ROTHAMSTED RESEARCH

Report for 1929

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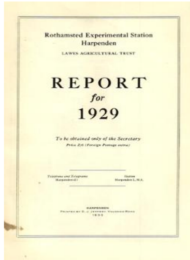
Rothamsted Experimental Station
Harpenden

REPORT
for
1929

Crop Experiments

Rothamsted Research

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In this country the Bessemer process of steel manufacture is not at present used, and Bessemer slags on the British market are entirely of foreign origin. So far as solubility is concerned, the slags fall into two groups only, few if any samples having solubility between 45% and 75%.

In practically all our experiments the high soluble slag has given the better results and there is no question that it is of greater value to the farmer. It acts more quickly and gives larger increases than the low soluble slag. Recent changes in steel making have tended to increase the output of this high soluble material, which is all to the good: and, further, the manufacturers are now prepared to offer slag of less than 45% solubility in the old official citric acid test at lower unit price than they ask for slag of 75% or higher solubility.

While the low soluble slags are inferior to those of high solubility as a source of phosphate, nevertheless they have value in certain humid conditions; fortunately these occur near the works where the slags are obtainable cheaply.

A further result of the investigation has been to show the limits of value of the old citric acid test which had fallen into some disrepute. The grading of the slags into two classes is almost entirely satisfactory, and the analysis is sufficiently easy and rapid.

The method is not, however, of a high order of accuracy, and it fails to place slags in their proper order within each class: a slag of 90% solubility may be less effective as a fertiliser than one of 75%. Occasionally it appears even to class a slag wrongly: it puts into the low soluble group a new type of slag which is said to have high agricultural value, and which is now being tested by the Rothamsted staff. A method has been worked out by Mr. R. G. Warren at Rothamsted (extraction with sodium chloride solution) which places the slags within each class more in accordance with their agricultural value; it is, however, less convenient than the citric acid method and is better suited to an experimental station than to an analysts' laboratory.

LUCERNE.

The inoculation process developed in the Bacteriological Department has proved very successful: in 1929 the issue of cultures to farmers again exceeded the previous records, and sufficed to sow 1,300 acres. The demand rose above our power to supply, and accordingly some of the leading biochemical firms were invited to tender for the taking over of the business. Arrangements were finally made with Messrs. Allen & Hanbury, of Bethnal Green, London, E. 2, to prepare cultures under Rothamsted tests and to supply them to farmers at the rate of 3/- for one acre of land. These arrangements have been in force for some months and are working satisfactorily: the demand has been greater than ever. Dr. Thornton has also devised a method for transmitting the cultures over great distances: cultures sent to Western Australia arrived in good condition and successfully increased yields of lucerne there.

The relationship of the nodule organisms to the plant has been further studied; Dr. Thornton has shown that they do not normally enter the plant until the true leaves begin to form: then there is extruded from the root a substance which facilitates or even determines their entry. The nature of this substance is not yet determined, but it does not appear to be made in the leaf. When the organisms are in the root they increase greatly in number, and they stimulate the plant cells to multiply, forming the well-known nodules. Around the colony of bacteria a network of conducting vessels develops as an offshoot from the main circulating system of the plant, and, this close connection being established, the bacteria take sugar from the plant, causing an increase in growth. If the supply of sugar is cut off by keeping the plants in the dark, or by stopping the development of the conducting vessels (which can be done by withholding the trace of boron needed for this purpose) the bacteria turn to the root tissue for food and begin to consume it: they thus change from being beneficial into harmful parasites. If the supply of air is restricted the bacteria fix less nitrogen, but they do not become parasitic.

POTATOES.

The potato experiments were conducted on much the same general lines as last year. The yields, however, were low, as the result of the very dry March and April: the plants were not able to start growing till May.

The increases given by fertilisers were, in cwt. per acre :—*

	1929			Average 1925–28 †		
Sulphate of Ammonia cwt. per acre	0	1.5	3	0	2	4
Sulphate of Potash cwt. per acre 0	–	12	15	–	20	24
,, ,, ,, 1	7	15	18			
,, ,, ,, 2	2	16	21	15	49	71
,, ,, ,, 4				16	55	75
	Basal crop 4.52 tons per acre.			Average Basal crop 6.62 tons per acre.		

* In all years except 1925 farmyard manure was also applied.
† In 1928, the weights of fertilisers used were as in 1929.

The increases are thus less than usual, nevertheless they cost less than £2 per ton. Taking the four years 1925-28, the expenditure in pence on manure per cwt. of additional crop has been :—

	1925–28		
Sulphate of Ammonia	0	2	4
Sulphate of Potash 0	0	13	21
,, ,, ... 2	21	12	12
,, ,, ... 4	39	16	15

The results show, as before, that neither sulphate of ammonia nor sulphate of potash acts best by itself : the gain in crop is small and the cost is high. The best results are obtained when both act together: these fertilisers are closely linked. Further, the total effect is more than the sum of the separate effects: 2 cwt. of sulphate of ammonia increased the yield by 20 cwt., and 2 cwt. of sulphate of potash increased it by 15 cwt., but when the sulphate of ammonia and sulphate of potash acted together the increased yield was 49 cwt. per acre: 4 cwt. sulphate of ammonia alone gave additional crop at a cost of 21 pence per cwt., and 4 cwt. sulphate of potash alone at a cost of 39 pence per cwt., but the two together gave it at a cost of 15 pence, while 4 cwt. sulphate of ammonia and 2 cwt. sulphate of potash gave it a cost of 12 pence per cwt. As a rule at Rothamsted our best results are obtained by a combination of 3 or 4 cwt. sulphate of ammonia with about 2 cwt. sulphate of potash: this corresponds to a ratio of 3 or 4N : 5 K_2O, a larger amount of potash than is usually provided in compound fertilisers.

The effects of the fertilisers are modified by the season. The responses in cwt. per acre to sulphate of ammonia in increasing dressings in presence of sufficient sulphate of potash, super. and dung have been :—

	Yield tons per acre. No Nitrogen.	Increase for 1st dose Sulphate of Ammonia cwt.	Further increase 2nd dose Sulphate of Ammonia cwt.	Further increase 3rd dose Sulphate of Ammonia cwt.	Quantity of Sulphate of Ammonia in single dose.	Basal dressing. cwt. per acre.
1925	7.92	52	8	(a) –9	2 cwt.	No dung, 3 super. 4 Sulphate of Potash
1926	7.79	24	29	(b) 38	1 cwt.	Dung, do. do.
1927	6.90	16	–5	(c) —	2 cwt.	,, ,, ,,
1928	7.06	35	37	(c) —	1½ cwt.	,, ,, and 2 Sulphate of Potash
1929	5.18	7	19	(c) —	1½ cwt.	Dung, 3 super. 2 Sulphate of Potash

(a) Basal potash was 6 cwt. sulphate of potash.
(b) Treble dose was 4 cwt. sulphate of ammonia.
(c) No experiment.

Except in 1927 and 1929, the average response per cwt. sulphate of ammonia is of the order of 20 cwt. potatoes, as usual in the earlier experiments. The second cwt. has in some years done better than the first.

The response to potash has been more variable, but the bad years were also 1927 and 1929: in 1927 the potatoes were planted late (May 24th) and 1929 was a dry and sunny season.

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The responses to sulphate of potash* in presence of sufficient sulphate of ammonia, super. and dung have been :—

Year	No Potash Yield. Tons per acre.	Increase for 1st dose. Potash cwt.	Further increase for 2nd dose. cwt.	Further increase for 3rd dose. cwt.	Quantity of Sul. Potash in single dose.	Basal dressings. cwt. per acre
1925	6.45	75	7	0	2 cwt.	No dung, 3 super, 4 Sulphate of Ammonia
1926	9.53	32	9	14	1 ,, †	Dung do. do. do.
1927	7.16	14	−8	—	2 ,,	do. do. do. do.
1928	8.26	56	−8	—	1 ,,	do. do. 3 Sulphate of Ammonia (Mean of all potassic fertilisers)
1929	5.94	−1	11	—	1 ,,	Dung, 3 super, 3 Sulphate of Ammonia

* Except 1928 when there were very few plots owing to frost damage.
† The 3rd. dose was 4 cwt. Sulphate of Potash.

The highest yields in each year and the manurings given were :

Yield given by best manurial treatment.

Year.	Tons.	Manuring (cwt. per acre) : Super +
1925	10.96	4 Sulphate of Ammonia : 4 Sulphate of Potash
1926	12.34	4 Sulphate of Ammonia : 4 Sulphate of Potash
1927	7.96	4 Sulphate of Ammonia : 4 Muriate of Potash
1928	11.05	3 Sulphate of Ammonia : 1 Sulphate of Potash
1929	6.82	3 Sulphate of Ammonia : 1 Potash Salts

The three potassic fertilisers, sulphate, muriate and potash manure salts, all gave similar increases in 1929 ; the differences recorded in 1927 did not appear.

The effect of phosphate has again been clearly marked, and again it has depended on the other fertilisers given : superphosphate at the rate of 3 cwt. per acre (0.4 cwt. P_2O_5) gave the following increases in cwt. per acre :—

		1929			1928		
Sulphate of ammonia : cwt. per acre ..		0	1.5	3	0	1.5	3
Sulphate of potash : cwt. per acre ..	0	5	8	11	10	7	5
	1	3	13	17	1	Nil.	26
	2	5	9	19	10	13	18
Basal yields tons per acre ..		4.5 to 5.6			6.1 to 9.7		

The superphosphate acted best when combined with the most effective mixtures of sulphate of ammonia and sulphate of potash. In these conditions it gave its extra yield at an expenditure of :—

1929		1928	
8	...	6	pence per cwt. of potatoes obtained.

The effect of superphosphate, however, depends very much on the soil. At Woburn, no response was obtained in 1927 or on the average in 1929 when yields were low (4 to 5 tons per acre), but there was a good response in 1928 when the crop grew better : a yield of 12.25 tons per acre was raised by 3 cwt. of super to 13.4 tons and by 9 cwt. to 14.7 tons per acre, the gains thus being 23 cwt. and 50 cwt. respectively, at an expenditure of 7 pence and 9½ pence respectively per cwt. of potatoes obtained.

The 1929 experiment was on a more elaborate scale than in 1927, and brought out a curious result: the superphosphate increased the crop so long as no nitrogen was given, but it apparently decreased the crop in presence of nitrogen and potash. At the outside centres the effects of superphosphate have varied, again mainly as the result of soil variations. There was a gain at Wisbech of 6.6 cwt. potatoes per cwt. of superphosphate used as compared with 4 cwt. potatoes per cwt. of super. at Rothamsted, but no gains at Bangor, Sutton Bonington or Owmby Cliff.

The work this year has been extended to include a full examination of the influence of manuring on the cooking and keeping qualities of the crop. Nearly four hundred samples were examined by Dr. Lampitt, of Messrs. Lyons' laboratories, and the very extensive data are being worked up. Certain results are already emerging: chipped potatoes were not affected in any uniform or definite way either in colour, flavour or consistency, but boiled potatoes were improved by potassic fertilisers in colour both "outside" and "mashed." Muriate of potash gave the best results, sulphate came second, and potash manure salts third: at times, indeed, the latter was somewhat harmful. For flavour the potassic fertilisers came out in the same order, but only the best of the samples were equal to those grown without potash, and the others were inferior.

Number of Plants per acre. The potatoes are planted 15 inches apart in rows which are 27 inches apart. The total possible number of plants per acre is 15,490. Actually the numbers found per acre in 1929 at Rothamsted were :—

Number found per acre, no artificials ...	14,480
,, ,, ,, complete artificials..	14,870
Average of all plots	14,593
Total possible	15,490

There is thus very little variation in number on the plots, though the numbers were all less than was expected. At Woburn, the numbers were smaller owing to depredations of pheasants.

SUGAR BEET.

The sugar beet experiments again emphasised the need for new varieties better suited to English conditions than those now grown. With no scheme of manuring is it possible to obtain the impressive yield increases given by mangolds or potatoes; the leaves respond but the roots do not, and it is not yet possible to control the leaves so as to make them send more material into the root. One ton of leaf may give from a few hundredweights up to about 3 tons of root, but rarely more, and the factors determining this are not in our control. Certain consistent features stand out. Nothing is gained by the large dressings of farmyard manure or of artificials sometimes given on the Continent,* the fertiliser must

* As an example : The Bernburg investigators find that the best manuring for sugar beet gives 400 dz. per hectare or 16 tons per acre. This manuring is :—

	Kgm per ha.	lb. per acre	Fertiliser per acre
N	160	143	9 cwt. nitrate of soda
P_2O_5 ..	60	54	3 cwt. superphosphate
K_2O ..	180	160	320 lb. sulphate of potash

in general be complete; potash and nitrogen are closely linked and each acts best in the presence of the other. The nitrogen should go on early. Potash manure salts are more effective than the sulphate or the muriate, and salt has a special value additional to that of potash. But when it comes to detailed recommendations the position is more difficult, as fertilisers behave differently towards different varieties.

Thus, in 1929 at Rothamsted, Kuhn on the whole did better than Kleinwanzleben, but it responded rather differently to fertilisers : it did better with sulphate of ammonia (along with salt, super. and muriate of potash) than with nitrate of soda, while Kleinwanzleben did better with nitrate of soda than with sulphate of ammonia. Cyanamide has given more promising results at the western than at the eastern centre.

The nitrogenous manures tend to depress the sugar content, but not by much, and so long as the dressings are not too high the loss is more than offset by the gain in yield. Salt and potash manure salts both slightly increase the sugar content. So long as additional fertiliser increases the yield of roots it does not, in our experience, have much effect on the sugar content, and our advice to farmers is to aim at yield and not worry about sugar. When, however, too much nitrogen is given, the excess that does not increase the yield lowers the sugar content. Apart from this, season has more to do with sugar content than manuring.

Owing to the high value of the tops as stock food, they have to be taken into account in assessing the value of fertilisers. 1 cwt. nitrate of soda or sulphate of ammonia has not infrequently given us an extra ton of tops which, as food for sheep, would have not much less value than a ton of turnips and for cattle more value than a ton of mangolds.* They must however be kept free from dirt and should therefore be raked up in heaps before carting of roots begins, so as to avoid damage by the carts.

Our experiments are not yet sufficiently advanced to indicate definite fertiliser recipes, and in view of the fact that some varieties respond better than others to manuring, we are always hoping that new varieties will be discovered that will respond still better and will therefore pay for more intensive manuring. For the present we suggest as a basis for trial: 10 tons farmyard manure ploughed under in autumn, 1½ cwt. sulphate of ammonia or nitrate of soda, 2½ cwt. superphosphate, 2 cwt. potash manure salt, and 1 cwt. salt per acre applied at or before the time of seeding. It is almost certain the mixture would need modification in different regions of different soil and climatic conditions: for example, where the soil is known to be rich the whole dressing could be reduced and the mixture given at the rate of 4 or 5 cwt. only per acre instead of the 7 cwt. here suggested.

The effect of fertilisers on the yield of roots in 1929 is shown in the following summary of the Rothamsted results in tons per acre :—

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* The Cambridge workers put five tons of tops as equal to eight tons of mangolds.

		NO NITROGEN		SULPHATE OF AMMONIA		NITRATE OF SODA	
		No Phosphate	Phosphate	No Phosphate	Phosphate	No Phosphate	Phosphate
No Potash	Klein	6.42	6.78	7.14	7.41	7.18	6.97
Muriate of Potash	Klein	6.83	6.44	7.19	7.31	7.34	7.78
No Potash	Kuhn	7.16	7.90	7.80	7.85	7.76	8.58
Muriate of Potash	Kuhn	7.00	7.04	7.50	8.84	8.08	8.10
		Standard Error = 0.193					

The complete fertiliser gave the best results and its action was improved by a dressing of salt:—

	Roots	Tops	Sugar %
No Salt	7.33	5.24	18.33
Salt	7.54	5.58	18.40
Standard Error	0.055	0.033	0.02

It is very easy to go wrong about the manuring of sugar beet. Taking all our experiments together, there have been many occasions when manuring did not pay, when indeed it depressed the sugar content and sometimes even the yield. The numbers of gains and losses have been:—

Manures.	Weight of Roots.			Weight of Tops.			Sugar per cent.			No. of times when financial result was:		
	Increase.	Decrease.	No Change.	Increase.	Decrease.	No Change.	Increase.	Decrease.	No Change.	Gain.	Loss.	No Change.
Nitrogenous *	26	6	0	25	0	0	3	19	1	20	12	0
Potassic ..	17	8	1	15	10	1	10	6	10	13	13	0
Potash Manure Salts ..	6	1	0	5	1	1	4	2	1	5	2	0
Phosphatic ..	7	6	1	7	7	0	6	4	4	6	8	0

* Up to 3 cwt. per acre but not more.

Using reasonably good fertiliser mixtures the gains per cwt. of fertiliser have been:—

	Sulphate of Ammonia or Nitrate of Soda.	Potash Manure Salts.	Salt.	Superphosphate.
Roots, cwt.	6– 9	3–9	3–5	2
Tops, cwt.	12–17	Nil.	4–10	2
Sugar, per cent. ..	—0.15	+ 0.10	+ 0.05	Nil.
Cash Increase ..	7/– to 18/–	10/– to 18/–	8/– to 14/–	Nil.

These figures show the need for improving our varieties and methods.

The care of the plant is more important than the manuring: proper seeding on a good seed-bed and proper care at singling are absolutely essential. There should not be much loss of plant: in 1929 we obtained about 85-90% of what was expected from the setting out, though in 1928 we had obtained only 70%. The figures are:—

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Spacing as set out	Rothamsted. 1928 24-inch rows. 10-inch singling.	Rothamsted. 1929 22-inch rows. 8-inch singling.	Woburn. 1929 I 22-inch rows. 8-9-inch singling.	Woburn. 1929 II 22-inch rows. 8-9-inch singling.
No. of plants expected ..	26,000	36,000	35,000	35,000
No. harvested ..	17,715	30,350	31,800	32,700
Plants obtained as percentage of what was expected ..	68%	83%	88%	94%
Yield tons per acre average ..	9.15	7.43	8.07	8.23
Average weight per root (lb.) ..	1.16	0.55	0.57	0.56

MANGOLDS.

The Barnfield mangold experiments bring out clearly the harmful effects of failure to balance nitrogenous manure with potash. So long as the complete fertiliser is given the plant grows well and responds to heavy dressings of manure: when potash is omitted, however, the leaves lose efficiency, they make much less root and tend to become diseased, and the whole plant is weakened so that the mortality is considerable. The plants are grown in rows 26½ inches apart: there are on the completely manured plots some 30,000 to 34,000 per acre. But where high nitrogen manuring is not balanced by potash the number of plants is much less and the roots are smaller.

This is shown in the following table:—

Barnfield Mangolds, 1924-29.
No. of plants and yield per acre *Roots* and *Leaves*.

Year	Heavy Nitrogenous Manuring with Potash (Plot 4 A.C.)			Heavy Nitrogenous Manuring without Potash (Plot 5 A.C.)		
	No. of Plants	Roots Yield per acre tons	Leaves Yield per acre tons	No. of Plants	Roots Yield per acre tons	Leaves Yield per acre tons
1924 ..	3328	34.16	5.62	2573	15.81	4.83
1925 ..	3201	22.43	6.05	2356	6.30	4.51
1926 ..	3035	25.77	4.12	1996	8.29	2.25
1927* ..	3423	13.42	3.89	3263	12.79	3.59
1928 ..	2978	29.22	5.01	2225	9.55	2.83
1929 ..	3075	20.67	3.94	1741	4.71	2.09

* Swedes.

BARLEY.

In 1929 comparisons were made between sulphate of ammonia, muriate of ammonia, cyanamide and nitrate of soda. Of these, nitrate of soda gave the largest increase, possibly as the result of the dry conditions; the others, however, came out practically alike. One cwt. of sulphate of ammonia gave its usual return of 6 bushels of barley, a second cwt. gave an additional 4 bushels. It has been our usual experience that cyanamide does as well as sulphate of ammonia. This year, in common with muriate of ammonia, it was, if anything, rather better. At Woburn also, muriate of ammonia was superior to sulphate of ammonia. For nitrate of soda the increased yields were 11 bushels of barley for the first cwt. and an additional 4 bushels for the second.

The figures are:—

Barley, yield of grain, cwt. per acre.

Size of Dressing.	No Nitrogen	Sulphate of Ammonia	Cyan-amide	Muriate of Ammonia	Nitrate of Soda	Urea.
Single	20.1	23.1	23.6	23.6	25.6	—
Double		25.2	26.3	26.2	27.8	25.4
Increase over no Nitrogen : 1st dose ..		3.0	3.5	3.5	5.5	5.3
Additional for 2nd dose ..		2.1	2.7	2.6	2.2	

At Rothamsted in 1929 potassic manures slightly depressed the yield of barley, as had also happened in 1924: the effect is most clearly seen with the double dressing of nitrogen; the figures were obtained by the sampling method and represent, in cwt. per acre :

	Grain		Straw	
	No Phosphate	Phosphate	No Phosphate	Phosphate
WITH DOUBLE NITROGEN				
No Potash	27.3	27.4	27.6	27.9
Potash	25.7	25.8	26.1	26.0
Standard Error ...	.57		.63	
WITH SINGLE NITROGEN				
No Potash	24.0	23.3	24.7	23.4
Potash	23.0	23.6	23.6	24.5
Standard Error ...	.70		.78	
WITH NO NITROGEN				
No Potash	19.5	21.5	19.1	21.6
Potash	21.5	20.1	21.6	20.4
Standard Error ...	1.40		1.57	

On the light soil at Woburn, sulphate of potash markedly increased the yield where there was no nitrogenous fertiliser, and somewhat increased it where muriate of ammonia was given, but not where sulphate of ammonia was used; superphosphate had no effect however.

On another light soil, the Lincoln Heath at Wellingore, superphosphate increased the yield of grain and of straw so long as nitrogen was applied. In absence of added nitrogen, it depressed the yield.

Yield of barley, light loam on Oolitic Limestone, Wellingore.
Grain, cwt. per acre.

	No Nitrogen.		Nitrogen.	
	No Phosphate.	Phosphate.	No Phosphate.	Phosphate.
No Potash	18.8	18.0	19.5	22.4
Potash	20.7	17.0	20.6	25.1
	Standard Error = 0.89 cwt.			
	Straw in cwt. per acre.			
No Potash	16.3	16.4	17.9	20.8
Potash	18.1	14.8	19.7	24.1
	Standard Error = 0.59 cwt.			

The barley at Woburn was attacked by a common fungus disease, *Fusarium culmorum*, which did, as usual, a certain amount of damage. Dr. Mann devised a system of marks to denote the severity of the attack and obtained the following results:—

	No Potash.	Sulphate of Potash.	No Phosphate.	Superphosphate.
Severity of attack	47	31	39	39

Potash thus reduced the attack of the disease; phosphate and nitrogen did not. This is a usual property of potassic fertilisers.

Effect of Chlorides. Pot experiments showed that chlorides delayed the rate of ripening of the straw, giving a lower percentage of dry matter than was obtained with sulphates. When the ears were ripe for cutting, the straw of the plants manured with chlorides contained 40.9 to 44.5 per cent. of dry matter, while those manured with sulphates contained 54.3 to 57 per cent. The total weight of straw, however, was substantially the same with both groups of fertilisers.

The Quality of the Barley. The valuers put the barleys in the following order of merit:—

I.	*43/- to 44/- per quarter.*	Muriate of ammonia both dressings, urea.
II.	*41/- to 42/- per quarter.*	Nitrate of soda, sulphate of ammonia and cyanamide in the double dressing.
III.	*35/- per quarter.*	Nitrate of soda, sulphate of ammonia and cyanamide in the single dressing. No nitrogen.

The nitrogenous manures this season increased the production of carbohydrates sufficiently to maintain the balance with the nitrogen taken up. In consequence, the percentage of nitrogen in the grain was hardly affected: the results were:—

Nitrogen per cent. in Barley Grain.

	No Nitrogen	Sulphate of Ammonia	Cyan-amide	Muriate of Ammonia	Nitrate of Soda	Urea
Single Dressing ..	1.461	1.456	1.480	1.469	1.470	
Double Dressing ..		1.477	1.470	1.485	1.532	1.498

It is slowly becoming possible to form a mental picture of the relationship between growth and quality in barley. The total nitrogen in the plant depends on the amount of nitrate in the soil at the time of sowing and during the following few weeks: the greater the amount in the soil the greater the uptake by the plant. The different varieties of barley compared by Dr. Bishop took up much the same amount of nitrogen, but they produced different amounts of carbohydrate: those that produce most give the highest yields and contain the lowest per cent. of nitrogen, and *vice versa*. For any given variety, however, the total carbohydrate in the plant is not constant, but depends on the other soil conditions, the supply of potash and phosphate, and the length of the vegetative period.

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Soon after the grain begins to form, the carbohydrates and the nitrogen compounds move into it together, and the proportions in which they go remain almost constant throughout the whole process of grain formation. Not quite constant, however, for drought seems to check the flow of carbohydrate more than that of nitrogen, and therefore to raise the percentage of nitrogen in the grain.

For the maltster one of the most important properties of barley is the amount of extract obtainable from the malt. Hitherto, this has been determined by a laborious malting test. Dr. Bishop has shown that it is simply related to the moisture content, the percentage of nitrogen and the 1,000 corn weight of the barley grain: he has constructed a slide rule by means of which the chemist, knowing these three easily ascertained quantities, can read off at once the number of pounds of extract obtainable from a hundredweight of barley.

A study of the nitrogen compounds during malting has shown that hordein and glutelin both break down rapidly from the third to the sixth day on the floor to give salt-soluble compounds, chiefly non-protein nitrogen. After this there is an approximate balance due to a resynthesis in the embryo equal in amount to the breakdown in the endosperm. No marked changes take place as a result of the subsequent kilning process, nor are the proportions much altered by variations (within limits) in the amount of moisture supplied to the germinating grain, or in the time of flooring.

Calcium Cyanamide. Reference to the detailed tables shows that calcium cyanamide has given as good results as sulphate of ammonia for barley, and distinctly good results for sugar beet at the western centre. Both these crops require lime. On the other hand, in our earlier experiments it did not give as good results for potatoes, a crop which does not in general benefit by lime. We are following up this distinction and it may help in deciding the conditions in which the expert could advise the use of cyanamide. On the Continent farmers are sometimes advised to apply cyanamide a few days after the sowing of the seed wherever it is impossible to adopt the better plan of applying it several days before the sowing. We found no advantage in this course: no harm was done when 1 or 2 cwt. was sown with the seed, though 4 cwt. proved distinctly injurious.

WINTER WHEAT.

The experiments with wheat were somewhat weakened by the circumstance that some of the plants died during winter and the survivors were too irregularly distributed to form good experimental material. This winter mortality probably explains the higher standard errors per plot as compared with those obtained in experiments on spring sown cereals (pages 46-7).

The results agreed with those of 1927 in that the early dressing of sulphate of ammonia was better than the late: they thus differed from the results of 1926 and 1928. Muriate of ammonia, however, gave better results late than early, again in accordance with 1927 and in opposition to 1926 and 1928.

In each year Square-Head's Master has the highest nitrogen content, Yeoman II. follows closely: then come Million III. and

Swedish Iron. In neither year did the nitrogenous dressing appreciably affect the percentage of nitrogen in the grain: though the muriate appeared to give a lower percentage than the sulphate in Square-Head's Master, as it usually does in barley. Nor did time of application have any effect. The results are shown in Table II.

Table II. Percentage of Nitrogen in dry matter of wheat grain.
Rothamsted 1928 *crop.*

	Square-Head's Master.			Yeoman II.		
	Early Dressing	Late Dressing	Early and Late Dressing	Early Dressing	Late Dressing	Early and Late Dressing
Sulphate of Ammonia ..	2.00	2.01	1.99	1.99	2.01	2.00
Muriate of Ammonia ..	1.96	1.97	2.01	2.00	2.05	1.99
No Nitrogen ..		2.02			1.98	
	Million III.			Swedish Iron.		
Sulphate of Ammonia ..	1.84	1.85	1.81	1.77	1.76	1.89
Muriate of Ammonia ..	1.78	1.84	1.95	1.77	1.85	1.84
No Nitrogen ..		1.83			1.80	

Note that the figures given on page 32 of the 1928 Report are for grain containing 15% moisture and not for dry grain, as there stated.

1929 *Crop.*

	Square-Head's Master.			Yeoman II.		
	Early Dressing.	Late Dressing.	Early and Late Dressing.	Early Dressing.	Late Dressing.	Early and Late Dressing.
Sulphate of Ammonia ..	1.80	1.79	1.76	1.75	1.76	1.71
Muriate of Ammonia ..	1.75	1.76	1.72	1.74	1.67	1.67
No Nitrogen ..	—	1.76	—	—	1.73	—
	Million III.			Swedish Iron.		
Sulphate of Ammonia ..	1.66	1.60	1.64	1.44	1.58	1.51
Muriate of Ammonia ..	1.65	1.55	1.62	1.49	1.51	1.55
No Nitrogen ..	—	1.55	—	—	1.60	—

WINTER OATS.

There was a serious loss of plant during the winter and, in consequence, many weeds appeared in spring. As not infrequently happens in these circumstances, the effect of nitrogenous manure was to increase the growth of the weeds as well as of the crop: in the end there was an increase in the straw (including the weeds) but not in the grain, indeed there was evidence that sulphate of ammonia lowered the yield of grain.

RELATION OF WEATHER CONDITIONS TO YIELD OF WHEAT AND BARLEY.

The Statistical Department is investigating the relationships between weather and crop yield under different fertiliser treatments. Of the weather factors, rainfall is at Rothamsted the most important in determining total yield, both the amount and distribution having great effect. For wheat, winter rainfall is harmful: for barley it is beneficial at Rothamsted, but not, apparently, on the lighter soils of East Anglia. Spring rainfall, January and February on light soils in East Anglia, and March and April on the heavy soil at Rothamsted, is harmful to barley but not to wheat, July rainfall benefits barley but not usually wheat. The effects, however, depend on the manurial treatment, and indeed one of the practical results of the investigation is to show the kind of treatment that would be most effective in seasons of various characters.

Up to the time of ripening, temperature is less important so far as the total growth is concerned, and hours of sunshine still less. Plant physiological work in the laboratories has partly explained the relatively small effect of temperature on the total growth of the plant: it appears that low temperatures tend to increase the size of the leaf but to reduce the amount of plant substance each unit area can make, while the higher temperatures tend to reduce the size of the leaf but to increase the amount of plant substance made by each unit area: as a result of this compensating action the yield varies less than might be expected from changes in temperature.

The position is altered however as soon as ripening begins: vegetative growth then slackens greatly or entirely ceases. High temperature hastens the setting in of this change, and if it comes early it may cut short a period of very active growth, so lowering the yield: for example, high temperatures in May and June reduce the yield of barley.

LOSSES FROM ARABLE LAND.

Weeds. Of all losses of arable crops those due to weeds are the most serious: there is no surer way of reducing yields than by allowing weeds to grow. Fallowing is a recognised method of keeping weeds down, but it is complicated by the fact that weed seeds can lie in the ground for some time without germinating. Dr. Brenchley and Miss K. Warington show that many of them have a period of natural dormancy during which they will not germinate even if the conditions are favourable. Poppy *(Papaver rhoeas)* for example has a long dormancy period and can survive for several years, so that it cannot be eliminated even in a whole year fallow: black bent *(Alopecurus agrestis)* has a short dormancy and can be eradicated by a short fallow. Comparatively few weeds germinate freely throughout the year, most of them do it best in autumn rather than in spring or summer.

Soil Acidity. The great importance of soil acidity has stimulated chemists to devise methods for measuring it and one of these, the quinhydrone method, has come into general use because of its convenience and simplicity. Dr. Crowther and Miss Heintze have found a serious flaw in it that has hitherto not been suspected. Some soils from the Gold Coast had been sent for a report on their

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