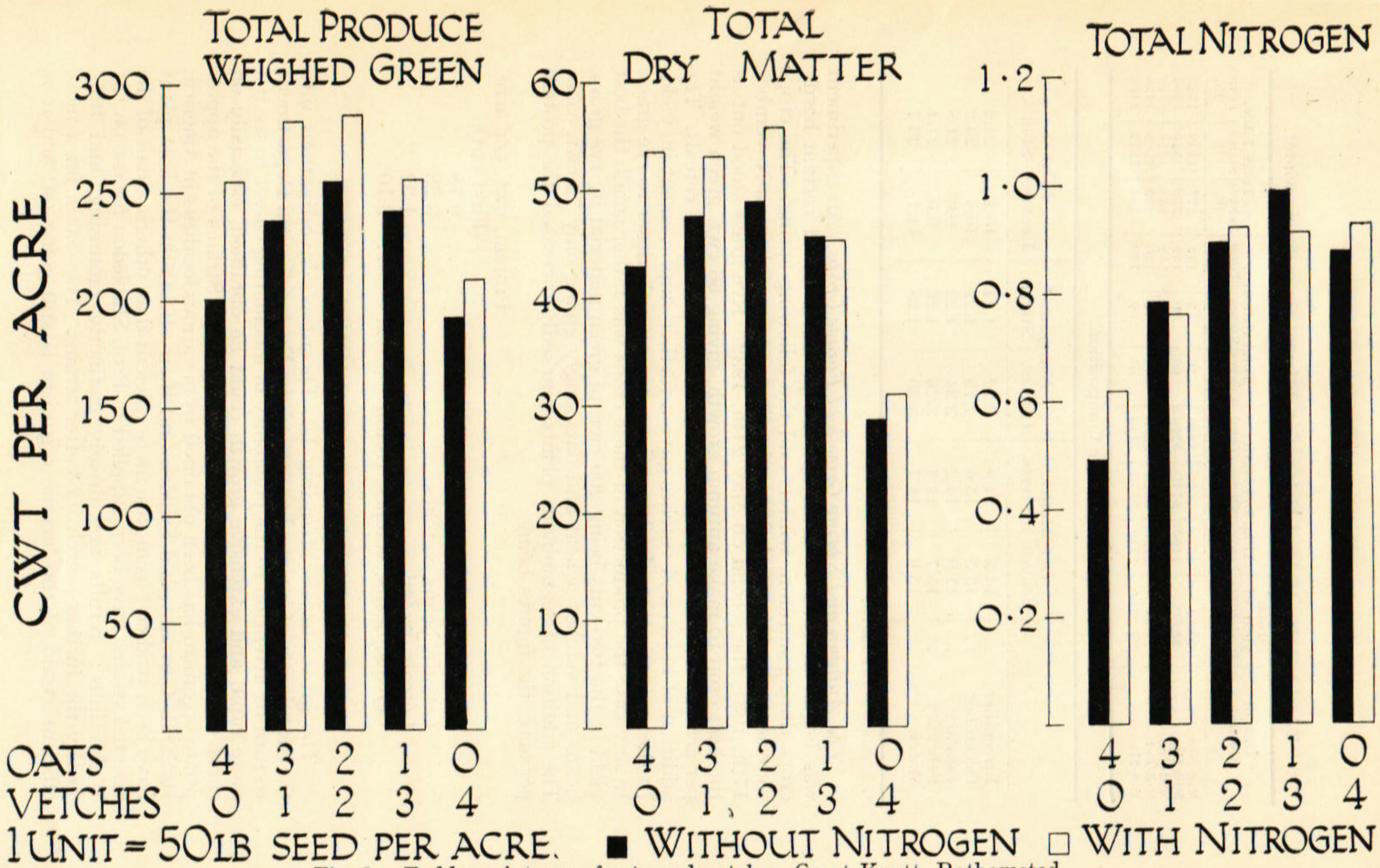

Fig. 1. Fodder mixtures of oats and vetches, Great Knott, Rothamsted.

TABLE III.—Yield of Kale cut at different times during winter.

Time of Cutting.	Total yield of fresh material, tons	Total Dry Matter. Leaves lb.	Stems, lb.	Total, lb.	Total Nitrogen. Leaves lb.	Stems, lb.	Total, lb.	Total Fibre. Leaves lb.	Stems, lb.	Total, lb.
Mid-Nov. ..	25.68	2570	5890	8460	70	73	143	277	1248	1525
Mid-Dec. ..	25.30	2450	5770	8220	69	70	139	258	1336	1594
Mid-Jan. ..	27.50	2400	5890	8290	80	72	152	238	1286	1524
Mid-Feb. ..	24.37	2180	5820	8000	71	79	150	209	1229	1438
Mid-March ..	21.22	1740	5370	7110	61	69	130	194	1272	1466

Percentage Composition.

	Dry Matter		*Nitrogen* *		*Fibre* *	
	Leaves.	Stems.	Leaves.	Stems.	Leaves.	Stems.
November ..	14.3	14.9	2.72	1.24	10.8	21.2
December ..	13.5	15.0	2.79	1.22	10.4	23.2
January ..	11.9	14.2	3.34	1.22	9.9	21.8
February ..	15.7	14.3	3.26	1.26	9.6	21.1
March ..	15.9	14.7	3.50	1.28	11.1	23.7

*Percentage in Dry Matter.

The Autumn and Spring Growth of Forage Crops. An experiment was begun in 1931 to ascertain the productivity of certain hardy crops during autumn, winter, and the following spring. The crops were sown on July 23rd, 1931, the first cut was taken on November 17th, 1931, the second on May 24th, 1932. Rye grass stood out as the best crop to make autumn growth, giving 66 cwt. green weight per acre as compared with 23 cwt. for the mean of the cereals. The addition of beans and vetches gave a further improvement in yield. In the spring cutting, barley and rye came much closer to rye grass. In any case the production of these crops was rather small, the best yield in the two cuts being 209 cwt. of green material by rye grass, beans and vetches, wheat and oats singly giving only 72 cwt. each. The addition of leguminous plants markedly increased the protein per acre, the figures being :

	Protein, cwt. per acre. (First cut)
Cereals alone	0.78
Cereals, beans, vetches	3.23
Cereals, trefoil	1.32
Cereals, beans, vetches, trefoil	3.10

INOCULATION OF LEGUMINOUS CROPS

The great success attending Dr. Thornton's investigations into the inoculation of lucerne has caused the Bacteriological Department to turn its attention to the possibility of inoculating clover to see if a more rapid and extensive growth could be obtained, especially on those soils where it does not thrive naturally. Strains of the appropriate organism has been obtained from various localities in America, Holland, Germany and Sweden and their effects on the host plant have been studied ; some are more efficient than others. Some of the selected strains have been supplied to Prof. Stapledon for use on the Welsh hills ; results are already distinctly promising, and fully justify the further search for better strains. The search for a more efficient strain of the lucerne organism is still going on, and it is

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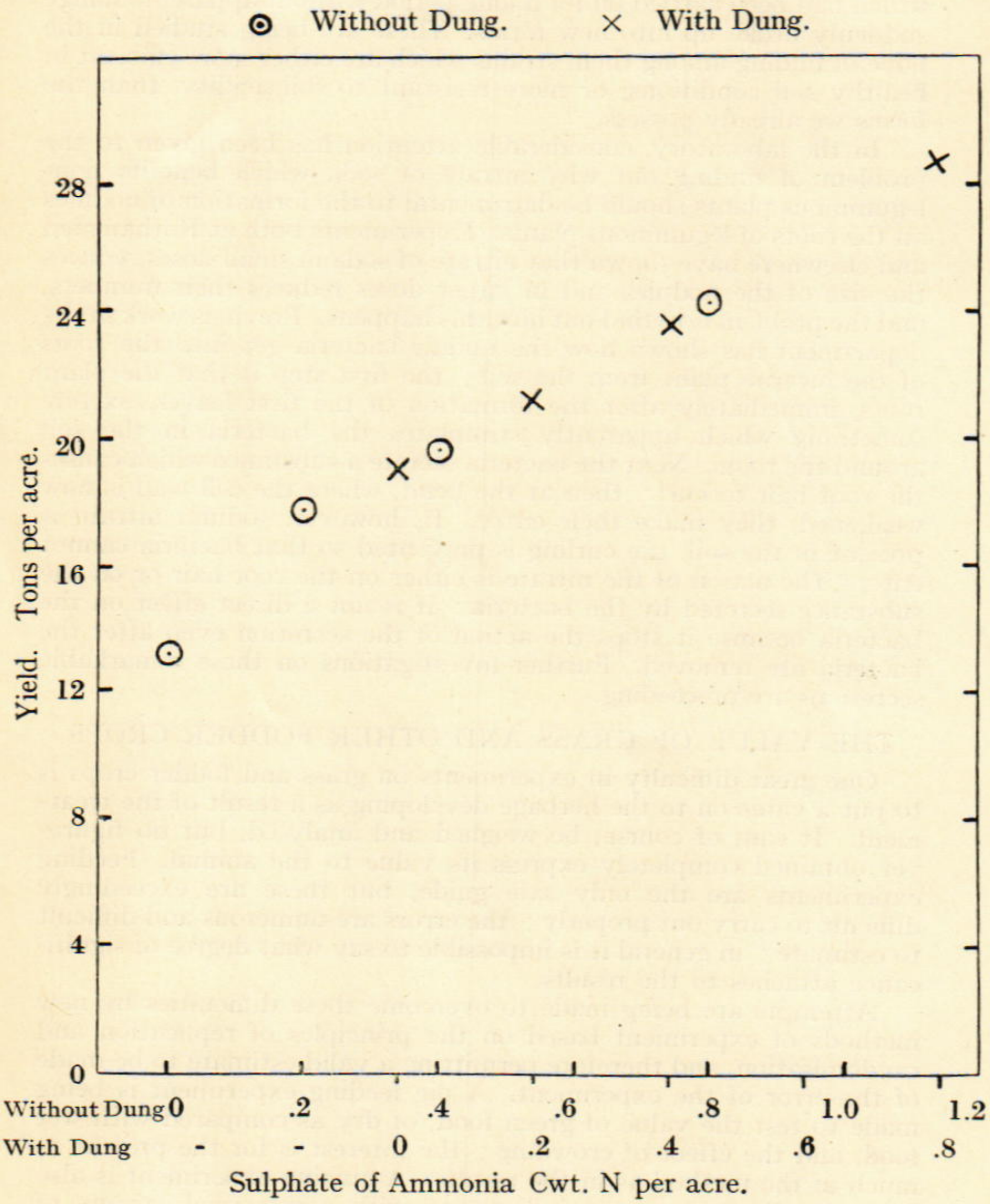

Fig. 2. Relation of Yield and Nitrogenous Dressing in Kale, Woburn, 1932.

The yield of the plots receiving dung (which, like the undunged plots, received 0, 0.2, 0.4, and 0.8 cwt. N as Sulphate of Ammonia) are plotted on the assumption that the dung applied is equivalent to 0.34 cwt. N per acre. This figure was chosen as being the one which most nearly brings the dunged and undunged yields on to the same straight line on the graph. The chemical analysis of the dung gave a total nitrogen content of 1.51 cwt. N per acre so that the results indicate a 22°/₀ availability of N in the dung.

encouraged by the discovery in our laboratory that some cultures which had been carried on for a long period without apparent change suddenly broke up into new forms. These are being studied in the hope of finding among them strains which are either more efficient in healthy soil conditions, or more resistant to soil acidity, than the forms we already possess.

In the laboratory, considerable attention has been given to the problem of finding out why nitrate of soda which benefits non-leguminous plants should be detrimental to the formation of nodules on the roots of leguminous plants. Experiments both at Rothamsted and elsewhere have shown that nitrate of soda in small doses reduces the size of the nodules and in larger doses reduces their numbers, and the problem is to find out how this happens. Previous work in the department has shown how the nodule bacteria get into the roots of the lucerne plant from the soil ; the first step is that the plant roots, immediately after the formation of the first leaves, excrete something which apparently stimulates the bacteria in the soil around the roots. Next the bacteria secrete a substance which causes the root hair to curl : then at the bend, where the cell wall is now weakened, they make their entry. If, however, sodium nitrate is present in the soil, the curling is prevented so that bacteria cannot enter. The action of the nitrate is either on the root hair or on the substance secreted by the bacteria ; it is not a direct effect on the bacteria because it stops the action of the secretion even after the bacteria are removed. Further investigations on these remarkable secretions are proceeding.

THE VALUE OF GRASS AND OTHER FODDER CROPS

One great difficulty in experiments on grass and fodder crops is to put a value on to the herbage developing as a result of the treatment. It can, of course, be weighed and analysed, but no figures yet obtained completely express its value to the animal. Feeding experiments are the only safe guide, but these are exceedingly difficult to carry out properly ; the errors are numerous and difficult to estimate ; in general it is impossible to say what degree of significance attaches to the results.

Attempts are being made to overcome these difficulties by new methods of experiment based on the principles of replication and randomisation, and therefore permitting a valid estimate to be made of the error of the experiment. A pig feeding experiment is being made to test the value of green food, of dry as compared with wet food, and the effect of crowding ; the interest is for the present as much in the method as in the results. A grazing experiment is also being made to compare indigenous with commercial strains of grasses ; sheep are used, tethered as in the Aberystwyth experiments.

THE SIX COURSE ROTATION

This rotation is : sugar beet, barley, clover, wheat, potatoes, fodder mixture (rye, vetches and beans) ; the purpose of the experiment is to test the effect of different combinations of nitrogen potash and phosphate on the yield of crops.

At Rothamsted the yields in 1932 were above those of 1930 and 1931, but the effect of fertilisers was in general less. Sulphate of ammonia benefited potatoes, clover hay and sugar percentage in