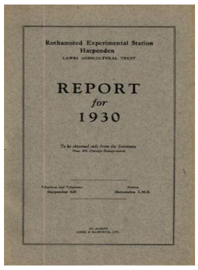
ROTHAMSTED RESEARCH

Report for 1930



Field Experiments

Rothamsted Research

Rothamsted Research (1931) *Field Experiments ;* Report For 1930, pp 21 - 38 **- DOI: https://doi.org/10.23637/ERADOC-1-63**

Thanks also to the sympathetic co-operation of the North Metropolitan Electric Power Supply Company, the farm is now to be connected up with their system. The buildings lie well off the track of the supply cables, nevertheless the company has been good enough to erect a special line, asking only a nominal guaranteed revenue, in order that we may be able to investigate the possibilities of using electricity in agriculture. The work will fall into three divisions:

(1) Use of appliances already known to be effective, so as to gain experience with them, to record their performance and to see how they compare in convenience, effectiveness, and cost with the older appliances. These will be fully demonstrated to all agriculturists interested.

(2) Tests for electrical engineers and implement makers of promising electrical devices not yet in common use about which more information is wanted.

(3) Investigations of possible new applications of electricity in agriculture.

It is hoped to begin work during the coming season.

The Committee has been fortunate in obtaining much valuable assistance from the General Electric Company and from Mr. R. Borlase Matthews, the well known electrical expert.

THE FIELD EXPERIMENTS.

CEREAL CROPS—BARLEY

An inquiry made in 1930 from the chief barley merchants in England, showed that about 65 per cent of the barley grown in England is sold for malting, a further 20 per cent is sold for seed, chicken mixtures, barley meal, etc., and the remaining 15 per cent is retained on the farm and crushed or ground for the animals.

This 65 per cent of barley sold by the farmer does not completely satisfy the maltsters demands. Only about one half of the barley used for malting is British grown[1]; the remainder comes from overseas. It is obviously important that the farmer should try to supply as much as possible, and with this end in view the Institute of Brewing has since 1922 carried out extensive investigations in co-operation with Rothamsted and the National Institute of Agricultural Botany to furnish all necessary information. The samples of barley grown in the various experiments are malted, and the more promising are brewed, so as to discover the effect of soil, season, manuring and variety on the malting and brewing qualities.

The characteristic of the season 1930 was the large response to nitrogenous manures, and the small returns from potash and phosphate. This held true of all the centres, with minor variations. At Rothamsted the increase was of the order of 4½ cwt. (9 bushels) of grain, and 4½ cwt. straw for 1 cwt. of sulphate of ammonia; at Woburn the return was even higher: over 11 bushels of grain. Phosphatic and potassic fertilisers, on the other hand, gave no

[1] "Report on the Agricultural Output and Food Supplies of Great Britain," 1929, Ministry of Agriculture. The proportions vary as between brewing and distilling; about three-fifths of the malt used in brewing is from British grown barley, as against one-third of the malt used in distilling.

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TABLE I.—Highest yields on Experimental Plots at Rothamsted, 1920–1930.
PRODUCE PER ACRE.

Years.	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930
Wheat in cwt.—Grain	20.4	19.9	19.7	16.2	25.7	13.6	25.7	27.3	36.5	21.8*b*	31.2
Ref. in Report ..	p. 79	p. 92	p. 86	p. 102	p. 112	p. 154	p. 137	p. 135	p. 129	p. 95	p. 132
Straw	45.4	37.5	37.4	38.6	39.7	25.0	48.4	55.8	62.0	57.6	81.2
Ref. in Report ..	p. 74	p. 85	p. 86	p. 108	p. 112	p. 132	p. 147	p. 135	p. 129	p. 87	p. 132
Barley in cwt.—Grain	23.4	22.1	19.1	18.6	22.3	23.2	22.3	23.8	20.5	30.5	30.5
Ref. in Report ..	p. 76	p. 90	p. 103	p. 114	p. 117	p. 151	p. 149	p. 132	p. 133	p. 98	p. 132
Straw	29.1	25.9	24.6	21.1	26.1	23.9	40.6	28.3	37.4	44.9	42.5
Ref. in Report ..	p. 81	p. 101	p. 101	p. 117	p. 117	p. 151	p. 149	p. 130	p. 133	p. 98	p. 131
Oats in cwt.—Grain ..		22.0		21.4	17.5	26.0	30.2	22.3	22.0*a*	15.9	16.8*c*
Ref. in Report ..		p. 93		p. 116	p. 128	p. 145	p. 146	p. 153		p. 93	p. 144
Straw		47.0		41.3	33.6	45.5	58.6	22.7		28.7	35.3
Ref. in Report ..		p. 93		p. 116	p. 128	p. 151	p. 146	p. 153		p. 93	p. 144
Hay—Cwt.	88.3	65.9	29.1	132.4	73.4	90.3	86.7	70.7	76.4	50.3	91.4
Ref. in Report ..	p. 70	p. 82	p. 95	p. 104	p. 104	p. 128	p. 128	p. 126	p. 126	p. 86	p. 121
Clover—Cwt.	24.1	54.9	26.4	78.8	72.3		32.2		28.0*a*		73.0*d*
Ref. in Report ..	p. 83	p. 102	p. 98	p. 112	p. 114		p. 125				p. 132
Potatoes—Tons	11.8	4.3	10.7	16.6	11.9	11.0	12.3	8.0	11.1	6.8	11.1
Ref. in Report ..	p. 81	p. 98	p. 94	p. 118	p. 120	p. 139	p. 140	p. 140	p. 142	p. 99	p. 146
Swedes in tons—Roots ..	21.7		32.6	17.1	21.6		21.8	15.2	22.8		
Ref. in Report ..	p. 77		p. 94	p. 119	p. 122		p. 136	p. 150	p. 152		
Tops	4.3			1.8	4.4		3.9	5.3	1.1		
Ref. in Report ..	p. 77			p. 119	p. 122		p. 136	p. 150	p. 152		
Mangolds in tons—Roots.. ..	37.7	31.0	31.6	37.4	34.2	27.1	34.7	17.3	29.3	20.7	30.9
Ref. in Report ..	p. 69	p. 81	p. 81	p. 103	p. 103	p. 127	p. 127	p. 125	p. 125	p. 85	p. 149
Tops	7.3	5.3	6.34	5.2	7.2	7.3	6.1	4.8	6.1	4.2	8.2
Ref. in Report ..	p. 69	p. 81	p. 81	p. 103	p. 103	p. 127	p. 127	p. 125	p. 125	p. 85	p. 149
Sugar Beet in tons—Roots ..							12.1	4.0	9.5	9.2	8.0
Ref. in Report ..							p. 142	p. 146	p. 147	p. 102	p. 132
Tops							26.0	13.0	12.6	6.9	11.7
Ref. in Report ..							p. 142	p. 146	p. 147	p. 102	p. 132

(*a*) Non-experimental.

(*b*) On great Harpenden (non-experimental) the yield was $31\frac{1}{2}$ cwt. per acre of grain as estimated by the sampling method and on Little Hoos it was $29\frac{1}{4}$ cwt. per acre of grain as measured from the threshing machine.

(*c*) Little Hoos and Long Hoos non-experimental oats yielded 22 cwt. per acre of grain. Yield on p. 132 is dry matter.

The 1926 sugar beet was grown on freshly broken grass land well manured ; the others are grown in the rotations.

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increases in grain on either farm ; indeed heavy dressings of phosphate appeared slightly to depress the yield of grain at Woburn, as had happened in some of the previous years. The straw was increased, though barely significantly, by phosphate, especially at Rothamsted ; possibly also, though not significantly, by potash. The figures, set out side by side, are as follows

Varying Nutrient	Rothamsted heavy soil Doses of Nutrient					Woburn light soil Doses of Nutrient				
	0	1	2	3	4	0	1	2	3	4
	Grain : cwt. per acre					Grain : cwt. per acre				
Nitrogen	21	25	27	22	31	13.6	18.9	18.2	20.7	23.0
Phosphate	28	26	27	25	26	22.0	22.1	22.1	19.4	20.5
Potassium	30	33	40	36	33	19.3	20.7	19.6	21.1	20.4
	Straw : cwt. per acre					Straw : cwt. per acre				
Nitrogen	23	27	30	23	35	29	36	37	46	45
Phosphate	30	24	31	39	37	36	38	37	38	39
Potassium	30	33	40	36	33	33	33	33	34	36

In another experiment at Rothamsted (p. 134) the returns from nitrogenous manure were lower, and less than last year.

On the light limestone soil at Wellingore the return from nitrogen was as high as at Woburn and there was a further return from potash, and a still further return from potash and phosphate, though not from phosphate alone. The result is similar to that of 1929, except that the yields are smaller and certain small effects then observed with phosphate alone hardly appeared in 1930. On the light chalk soil of Sparsholt the nitrogen was less effective, giving an additional 4 bushels per cwt. sulphate of ammonia. Phosphate and potash were ineffective excepting only where nitrate of soda had been used. On the light chalk soil at Wye muriate of potash and salt had no effect on yields of grain or of straw.

Of the nitrogenous manures nitrate of soda was most effective, as in 1929, excepting only at Wellingore where it was no better than sulphate of ammonia or cyanamide. At Rothamsted, cyanamide was less effective than in 1929 ; the difficulty of applying it to barley is that it should be put on the land a few days before seeding, but this proved impossible. A method sometimes advocated on the Continent was therefore used, and the cyanamide was put on three days after the seed was sown. The result showed that this is not the proper way ; we should in future put on the cyanamide first, and harrow the soil before drilling the seed. In this way no time would be lost, and the risk of damage to the seed would be minimised. Whenever possible a few days should elapse between harrowing in the cyanamide and sowing the seed.

The effect of the phosphatic fertilisers was tested on the exhausted land of Rotation I (four course) : superphosphate proved considerably more effective than rock phosphate.

Behaviour of Different Varieties of Barley. For the past two years Spratt Archer and Plumage Archer have been sown in alternate strips in Hoosfield so as to compare their behaviour towards the different fertilisers. The differences are small, but the experiment is being continued. The method is in 1931 being adopted on the permanent barley plots at Woburn, Plumage and Archer being here compared.

Effect on Quality. The effect of nitrogenous fertilisers on yield and quality of the grain is well illustrated by a series of experiments repeated during the three years 1927 to 1929, comparing the effects of 1 and of 2 cwt. of sulphate of ammonia.

The 1 cwt. dressing raised the yield by 3 to 5 cwt. of grain per acre, and 3.6 to 7.7 cwt. of straw without injury to the nitrogen content, 1,000 corn weight, or malting properties. Two cwt. per acre of sulphate of ammonia, however, added little to the yield, and considerably injured the quality. The figures are given in Table II.

The chemical factors involved in quality are discussed on p. 55

Growing for Quality. The general results of the experiments are as follows:

(1) Early sowing is essential for high quality.

(2) The preceding crop is not of great importance provided the land can be cleared in time. A cereal crop is the most convenient because it allows ample time for preparation. A root crop fed off has the disadvantage that the land may be occupied too long.

(3) Modern varieties of barley stand up to nitrogenous manures better than the older ones. It is therefore quite unnecessary to withhold manure. The farmer should aim at large crops, and so long as the treatment gives a good increase, such as that shown in Table II, by 1 cwt. sulphate of ammonia, no harmful effect on quality need be feared.

(4) When clover is sown in the barley a dressing of muriate of potash (1 cwt. per acre), or 30 per cent potash manure salts (1½–2 cwt. per acre) may benefit the barley and will help the clover in the next year. If the land recently had a dressing of superphosphate none need be given to the barley; otherwise a dressing of 2 cwt. per acre should be given.

TABLE II.—Effect of Increasing Amounts of Sulphate of Ammonia on the Yield and Quality of Barley at Rothamsted.

Yield.

Sulphate of Ammonia cwt./ac.	Grain: cwt. per acre. 1927	1928	1929	Straw: cwt. per acre. 1927	1928	1929
None	11.8	14.3	20.1	15.4	24.4	20.3
1	17.0	17.8	23.1	20.4	32.1	23.9
2	18.9	17.3	25.2	22.2	34.5	24.9

Quality of Barley.

S/Am.	Nitrogen per cent. on dry matter. 1927—All Plots.	1927—Plots Malted.	1928	1929	1,000 corn weight, dry. 1927—all Plots.	1927—Plots. Malted	1928	1929
None	1.458	1.427	1.928	1.464	36.0	36.3	38.2	39.7
1cwt/ac	1.451	1.470	2.049	1.459	35.6	34.8	38.1	39.6
2cwt/ac	1.488	1.510	2.174	1.482	34.6	34.6	37.2	37.0

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Quality of Malt.

S/Am.	Extract, lb. per barrel, on dry matter. 1927 Plots Malted	1928	1929	Diastatic Power, Lintner. 1927 Plots Malted	1928	1929	Colour. 1927	1928	1929
None	(99.6)	95.8	98.8	(43.5)	59.0	38.5	4.2	5.4	4.8
1cwt/ac	(99.1)	95.0	98.7	(39.5)	64.0	38.0	4.0	3.9	4.8
2cwt/ac	(98.1)	94.2	98.8	(41.0)	69.0	41.0	4.7	5.2	4.8

Valuation of Barley and Malt.

S/Am.	Barley. Shillings per qr. of 448lb.			Malt. Shillings per qr. of 336lb.		
	1927.	1928.	1929.	1927.	1928.	1929.
None	38	37	35	68	(2)	54
1 cwt/ac.	41	37	35	68	(1)	54
2 cwt/ac.	39	37	42	68	(3)	54

Notes.—The bracketed Malt Extracts and Diastatic Powers refer to the results on single plot samples : others are means of replicates.

Diastatic Power is depressed with increasing colour.

The 1928 Malts were noted as "unsaleable" by the valuers, but placed in the relative order given in brackets.

WHEAT

No crop is more discussed than this. It is easy to grow and it is especially suited for the somewhat dry regions which in Australia, Canada and Russia are now being populated ; hence a large increase in the amount grown and sent to these shores.

We could, however, grow much larger quantities ourselves if we desired. The present method of growing wheat gives about 33 bushels to the acre which is quite unprofitable. Considerably higher yields, however, are possible. Recent Rothamsted experiments have shown the remarkable effects of a summer fallow in raising the yield ; where rents are low the cost is small, the necessary cultivations being done entirely by tractor. With the ordinary methods our highest yields, as shown in Table I (p. 22) were usually about 37 bushels per acre from 1920 to 1925 (excluding 1924) ; since then they have been 50 to 55 or more. The 1930 Great Knott crop yielded 27 cwt. of grain (50.5 bushels) per acre, and 54 cwt. of straw on the unmanured land ; nitrogenous top dressings added nothing to the grain and 8 cwt. to the straw, which caused the crop to lodge. The preparation had been a fodder crop folded by sheep, which had paid for itself, then the summer fallow. In these circumstances one might expect damage from the wheat bulbfly (*Hylemya coarctata Fall*), and it was present and destroyed many tillers, but there still remained a good crop.

In another experiment, made in Long Hoos field, the wheat followed a seeds ley. The yield without nitrogen averaged only 15.2 cwt. of grain (28.4 bushels) and 21.9 cwt. of straw. There had been much loss of plant during the winter. Four varieties were tested : Square-Head's Master, Million III, Yeoman II and Swedish Iron ; of these the Square-Head's Master gave the lowest yield, 13.1 cwt. of grain per acre, and Swedish Iron as in 1929 the highest, 18.5 cwt. per acre, but on all alike nitrogenous manuring, whether applied early or late, was almost ineffective. Muriate of ammonia applied late appeared somewhat to reduce the yield both of grain and of straw. Sulphate of ammonia applied late gave a better increase of straw, and possibly of grain, than when applied early, thus agreeing with the results of 1926 and 1928, but opposite to those of 1927 and 1929. In the Great Knott experiment the small differences in result, associated with differences in time of application of the fertilisers, were not in themselves significant but were in the direction of the 1927 and 1929 results.

On another experiment in Hoos field the unmanured wheat gave only 14 cwt. of grain per acre (26 bushels) and 22 cwt. of straw, but there was a considerable response to sulphate of ammonia (1.8 cwt. per acre) the yield rising to 20.5 cwt. of grain (38.2 bushels) and 29 cwt. of straw.

A new experiment in the management of the wheat crop was tried. Now that we have gone in extensively for sheep we are in constant need of fresh grazing land in spring. It is therefore important to know how far one can safely follow the old Hertfordshire custom and graze wheat in March or April. This was tried in 1930 on Long Hoos field; part of the wheat was grazed on, part was left ungrazed. The ungrazed portion yielded 15.7 cwt. of grain per acre (29.3 bushels), and the grazed portion 13.5 cwt. (25.2 bushels), a loss of 4 bushels of grain and 4 cwt. of straw together worth 20s. at selling price; the value as grazing was estimated by the farm manager at about the same price.

The quality of the wheat is assessed by Dr. E. A. Fisher of the Research Association of British Flour Millers, St. Albans. He finds that the Rothamsted wheats are all somewhat poor in quality, the Broadbalk wheats especially so. None of the methods of increasing the yield has improved the quality.

Another important investigation has been begun, thanks to the co-operation of the Dunn Nutritional Laboratory at Cambridge. Dr. Harris and Dr. Moore propose to examine samples of our various wheats for vitamin content. The results promise to be of great interest, and they may open out entirely new lines of work.

THE FALLOWING OF BROADBALK WHEAT FIELD

The year 1929-30 was the first in which the whole of Broadbalk wheat field was again under wheat after the four years in which parts had been fallowed. The crop was harvested in five portions:

1 and 2	The upper two fifths (west end) fallowed 1925-1927, then cropped.
3	The middle fifth, fallowed 1925-1929, then cropped.
4 and 5	The lower two fifths (east end) fallowed 1927-1929, then cropped.

We therefore had in 1930 a crop grown after two years' fallow, another after four years' fallow, and a third after two previous wheat crops. The yields are given on pp. 122-3.

The first crop after the fallow was exceptionally high, with a ratio of grain to straw well up to the average. The effect of the fallow, however, was only transient; both yield and Grain/Straw ratio rapidly fell; in the second year the yield was approximately equal to the average and in the third year after fallow it was well below. The weeds are rapidly coming back. *Alopecurus agrestis* is already established.

Dr. Brenchley's observations show that the value of bare fallowing for weed eradication depends largely upon the species it is desired to eliminate. Some species, as Shepherd's Purse (*Capsella Bursapastoris*), which germinate and flower throughout the year, are not reduced by fallowing, because they grow and form seed so quickly that they re-stock the ground in the interval between autumn ploughing and the first spring cultivation. Others, as Poppy (*Papaver sp.*), have so long a period of natural dormancy, that they leave enough viable seeds in the soil to yield a big crop even after the fallowing. On the other hand, Black Bent (*Alopecurus agrestis*) and others with a short period of dormancy, are so reduced by fallowing that they can be kept within bounds ; sufficient viable seeds are, however, left in the ground to recolonise the land rapidly unless adequate cultivation be given.

Fallowing also improves the physical condition of the soil. It had so marked an effect on the tilth that we were able in the first year of cropping to obtain a seed-bed with no more cultivation than harrowing. However this effect soon passed away, and in the second year the seed-bed was no more easy to obtain than usual ; it was less fine than in the first year.

It is proposed in future to continue the separate harvestings and to continue the fallowing indefinitely but in a somewhat different way. In 1930-31 Strip 1 is being fallowed (the west end) ; in 1931-32 Strip 2 will be fallowed, and so throughout. In each year, therefore, one-fifth of the field will be under fallow and four-fifths under crop, of which one-fifth is in the first year after fallow, another in the second year, and the others in the third and fourth years respectively. This will give opportunities of studying the effects of fallowing and also of keeping the field clean.

POTATOES

The variety planted was again Ally. It yields less on our land than Kerr's Pink, which we grew from 1921 till 1926, but it matures earlier and fits in better with our programme of autumn work.

There were two sets of experiments, both in the same field and with the same variety ; in one the maximum yield was 11 tons, in the other with equally efficient mixtures of artificial fertilisers, it was 7 tons only. The heavy yielding crop had had farmyard manure, the other had not. In general one would not have expected so marked a difference[1], but in 1930 the crop receiving farmyard manure continued growing well throughout the latter part of the season, while the crop without it weakened early and became smothered in weeds, mainly chickweed (*Stellaria media*) ; no fertiliser scheme helped much, although no fewer than 13 were tried ; the yield without nitrogen, like that without potash, was 4 tons per acre ; this was raised to 7 by the heaviest dressings of artificials. The number of plants per acre averaged 14,760. In the other set the crop gave a yield of 7.5 tons from farmyard manure without any artificials. One cwt. sulphate of ammonia gave an additional 30 cwt. of potatoes as also did 1.6 cwt. sulphate of potash so long as sufficient superphosphate was given, otherwise the increase was only 24 cwt. Superphosphate (3 cwt. per acre)

[1] See Report for1923-24, pp. 120, 121, for and 1921-22, p. 98

gave the very satisfactory increase of 36 cwt. of potatoes per acre so long as there was sufficient nitrogen and potash; with insufficient quantities the increase was only 11 cwt. The results are as follows:

Average yield in tons per acre.

Sulphate of Ammonia, cwt. per acre.		Without Phosphate. 0	1	2	With Phosphate. 0	1	2
Sulphate of Potash, or equivalent cwt. per acre	0	7.55	8.12	8.78	7.89	8.32	9.75
	1	7.64	9.29	9.00	8.30	9.84	10.16
	2	8.01	9.53	9.22	8.85	10.25	11.00
		Mean 8.57 tons.			Mean 9.37 tons.		

General mean — 8.97 tons. Standard error for above table —0.215 tons or 2.40 per cent.
Mean number of plants per acre, 14,341.
All plots received farmyard manure.

As betweeen the various potassic fertilisers sulphate of potash, muriate of potash and potash manure salts all gave approximately equal yields when used with a complete fertiliser. When, however, superphosphate was omitted the muriate and the manure salts were less effective than the sulphate suggesting that the potato needs sulphate as well as nitrogen, potassium, and phosphorus; a result also obtained at Woburn (p. 152).

The maximum yield was 11 tons per acre; it is remarkable how often this figure has been attained as the highest on our farm. The number of plants per acre was about 14,500.

No quality determinations were made this year, but chemical analyses were made of the tubers of the heavier crop. The percentage of dry matter in the tubers was about 23; it was not affected by nitrogenous, or phosphatic manuring, or by sulphate of potash; it was, however, lowered by chlorides; thus potash manure salts in the larger dressing lowered it from 23.3 per cent to 22.1 per cent. The nitrogen content of the tubers was about 0.3 per cent; it was raised by nitrogenous but lowered by phosphatic and potassic manuring, and by the chlorides; it was, however, least affected by sulphate of potash. The figures are given in Table III.

TABLE III.—Composition of Potatoes as influenced by Manuring.
Potatoes, Long Hoos, 1930.
Percentage of Dry Matter.

		No Superphosphate given. No S/Amm.	Single S/Amm.	Double S/Amm.	Superphosphate given. No S/Amm.	Single S/Amm.	Double S/Amm.
	No Potash	22.94	23.37	22.94	22.83	23.14	23.54
Single Potash	Sulphate	23.25	22.66	23.87	23.26	22.95	22.97
	Muriate	22.95	23.25	22.98	23.32	23.04	22.56
	Potash Salts	22.82	22.72	23.22	22.35	23.15	22.59
Double Potash	Sulphate	23.39	23.56	23.28	22.61	23.68	23.47
	Muriate	22.29	22.94	22.51	22.42	23.03	22.81
	Potash Salts	22.43	21.99	22.05	22.32	21.99	21.73
Mean		22.87	22.93	22.98	22.73	23.00	22.81
General Mean			22.92			22.85	

Potatoes, Long Hoos, 1930.

Percentage of Nitrogen.

		No Superphosphate given			Superphosphate given		
		No S/Amm.	Single S/Amm.	Double S/Amm.	No S/Amm.	Single S/Amm.	Double S/Amm.
	No Potash	.320	.342	.354	.298	.320	.342
Single Potash	Sulphate	.313	.331	.350	.297	.318	.288
	Muriate	.318	.317	.335	.293	.298	.333
	Potash Salts	.321	.327	.359	.295	.322	.322
Double Potash	Sulphate	.316	.334	.358	.330	.324	.338
	Muriate	.286	.331	.322	.286	.311	.323
	Potash Salts	.294	.310	.334	.295	.292	.318
	Mean	.310	.327	.345	.299	.312	.323
General Mean			.327			.312	
In dry matter— Means		1.316	1.426	1.501	1.315	1.357	1.416
General Mean			1.427			1.365	

Summary of Potassic Manures : Mean of all.

Amount of K_2O cwt. per acre.	Dry matter : per cent. in tubers.	Nitrogen per cent. in fresh tubers.	Nitrogen per cent. in dry matter.
None	23.1	0.329	1.42
0.4	23.0	0.319	1.38
0.8	22.7	0.317	1.39
Standard error	0.10	0.0028	

Effect of Different Salts.

	Dry matter per cent. in tubers.		Nitrogen per cent. in fresh tubers.		Nitrogen per cent. in dry matter.	
Amount of K_2O cwt. per acre	0.4	0.8	0.4	0.8	0.4	0.8
As Sulphate	23.2	23.3	0.316	0.334	1.36	1.43
As Muriate	23.0	22.7	0.316	0.310	1.37	1.36
As 30 per cent. P.M.S.	22.8	22.1	0.324	0.307	1.47	1.39
Standard errors	0.17		0.0049			

The potatoes at Woburn (also Ally) yielded even better than at Rothamsted giving up to 13 tons per acre. The most marked effects were from nitrogenous manuring ; phosphatic and potassic fertilisers had less effect, contrary to expectation on this light soil. In another experiment cyanamide and sulphate of ammonia were found equally effective, as also were superphosphate and basic slag, compared on the basis of equal amounts of nitrogen and of phosphoric acid respectively. Another experiment indicated, like the one at Rothamsted, that a certain amount of sulphate, in the forms of sulphates of magnesium, potassium and calcium, had been beneficial ; larger amounts, however, were not (p. 152).

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In our Rothamsted and Woburn experiments we have commonly obtained very satisfactory yields from the following mixture of fertilisers :

10 tons farmyard manure ploughed under in autumn or winter.
3 or 4 cwt. sulphate of ammonia.
3 or 4 cwt. sulphate of potash.
4 cwt. super. (17 per cent P_2O_5)

applied in the drills at the time of setting the seed ; the 3, 3, 4 mixture correspond to the proportions 1N : $2.5K_2O$: $1P_2O_5$. Where muriate of potash or potash manure salts are used instead of the sulphate the amount of chlorine (Cl) should not be more than double the nitrogen (N).

Experiments were also made at other centres in various parts of England. The most striking result has been the marked benefit from superphosphate, the average increase at the seven responsive centres per cwt. of 36 per cent super. (17 per cent P_2O_5) having been 12 cwt. per acre ; the same figure as is obtained at Rothamsted. The actual increase varied ; at one of the centres the response was only 3 cwt., at another it was 24 cwt. ; at three centres there was no response. The average increases for the past three seasons per cwt. of 36 per cent superphosphate (17 per cent P_2O_5) are given in Table IV.

TABLE IV.—Increases in Yield of Potatoes per cwt. of 36 per cent. super.

	1928 cwt.	1929 cwt.	1930 cwt.
Wisbech	2	6	10*
Stowbridge	19	—	—
Woburn	9	−2	—
Rothamsted	6	6	12
Owmby Cliff	−14	Nil	8
Bangor	−2	−4	—
Midland Agric. College ..	—	−2	10
Haverfordwest	—	—	13
Nateby	—	—	3
Welshpool	—	—	24

* British Queen : King Edward gave no increase.
Details are given on p. 00.

The result at Owmby Cliff is especially interesting because it was here that super. had apparently depressed the yield in 1928, a result similar to that at Kirton. In 1929 it had no effect, and in 1930 it has increased the yield. However the depression may have been caused, it is obviously only an exceptional occurrence and we are not yet prepared to account for it.

A number of experiments have now been made to ascertain how heavily a crop can advantageously be fertilised with superphosphate. In general the effect depends on the level of nitrogen and of potash given, and the broad results are (1) that these two fertilisers can act well only when the crops are sufficiently well supplied with phosphate ; and (2) that superphosphate is effective even in large dressings where the level of crop production varies from 9 to 14 tons per acre—the usual case in good potato districts—but it had little action where the yields without it, or with only a small dressing, were below 8 tons or above 14 tons per acre :

Yield of potatoes when only one dose of superphosphate was given.	No. of experiments.	Average yield, tons per acre. No Super.	Super. given. Single dose.	Double dose.	Quadruple dose.
Below 8 tons ..	4	6.92	6.54	6.66	6.65
9–14 tons	8	9.97	11.19	11.40	11.77
Above 14 tons	5	15.37	15.39	15.80	15.80

The details are given in Table V the " dose " is usually 2 cwt. 36 per cent. super. per acre.

TABLE V.—Effect of Superphosphate on Yield of Potatoes : Tons per acre.

Year	Centre.	Soil.	No Super.	Single dose[1]	Double dose.	Quadruple dose.
1927	Woburn[3]	Light sand	4.06	4.10	3.96	4.08
1928	Woburn[3]	"	12.25	13.43	14.00	14.69
1928	Stowbridge, Norfolk ..	Black fen	8.10	10.05	10.97	12.57
1928	Owmby Cliff, Lincs. ..	Oolitic limestone	8.18	6.79	7.73	7.25
1929	Owmby Cliff ..	" "	7.42	7.44	7.34	7.30
1928	Bangor	Light gravelly	15.78	15.62	16.12	16.03
1929	Bangor	loam	14.66	14.25	14.53	14.66
1929	Midland Agric. Coll...	Light loam	8.00	7.82	7.63	7.97
1928	Wisbech[4]	Deep silt	16.98	17.32	17.55	17.75
1929	Wisbech[2]	" "	11.67	12.48	12.82	13.11
1930	Owmby Cliff ..		11.37	12.19	11.85	12.34
1930	Midland Agric. Coll. ..		10.03	10.98	9.05	9.70
1930	Wisbech[4]		13.18	14.14	14.42	14.62
1930	Wisbech[2]		16.27	15.60	16.39	15.93
1930	Haverfordwest ..	Hungry sand	7.94	9.21	9.68	9.96
1930	Nateby (Lancs.) ..	Moss soil in deep peat	9.24	9.54	9.50	9.44
1930	Welshpool	County School garden	9.18	11.64	13.29	12.36
1930	Bourne[5]	Light black fen	10.22	—	12.07	12.18

[1] Single dose usually 2 cwt. superphosphate per acre.
[2] King Edward. Single dose $2\frac{1}{2}$ cwt.
[3] Single, double and treble doses, unit 3 cwt. in this case.
[4] British Queen. Single dose $2\frac{1}{2}$ cwt.
[5] Single dose $2\frac{1}{2}$ cwt.

Both at Bourne and at Wisbech 5 cwt. of super. gave profitable returns : 1.85 tons of potatoes at the former, and 1.24 at the latter centre ; at Wisbech, however, the response was confined to British Queen and there was no gain with King Edward. These differences in behaviour of different varieties are now being studied.

At Bourne the first 2 cwt. of sulphate of potash increased the yield of potatoes by 1 ton per acre, and the second 2 cwt. gave a further increase of 16 cwt. per acre, both profitable.

Perhaps the most dramatic result at the outside centres is that obtained at Tunstall by Mr. A. W. Oldershaw on a light sandy soil in Suffolk, reckoned as hopelessly bad, which yet when chalked and given a dressing of $3\frac{1}{2}$ cwt. superphosphate and 4 cwt. nitrate of soda per acre, yielded over 13 tons of potatoes per acre.

Finally, in experiments on light land at Biggleswade and at Burford, and on heavy land at Hull, we this year compared inor-

TABLE VI.—Comparison of Artificial Manures with Organic Manures.
Outside Centres, 1930.
Potatoes, tons per acre.

Locality.	Soil.	Sulphate of Ammonia. Super.	Dried Blood. Steamed bone flour.	Sulphate of Ammonia. Steamed bone flour.	Dried Blood. Super.	Standard error.	Significant results.
Sailors' Orphan Home Hull	Heavy alluvium	11.69	9.01	9.86	10.88	0.425	Super. better than bone flour. Sulphate of Ammonia better than blood.
Grammar School, Burford.	Light loam on lime-stone	9.05	8.82	9.03	9.91	0.554	No difference.
Mr. H. Inskip, Stanford, Beds.	Light sand	5.52	5.06	5.31	5.28	0.127	No difference. No significant effect was produced by potassic fertilisers. With potash 5.44 Without potash 5.14 Standard error—0.124
Ditto.	Heavy clay	15.03	14.50	14.55	14.84	0.311	No difference.
Mr. H. Inskip, Stanford, Beds.	Heavy clay	16.09	Fish Meal. 16.11			0.346	No difference.

All plots had potassic fertiliser unless otherwise stated.

The comparison between artificial and organic nutrients was on the basis of equal amounts of nitrogen and equal amounts of phosphoric acid per acre.

No farmyard manure was given.

ganic with organic manuring for potatoes, testing dried blood against sulphate of ammonia and steamed bone flour against superphosphate. On the light land there was no difference in effect, on the heavy soil the organic fertilisers were distinctly inferior, super. giving 1.85 tons more than steamed bone flour, and sulphate of ammonia 0.83 tons more than blood on yields of about 10 tons (Table VI). The organic fertilisers certainly require little knowledge for handling, and they are convenient for garden use, but we have no evidence that they ever act better than, or even as well as, the artificial fertilisers.

The effect of the bulky organic manures, farmyard manure and rotted straw, is shown on pp. 130-1.

SUGAR BEET

The variety grown was again Kuhn (Johnson's Perfection). The average yield of washed roots was the same as last year; the percentage of sugar was slightly higher while the yield of tops was considerably higher. It was a good growing season and the leaves did well but the roots could not keep pace. The results bring out strikingly the variation in efficiency of the tops from season to season, and their low efficiency as compared with that of the mangold. The results of recent years have been:

	Sugar Beet. (*washed*)			*Mangolds.*[1] (*scraped*)		
Year.	Yield of tops in tons per acre.	Yield of roots in tons per acre.	1 part of top makes of root	Yield of tops in tons per acre.	Yield of roots in tons per acre.	1 part of top makes of root
1926	25.23	12.10*a*	0.48	6.05	22.43	6.25
1927	10.82	3.38	0.31	3.89	13.42	3.45
1928	11.43	9.15	0.80	5.01	29.22	5.83
1929	5.41	7.43	1.37	3.94	20.67	5.25
1930	9.15	7.44	0.81	6.23	26.78	4.30
Mean	12.41	7.85	0.75	5.02	22.50	5.02

(*a*) The figures given in the 1926 Report on p. 142 are for unwashed beet.
[1] Barnfield, Plot 4 A.C.

The yields of tops vary a good deal according to season and manuring, but the yields of roots vary much less.[1] The root is able to keep pace with the top up to a certain stage, but then it can do no more, no matter how much the top grows. Mangold roots, on the other hand, can continue growth much further and so keep pace with the better leaf growth of good seasons. This restriction or congestion of the root of the sugar beet may result from its constitution; its sap is so highly concentrated that new soluble material from the leaf may not readily enter so that the process of translocation from leaf to root may be considerably retarded. Increased concentration of the leaf sap might improve matters; this may explain the special value of salt as a fertiliser.

The manurial results show that the leaves behave normally giving their full increase with fertilisers, but the roots do not. Thus in Rotation II the yields for varying dressings of nitrogen were:

[1] Excluding 1927, where the failure was due to very late sowing.

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Cwt. N per acre applied as Sulphate of ammonia	0	0.15	0.30	0.45	0.60
Tops, tons per acre	7.3	9.3	7.8	10.5	11.7
Roots, tons per acre	6.3	7.1	6.0	8.0	7.0

Neither phosphate not potash had any important effects on the roots or tops either at Rothamsted or at Woburn. One general result up to the present is that sulphate of ammonia applied with the seed usually gives an increased yield of root which is still further increased by potash manure salts or by muriate of potash and salt (Table VII). Nitrate of soda usually gives a greater increased yield of root, but there is not always a further gain by adding potassic fertiliser and salt ; apparently its soda exerts some beneficial effect. The effects at Rothamsted are not very great ; a dressing of 23 lb. of nitrogen, the equivalent of 1 cwt. of sulphate of ammonia, or 1½ cwt. nitrate of soda, has usually given an additional 6 to 9 cwt. of roots, and 12 to 17 cwt. of tops per acre. At the outside centres the figures are better, the roots having been increased on the average by 12.3 cwt., and the leaves by 23.9 cwt. per acre by a dressing containing 23 lb. nitrogen :

Mean of 17 comparisons at Outside Centres, 1929–30.
Effect of Nitrogenous Manures.
Calculated to basis of 23lb. N. per acre.*

Yield without added Nitrogen.			Increase per 23lb. N.		
Roots, Tons.	Tops, Tons.	Sugar, per cent.	Roots, cwt.	Tops, cwt.	Sugar, per cent.
9.66	11.29	17.87	12.3	23.9	0.05

* The actual rates of application were either 46 or 69lb. N. per acre.

TABLE VII.—The Effect of Potassic Fertilisers and of Salt on Sugar Beet at the outside centres in 1929 and 1930.

	Average Increase per 1 cwt. potash or salt fertilisers.		
(*a*) No potash or salt in basal dressing :	Roots, cwt.	Tops, cwt.	Sugar, per cent.
Mean of 4 expts. [1]Muriate of potash ..	9.5	7.5	0.10
„ „ 3 expts. [2]Salt	14.0	8.5	0.27
„ „ 3 expts. [1]Muriate and Salt Mixture	6.5	9.5	0.14
1 expt. 20 per cent. Potash Salts	9.5	—	0.10
(*b*) Salt in basal dressing :			
Mean of 2 expts. [2]Muriate of potash ..	0	0	0.10
(*c*) Muriate of potash in basal dressing :			
Mean of 3 expts. [1]Salt	2.0	12.0	0.17

[1]Two only for tops.
[2]One only for tops.

These various points are well illustrated in the experiment made on Messrs. Wilson's farm at Colchester on a good sugar beet soil (pp. 166-7).

It does not always happen, however, that nitrate of soda is superior to sulphate of ammonia ; at the County School, Welshpool, in 1930, in one of the most accurate experiments yet made, the sulphate of ammonia came out superior (p. 169) as it had done at Rothamsted in 1929, when muriate of potash, salt, and super. were also given. We are not yet in a position to put forward a general recommendation for the manuring of sugar beet. As a basis for experiment we should suggest, per acre :

10 tons farmyard manure applied in autumn.
2 cwt. nitrate of soda.
3 cwt. super.
3 cwt. potash salt all applied at or before seeding.

The effect of 2 cwt. salt should also be tried instead of the potash manure salts. Possibly new varieties will be more responsive than the present ones, but our whole scheme of management may be unsuitable for the crop. It is possible that the additional saline material taken up by the root from the fertilisers, and remaining in solution in the juices of the root, adds to the difficulty of entry of sugar from the leaf, and that the proper way of fertilising sugar beet would be from the exchangeable bases in the soil and not from soluble salts ; this may explain the continental preference for putting on the manures some long time before the seed is sown so that all unwanted ions can be washed away.

The average percentages of sugar at Rothamsted and Woburn have been :

	1926.	1928.	1929.	1930.	Mean.
Rothamsted ..	17.4	17.6	18.4	17.6	17.8
Woburn ..	16.7	18.0	17.1	19.4	17.8

No determinations were made in 1927 owing to lowness of yield.

The sugar content is only slightly affected by phosphatic or potassic manuring ; superphosphate, however, slightly raised it at Woburn, both in 1929 and in 1930, while potassic fertiliser had no effect. At Rothamsted superphosphate did not alter the sugar content in 1929 ; potassic fertilisers slightly raised it except where nitrate of soda was given.

The one result that almost always emerges is the lowering of the percentage of sugar by nitrogenous manures. It is not necessarily large ; in the preceding years the reduction has averaged 0.15 per cent ; in 1930 it was 0.05 per cent only.

The loss of plant was not heavy ; the proportion actually obtained was on the average 98 per cent of the number expected at Rothamsted as compared with 84 per cent of those expected at Woburn.

The figures are, per acre :

	Rothamsted.	Woburn.
Number of plants expected	35,280	32,000
Number of plants harvested	34,534	26,795
Plants obtained as percentage of those expected	98	84

FORAGE MIXTURE CROPS

Forage mixture crops have the great advantage that they can be grazed in May or June, cut green in June or July, made into silage or hay in July, or left to ripen, cut in August and threshed, when the straw can be chaffed and the grain crushed. No other crop, not even grass, is so elastic in its uses. Being sown annually the early grazing, if it is used, is always clean ; the land can never become " sheep sick."

The mixtures at present in use at Rothamsted are made up of :

	Bushels per acre.
Wheat, Oats or Barley	2
Peas or Vetches	2
Beans	1

Other proportions are being tested.

The vetches, wheat, winter oats and beans are sown in autumn. The peas have to be drilled in spring in an autumn sown oat or wheat and bean mixture ; the barley and spring oat mixtures are entirely sown in spring.

In 1930, the first year of the trial, the barley mixtures did better than the oat mixtures in yield both of hay and of grain, though not of straw, but there was little difference between peas and vetches. The barley mixtures gave, without manure, good hay, containing 26½ cwt. of dry matter per acre when cut early, or 22 cwt. of grain and 24 cwt. of straw when left to ripen ; the advantage of leaving the crop to finish its growth is considerable, but not quite as great as it looks, for after cutting the hay there still comes up an aftermath which gives clean fresh grazing, or the land can be summer fallowed for a winter crop.

The manuring of the fodder mixtures, however, is difficult, because it involves some entirely new principles. Any fertiliser that is added is likely to benefit one constituent more than the others, increasing its growth and also its power of competition with the others ; the favoured plants tend to crowd out the rest exactly as has happened on the Park grass plots. This is well illustrated by the effect of sulphate of ammonia. Applied at the rates of 1 and of 2 cwt. per acre it greatly increased the growth, especially of the barley mixtures ; with these the larger dressing gave a fine looking crop of 38 cwt. of hay or 24 cwt. grain and 32 cwt. straw. But analyses showed that the gain was entirely on the barley or the oats ; not at all on the peas, vetches and beans ; indeed these had been actually depressed by the manuring. This change affected the feeding value of the product. In place of a foodstuff having nearly the same protein value as good meadow hay, we obtained one of much lower value, though it was better than poor hay or straw. The results are given in Table VIII.

TABLE VIII.—Yield and composition of mixed crops grown for fodder and cut as hay.

Nitrogen added in manure, cwt. per acre.	0	0.2	0.4
Yield of dry matter, cwt. per acre—			
Oats—Vetches	21.9	32.1	32.4
Oats—Peas	26.0	31.3	34.1
Barley—Vetches	27.3	30.7	37.6
Barley—Peas	26.1	33.0	38.9
Mean	25.3	31.8	35.8
Percentage composition of dry matter of all mixture—			
Protein	11.7	9.6	8.6
Soluble carbohydrates	46.2	48.8	49.1
Crude Fibre	32.9	32.5	33.4
Oil	2.4	2.6	2.5
Ash	6.8	6.5	6.4
Percentage by weight of leguminous plants in hay	41	27	20
Leguminous plants, cwt. of dry matter per acre	10.3	8.7	7.2
Cereals, cwt. of dry matter per acre ..	15.1	23.1	28.6
Nitrogen in crop cwt. per acre	0.42	0.44	0.44

Composition of Meadow Hay (T. B. Wood).

	Very good	Good	Poor.
Protein	16.1	11.3	8.8
Soluble carbohydrates	48.2	47.9	44.6
Crude Fibre	23.0	30.7	39.1
Oil	3.6	2.9	1.8
Ash	9.2	7.2	5.8

In yield of grain the barley mixtures responded somewhat to potassic fertilisers, but the oat mixtures did not, and there was little if any response to superphosphate. Different combinations of manures are being tested this season ; there is clearly much to be learned about the manuring of these important crops.

A second forage mixture of rye, beans and vetches in Pastures Field cut as hay gave substantial increases, up to 20 cwt. per acre but not beyond, to sulphate of ammonia, and increases up to 10 cwt. per acre but not beyond, to potash. There were no increases, however, to phosphate. The yields were, in cwt. of hay per acre :

Rothamsted

Varying Nutrient.	Hay : cwt. per acre Doses of Nutrient.				
	0	1	2	3	4
Nitrogen ..	56	66	74	75	72
Phosphate ..	71	66	69	69	65
Potassium ..	59	69	68	61	64

SEEDS HAY

The " seeds ley " sown at Rothamsted is pure clover without admixture of grasses ; the reason being that under our conditions of farming, the fritfly (*Oscinella* (*Oscinis*) *frit* L.) and other insects may winter on the grasses and pass over to the cereals as soon as spring appears; they do not survive on clover, however. Usually the seeds ley receives no manure except what may be given to the barley. Our general experience has been that a dressing of sulphate of ammonia may depress the clover while potash may help it. In the Long Hoos experiment (Rotation II) fertiliser is given to the clover itself as a top dressing in spring, and here quite a different result was obtained; nitrogen greatly increased the yield, potash slightly increased it, but phosphate had no effect. The yields of dry matter were, in cwt. per acre:

Rothamsted heavy soil.

Varying Nutrient.	Dry matter cwt. per acre Doses of Nutrient.				
	0	1	2	3	4
Nitrogen ..	22	33	34	42	47
Phosphate ..	36	35	36	36	39
Potassium ..	33	37	36	37	36

To convert these figures into hay they should be raised by about one-fifth.

In another experiment on Hoos Field the unmanured clover yielded 12 cwt. dry matter per acre (equal to about 15 cwt. hay), while a dressing of superphosphate, muriate of potash, and 2 cwt. sulphate of ammonia raised it to 22 cwt. dry matter or about 26 cwt. hay and heavier dressings yielded as much as 42 cwt. dry matter or 50 cwt. hay per acre.

Evidently if ever hay were needed there would be great scope for manuring the seeds ley.

These results appear to be contradictory to those given by the earlier experiments where the manuring was given to the barley. There is, however, no contradiction. A mixture of barley and clover responds very differently from pure barley or pure clover to manures. Sulphate of ammonia favours the barley more than it does the clover, so causing the young barley to make more vigorous growth and to crowd out the clover. With the pure clover this element of competition is absent, and so long as the crop is not too weedy there seems the possibility that it could advantageously receive nitrogenous manure. Possibly there would be less fixation of nitrogen from a manured crop than from one receiving no nitrogen, but in these days of cheap nitrogenous fertiliers that point is of less importance than it was.

EFFECTS OF FARMYARD MANURE: HOW LONG DO THEY LAST?

Two sets of experiments, one at Rothamsted and one at Woburn, give useful information on this subject. The remarkable result is the persistence of the effect when the farmyard manure has been given sufficiently often. Of three plots of barley on Hoos Field, two had farmyard manure every year from 1852 to 1871, both being treated exactly alike, the third had no manure. This unmanured plot and one of the manured plots have remained under the same