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Report for 1937

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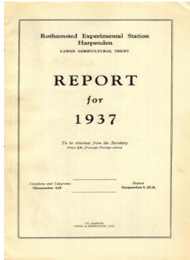

Arable Crops

Rothamsted Research

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Reviewing the whole of the experiments it appears that poultry manure is not uniformly better than sulphate of ammonia in the cumulative series, but it approaches sulphate of ammonia closer than in the series testing first year effects. Kale appears to be a particularly unsuitable crop for poultry manure, while the only two cabbage crops grown in 1937 showed a significant superiority of poultry manure over sulphate of ammonia.

ARABLE CROPS

Sugar Beet

Each year since 1933 the Rothamsted staff has co-operated with what has now become the Committee on Research and Education of the Sugar Commission in carrying out experiments on the manuring and cultivation of sugar beet at Rothamsted, Woburn and on a number of representative sugar beet growers' farms.

During the first three years 1933, 1934 and 1935, the responses to fertilizers were comparatively small. The summers were hot and dry, and apparently provided little opportunity for the phosphate and potash to exert their full effects. Nitrogen was the only fertilizer to justify itself in the average in these years, and the single dose of potash came next in order of effectiveness. In 1936, however, there were good responses to all nutrients and especially to phosphate; the results provided us with our first favourable opportunity for relating field responses to chemical analysis of the soils. In 1937 the responses to nitrogen and phosphate were less than in 1936, but the results from potash were the best so far recorded.

The mean increase to the three nutrients in terms of sugar per acre are shown in Table XVIII.

TABLE XVIII

Mean Responses to Nutrients in Single and Double Dressings. 1933-1937
Sugar (cwt. per acre)

Year	No. of expts.	Mean yield of roots tons p. a.	Mean yield of sugar	Sulphate of ammonia		Superphosphate		Muriate of potash	
				2 cwt.	4 cwt.	3 cwt.	6 cwt.	1¼ cwt.	2½ cwt.
1933	13	11.5	37.5	+0.4	—	+0.3	—	+0.8	—
1934	15	13.5	47.6	+1.8	+3.0	+0.4	+1.0	+1.4	+0.4
1935	23	9.5	32.4	+1.8	+2.7	+0.1	+0.4	+0.8	+0.9
1936	26	10.4	36.6	+5.5	+7.7	+1.9	+3.0	+1.2	+1.9
1937	30	11.6	40.3	+3.8	+5.2	+1.5	+1.9	+1.5	+2.8

The quantity of sugar per acre required at January 1938 prices to pay for the expenditure on fertilizers is as follows :—

cwt.		*Cwt. per acre*
2	Sulphate of ammonia ..	1.4
4	,, ,, ..	2.7
3	Superphosphate ..	1.1
6	,, ..	2.1
1¼	Muriate of potash ..	1.0
2½	,, ,, ..	1.9

So far as the experiments have at present gone the fertilizer results may be summarised as follows :—

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(1) Nitrogen is almost always profitable on the average to the extent of 4 cwt. sulphate of ammonia per acre except on rich silts and fens.

TABLE XIX

Effect of Nitrogenous Fertilizers on Different Soils
Increases (+) or Decreases (—) in Sugar (cwt. per acre)

Year	Sulphate of ammonia	Coarse sands	Fine sands	Light loams	Heavy loams	Clay loams	Fens
	cwt.						
1936	2	+8.3	+4.4	+4.0	+4.9	+7.0	+3.1
	4	+11.6	+5.9	+5.6	+9.2	+9.9	+0.8
1937	2	+6.1	+3.0	+2.9	+3.4	+4.7	+0.6
	4	+7.1	+4.3	+5.4	+4.5	+6.6	—2.6

It almost invariably reduces the sugar content but this loss is more than compensated by increased yield.

TABLE XX

Effect of Sulphate of Ammonia on Sugar Content

	Mean sugar percentage	Effect of sulphate of ammonia	
		2 cwt.	4 cwt.
1933 ..	16.2	—0.3	—
1934 ..	17.7	—0.2	—0.4
1935 ..	16.9	—0.2	—0.6
1936 ..	17.6	—0.1	—0.2
1937 ..	17.3	—0.1	—0.3

The effectiveness of nitrogen on the yield of sugar per acre (Table XVIII) falls off as the dressing increases from 2 cwt. sulphate of ammonia per acre to 4 cwt. On the tops, however, the effect of nitrogen is so marked that there is no sign of falling off even when 4 cwt. sulphate of ammonia is given.

TABLE XXI

Effect of Increasing Dressings of Sulphate of Ammonia on Tops (tons per acre).
Increase due to Sulphate of Ammonia

	No. of expts.	Mean yield	2 cwt.	4 cwt.
1934 ..	11	10.9	+1.2	+2.8
1935 ..	20	8.1	+1.3	+2.6
1936 ..	18	8.4	+1.8	+3.4
1937 ..	24	9.4	+1.5	+3.0

(2) Phosphate varies in its effect from centre to centre and from season to season. Table XXII shows that the smaller dose of 3 cwt. superphosphate per acre was profitable on the average of all centres in 1936 and 1937, while the double dose was profitable over all centres in 1936 only. The sugar content is practically unaffected by phosphate, but the rate of growth of the young plant seems to be benefited in many cases. Up to the present basic slag has been no better than superphosphate even on acid soils, rather the reverse. The

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effect of phosphate on tops is in the same direction as on roots but somewhat smaller.

TABLE XXII

Effect of Phosphatic Fertilizers on Different Soils
Increases (+) or Decreases (—) in Sugar (cwt. per acre)

Year	Superphosphate	Coarse sands	Fine sands	Light loams	Heavy loams	Clay loams	Fens
	cwt.						
1936	3	+2.3	+1.3	+3.0	+0.6	+2.5	+1.2
	6	+4.2	+2.7	+3.7	+1.2	+4.3	+0.2
1937	3	+1.2	+0.7	+2.6	+0.5	+0.5	+2.2
	6	+1.5	+1.4	+2.9	+2.3	+1.0	+1.0

(3) Potash had generally worked well on the lighter soils and on the fens: it had much less effect on the heavy loams and on the clays.

TABLE XXIII

Effect of Potassic Fertilizers on Different Soils
Increases (+) and Decreases (—) in Sugar (cwt. per acre)

Year	Muriate of potash	Coarse sands	Fine sands	Light loams	Heavy loams	Clay loams	Fens
	cwt.						
1936	1¼	+1.8	+2.6	+0.3	+0.2	0.0	+2.1
	2½	+3.8	+4.4	+1.5	−1.2	−1.4	+4.2
1937	1¼	+2.6	+1.7	+1.4	+1.8	+0.6	+1.0
	2½	+4.0	+3.4	+2.4	+0.7	+1.1	+3.2

It almost always improves the sugar content.

TABLE XXIV

Effect of Muriate of Potash on Sugar Content
Increase (+) or Decrease (—) Per cent.

	Mean sugar percentage	Muriate of potash cwt. 1¼	Muriate of potash cwt. 2½
1933 ..	16.2	+0.2	—
1934 ..	17.7	+0.2	+0.2
1935 ..	16.9	+0.2	+0.2
1936 ..	17.6	+0.1	+0.2
1937 ..	17.3	+0.1	+0.3

Potash also has the valuable property of bringing out the best value of nitrogenous manures; the joint action of nitrogen and potash has usually been greater than the sum of their separate effects.

TABLE XXV

Effect of Potash on the Action of Nitrogenous Manure. Sugar (cwt. per acre)
Increase due to 4 cwt. Sulphate of Ammonia

	No potash present	2½ cwt. muriate of potash present
1934	+2.0	+4.1
1935	+1.7	+3.7
1936	+6.9	+8.5
1937	+4.8	+6.5

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Potash also increases the tops, but to a less extent than the roots.

The effect of fertilizers on plant number per acre is somewhat variable but tends to be favourable: the magnitude of the effects, however, is usually small.

TABLE XXVI

Effect of Fertilizers on Plant Numbers

Increase, thousands per acre due to

Year	Mean thousands per acre	Sulphate of ammonia		Superphosphate		Muriate of potash	
		2 cwt.	4 cwt.	3 cwt.	6 cwt.	$1\frac{1}{4}$ cwt.	$2\frac{1}{2}$ cwt.
1933	22.8	+0.3	—	+0.5	—	+0.4	—
1934	27.4	+0.2	+0.4	0.0	+0.1	+0.2	+0.2
1935	29.7	+0.4	+0.3	+0.2	0.0	+0.2	+0.1
1936	25.9	+0.2	0.0	+0.4	+0.6	+0.1	+0.3
1937	28.3	+0.3	+0.3	+0.5	+0.3	+0.4	+0.7

No clear relationships have yet been found between fertilizers and the purity of the juice.

Methods of applying mineral manures to sugar beet. Experiments to compare several methods of applying mineral manures to sugar beet were carried out at five centres in **1936** and six centres in **1937**. The treatments consisted of no minerals, minerals ploughed in or broadcast during December or January, and minerals broadcast in spring, shortly before sowing. Though minerals increased the yields at ten of the eleven centres, none of the three methods of application proved consistently superior to the others. The only significant differences occurred in both years on a sandy loam soil at East Kirkby, where winter applications proved superior to the spring application.

TABLE XXVII

Effect of Time and Method of Applying Minerals

Sugar. Cwt. per acre

Centre	None	Minerals Pl/w	Minerals Br/w	Minerals Br/s	Mean of minerals	Pl/w minus Br/w	Standard error	Winter minus spring	Standard error
			1936 Experiments				±		±
Wragby	42.2	46.0	46.8	46.0	46.3	−0.8	0.993	+0.4	0.860
Scotter	45.0	46.3	45.9	46.2	46.1	+0.4	0.970	−0.1	0.840
Habrough ..	59.2	59.7	58.1	57.8	58.5	+1.6	2.02	+1.1	1.75
East Kirkby ..	25.4	34.4	37.4	33.7	35.2	−3.0*	1.25	+2.2*	1.08
Harper Adams ..	62.4	66.8	66.8[1]	68.6	67.4	0.0	1.37	−1.8	1.19
			1937 Experiments						
Rothamsted ..	42.8	43.7	47.4	48.1	46.4	−3.7	2.33	−2.5	2.02
Woburn	53.3	54.8	56.6	57.0	56.1	−1.8	1.65	−1.3	1.43
Wragby	44.6	50.3	49.6	49.0	49.6	+0.7	1.56	+1.0	1.35
Market Rasen ..	34.3	39.4	40.8	40.9	40.4	−1.4	1.48	−0.8	1.29
East Kirkby ..	38.7	48.7	48.8	45.0	47.5	−0.1	1.73	+3.8*	1.49
Blyborough ..	49.7	54.0	53.6	51.3	53.0	+0.4	2.06	+2.5	1.79

(1) Minerals harrowed in. * Significant difference.

Pl/w = Winter ploughed. Br/w = Winter broadcast. Br/s = Spring broadcast.

Minerals at all centres: superphosphate plus muriate of potash, except Rothamsted and Woburn: salt plus muriate of potash.

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The Fertilizer Effects of Salt

1. *Sugar beet.* Experiments on the manurial value of salt have been confined mainly to sugar beet : two, however, were made on celery and two on mangolds.

The results of 16 experiments in which salt was compared with muriate of potash are shown in Table XXVIII. In 10 of these experiments the comparison was made on an equivalent chloride basis, with dressings of salt varying from 1.0 to 2.5 cwt. per acre and of potash from 1.2 to 3.0 cwt. per acre. Salt proved consistently the more effective, the average response to 1 cwt. being 0.47 tons roots, while the corresponding dressing of 1.2 cwt. muriate of potash gave an average increase of 0.33 tons roots. Apart from this difference, the effects of the two minerals were generally similar ; where one gave a good response, the other did likewise.

TABLE XXVIII

Sugar Beet : Roots

Year	Place	Amount cwt. per acre: Salt	Amount cwt. per acre: Muriate of potash	Mean yield roots (tons)	Increase to salt	Increase to potash	Increase to combined dressing	S.E of increase
1929	Rothamsted	1.4	1.7	7.42	+0.28	+0.12	+0.26	±0.112
	Colchester	3.9	1.6	6.73	+0.95	+0.57	—	±0.362
1930	Rothamsted	1.4	1.7	7.44	+0.27	+0.23	+0.07	±0.182
	Woburn	1.0	1.2	9.27	+0.52	+0.17	—	±0.396
	Wye	1.6	2.0	13.04	+0.44	+0.71	+0.69	±0.194
	Northampton	1.8	2.0	11.31	+1.77	+1.68	+1.46	±0.683
1931	Wye	1.1	1.6	11.11	+0.13	−0.36	−0.06	±0.239
1932	Colchester	1.5	2.0	5.63	+0.53	+0.22	+0.58	—
1934	Rothamsted	1.3	1.5	15.36	+0.39	+0.74	+0.88	±0.379
	Lincoln	5.0	2.0	10.38	+0.11	−0.18	+0.89	±1.12
	Doncaster	2.5	3.0	8.21	+1.51	+0.95	—	±0.279
	Wood Norton	1.5	1.8	14.55	+1.19	+0.67	+1.62	±0.740
1935	Mattersey	5	3	5.80	+1.74	+0.88	+2.38	±0.359
1936	Rothamsted	5	1	14.84	+1.04	−0.18	+0.58	—
1937	Rothamsted	5	1	14.08	+1.46	+0.21	+1.38	—
	Woburn	5	1	16.06	+0.63	+1.11	+0.65	—

In five of the remaining six experiments in the table, the dressing of salt was 5 cwt. per acre, while that of muriate of potash varied from 1 to 3 cwt. To compare equivalent dressings of the minerals from these experiments might be unfavourable to salt, since large dressings of a fertilizer frequently prove less effective per unit of the fertilizer than small dressings. At Lincoln (1934) neither dressing was effective. Both minerals produced significant increases in roots at Mattersey (1935), salt being superior to potash even on an equivalent chloride basis. At Rothamsted (1936 and 1937) salt gave good responses, although muriate of potash had little or no effect. At Woburn (1937), on the other hand, 1 cwt. muriate of potash per acre increased the roots by 1.11 tons, while 5 cwt. salt produced an increase of only 0.63 tons. The dressings in the only remaining experiment (Colchester 1929) were 3.9 cwt. salt and 1.6 cwt. muriate of potash. Salt gave the larger response.

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The combined dressing was not in general so effective as the individual dressings. Where there was a clear response to minerals, the sum of the responses to the individual dressings of salt and muriate of potash was always greater than the response to the combined dressing.

The experiments do not provide sufficient material to determine whether salt is chiefly a light land fertilizer, because all the experiments except those at Rothamsted were on light or sandy soils. Salt, however, increased yields in all five experiments at Rothamsted. The contrast between the 1937 results at Rothamsted and at Woburn is striking, salt giving good increases at Rothamsted where muriate of potash had little effect, whereas with the same dressings at Woburn muriate of potash was the more effective.

Both salt and muriate of potash slightly, but fairly consistently, increased the sugar percentage. In the 10 experiments with small applications the equivalent dressings of the two minerals produced exactly the same average increase in sugar percentage, 0.21 for 1 cwt. salt or 1.2 cwt. muriate of potash. In the remaining experiments both minerals produced substantial increases in sugar percentage at Lincoln and Mattersey, but at other centres their effects were small.

The factory series of sugar beet experiments have shown that the addition of muriate of potash tends to increase the response to sulphate of ammonia. Little information has yet been obtained on the behaviour of salt in this respect. Three experiments contained salt and muriate of potash alone and in combination with a nitrogenous fertilizer. In no case, however, was the response to nitrogen appreciably affected by the presence of either salt or muriate of potash.

2. *Celery*. Experiments on celery were carried out at Mepal (Isle of Ely) in 1935 and 1936. In the first year there were significant increases in total produce of 0.43 tons per acre to 5 cwt. salt and of 0.89 tons per acre to 3 cwt. muriate of potash. Both minerals also produced a significant increase in the size of heads. The latter result is important commercially, the heads being graded by size when packed for market.

The effect of salt was strikingly different in 1936. Salt was applied in dry weather, six days before planting. No rain fell for some time afterwards. The salt decreased plant numbers by nearly 30 per cent. and yields of total produce by 16 per cent. Superphosphate visibly mitigated the salt damage, and to some extent this effect is also reflected in the yields of total produce. Under the same conditions muriate of potash produced a small but not significant increase in total yield and a significant increase in size of heads.

3. *Mangolds*. The effects of salt on mangolds are summarised on p. 43.

Mangolds

The classical experiments on Barnfield are made in the somewhat exceptional conditions of continuous growth of mangolds on the

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same land. Experiments under more normal conditions were made on Great Harpenden field in 1936 and on Great Knott field in 1937 in which two levels of each of five different fertilizers were tested in all combinations. The design of the experiment was such that each experiment involved only 32 plots, thus making efficient use of the land available.

The results in the two years agreed well, and accorded with those obtained on the Barnfield experiments.

The mean yields and average responses in roots are shown in Table XXIX

TABLE XXIX

	Mangolds roots : tons per acre 1936	1937
Mean yield	25.50	21.40
Response to :—		
Dung (10 tons)	+4.20	+2.04
Sulphate of ammonia (0.6 cwt. N) ..	+7.73	+4.95
Salt (5 cwt.)	+3.12	+4.92
Muriate of potash (1 cwt. K_2O)	+0.22	+0.74
Superphosphate (0.5 cwt. P_2O_5)	−0.45	+0.22
Standard error	±0.675	±0.686

There were good responses to nitrogen (dung and sulphate of ammonia) in both years, the responses being higher in 1936 than in 1937.

There was also a good response to 5 cwt. salt in both years, particularly in 1937, and this is the more remarkable in that in both years the average response to muriate of potash was small and not significant. Superphosphate had little if any effect.

The value of potash as a general rule is of course well established. Its effect in increasing the response to nitrogenous manure (sulphate of ammonia) was strikingly demonstrated in the continuous experiments on Barnfield. There are indications of this effect (and also of a similar effect of salt) in the present experiments, as Table XXX shows.

TABLE XXX

Roots : tons per acre

	Sulphate of ammonia	Mineral Manures: None	Potash	Salt	Potash and salt
1936	None	22.55	18.67	22.31	23.03
	0.6 cwt. N ..	26.56	28.00	30.16	32.76
	Increase	+4.01	+9.33	+7.85	+9.73
1937	None	16.99	18.51	20.64	19.56
	0.6 cwt. N ..	18.78	21.49	27.71	27.53
	Increase	+1.79	+2.98	+7.07	+7.97

In both years the addition of either muriate of potash or salt increased the response to sulphate of ammonia, while the highest

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response was obtained in presence of both potash and salt. In 1936 potash appeared the more effective in this respect, while in 1937 salt was more effective.

The average effects of the treatments on tops were similar to those on roots. The experiments also provide information on the question whether it is worth while applying artificials if dung is being used.

Response to	1936 Dung		1937 Dung	
	Absent	Present	Absent	Present
Sulphate of ammonia ..	+7.87	+7.59	+5.80	+4.11
Salt	+4.09	+2.16	+5.22	+4.61
Standard error	±0.955		±0.970	

Both sulphate of ammonia and salt gave substantial increases in the presence of dung, although the increases were somewhat less than those obtained in the absence of dung.

Experiments in conjunction with Mr. J. R. Bond at Oakerthorpe, Derby, in 1932, 1933 and 1934 tested the effects of dung, sulphate of ammonia and potash salt. The results are similar to those obtained at Rothamsted.

TABLE XXXI

	Mangolds roots : tons per acre 1932	1933	1934
Mean yield	31.20	20.58	19.56
Response to :—			
Dung (15 tons)	+8.13(1)	+4.21	+9.75
Sulphate of ammonia (0.6 cwt. N)	+8.76*	+1.42	+2.21
30% Potash Salt†	+5.63	+3.68	+6.82
Standard error	±0.354	±0.976	±0.856

* 1.2 cwt. N.
† 1932, 2.4 cwt. K_2O., 1933, 0.9 cwt. K_2O., 1934, 1.2 cwt. K_2O.
(1) S.E. = ±0.488.

There were large responses to dung and potash salt in all three years. The double dressing of ammonia gave a good response in 1932, while the single dressings in 1933 and 1934 were not so effective.

Responses to sulphate of ammonia

1932		1933		1934	
Potash salt		Potash salt		Potash salt	
Absent	Present	Absent	Present	Absent	Present
+7.27	+10.27	+1.81	+1.03	+0.98	+3.44
±0.498		±1.38		±1.21	

In 1932 and 1934 the presence of potash salt increased the response to sulphate of ammonia, agreeing in this respect with the Rothamsted experiments.

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	1932		1933		1934	
	Dung		Dung		Dung	
	Absent	Present	Absent	Present	Absent	Present
Response to : Sulphate of ammonia ..	+11.74[1]	+5.79[1]	+2.28	+0.56	+3.02	+1.39
Potash salt ..	+6.18[2]	+5.08[2]	+4.90	+2.44	+9.26	+4.38
	([1]) ±0.690 ([2]) ±0.498		±1.38		±0.856	

As in the Rothamsted experiments both sulphate of ammonia and potash salt produced increases in the presence of dung, while in the absence of dung larger (in some cases considerably larger) increases were obtained.

Potatoes

For the past thirteen years experiments on the manuring of potatoes have been made at Rothamsted and Woburn and on potato growing farms in different parts of the country : some of the recent results are collected in Table XXXII.

TABLE XXXII

Main Crop Potatoes. Summary of Experiments 1932-37[1]
Mean Yields and Mean Increases, Tons per Acre

	Yield without nitrogen	*Increase for* N_1	N_2	Yield without phosphate	*Increase for* P_1	P_2	Yield without potash	*Increase for* K_1	K_2
MINERAL SOILS									
No dung									
Light (1 expt.) ..	11.84	+0.60	+0.84	—	—	—	12.34	−0.08	+0.03
Medium (1 expt.)	12.25	+1.03	+1.91	12.42	+0.80	+1.63	12.87	+0.23	+0.85
Heavy (2 expts.) ..	10.61	+1.19	+1.47	—	—	—	11.59	−0.21	−0.08
With Dung									
Light (2 expts.) ..	7.16	−0.20	−0.17	—	—	—	6.98	−0.07	+0.24
Medium (2 expts.)	10.86	+1.32	+1.50	11.49	+0.60	+0.32	11.55	+0.53	+0.21
Heavy (1 expt.) ..	10.24	+2.34	+3.22	—	—	—	12.07	+0.16	−0.10
FENLAND SOILS									
No Dung									
Light (6 expts.) ..	7.01	+1.11	+1.53	6.96	+1.23	+1.56	6.16	+2.08	+2.67
Heavy (5 expts.) ..	10.11	+2.10	+3.13	9.92	+2.54	+3.26	11.00	+0.28	+0.46
With Dung									
Light (2 expts.) ..	8.08	+1.16	+1.17	8.43	+0.36	+0.93	8.09	+0.75	+1.55
Heavy (1 expt.) ..	12.73	+1.59	+2.56	13.60	+0.55	+0.99	13.49	+0.58	+1.29

[1] Dressings per acre :
$N_1 = 1\frac{1}{2}$ cwt. sulphate of ammonia (0.3 cwt. nitrogen).
$N_2 = 3$ cwt. sulphate of ammonia (0.6 cwt. nitrogen).
$P_1 = 4\frac{1}{2}$ cwt. superphosphate (0.75 cwt. P_2O_5).
$P_2 = 9$ cwt. superphosphate (1.5 cwt. P_2O_5).
$K_1 = 1\frac{1}{2}$ cwt. sulphate of potash (0.75 cwt. K_2O).
$K_2 = 3$ cwt. sulphate of potash (1.5 cwt. K_2O).

They show that one dose of the fertilizer usually gives a good result even when farmyard manure is also supplied but the double dose may not give a sufficiently greater increase to pay for the extra manure. Nitrogen (sulphate of ammonia) has given the most consistent increases both on mineral and on fenland soils, whether dung is added or not. Phosphate and potash have given marked increases on fenland soils, greater indeed than on the mineral soils.

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The results thus resemble those for sugar beet in that the effects of phosphatic and potassic manures vary considerably from soil to soil: attempts are being made in the Chemical Department to find some chemical method of ascertaining beforehand whether the soil is or is not likely to respond. This is well illustrated by the following pair of results obtained in our "3 x 3 x 3" experiments, one obtained on a light, the other on a heavy fen soil; both soils responded to nitrogenous fertilizer; the light soil responded to potash but not to phosphate while the heavy soil responded to phosphate but not to potash.

TABLE XXXIII

Effect of Phosphate

	Yields, tons per acre ±0.354 Heavy Soil (Little Downham, 1934) Marked response				*Yields, tons per acre* ±0.970 Light Soil (Thorney, 1934) No response			
Super-phosphate cwt. per acre	No sulphate of ammonia	Sulphate of ammonia		Mean ±0.204	No sulphate of ammonia	Sulphate of ammonia		Mean ±0.560
		1½ cwt.	3 cwt.			1½ cwt.	3 cwt.	
0	10.0	12.3	12.9	11.7	6.3	7.1	9.3	7.6
4½	13.8	15.8	16.8	15.5	5.5	8.4	9.1	7.7
9	14.8	16.7	18.4	16.6	8.6	7.3	8.9	8.2
Mean ±0.204	12.9	14.9	16.0	14.6				
Mean ±0.560					6.8	7.6	9.1	7.8

TABLE XXXIV

Effect of Potash

	Yields, tons per acre ±0.354 Heavy Soil (Little Downham, 1934) No response				*Yields, tons per acre* ±0.970 Light Soil (Thorney, 1934) Clear response			
Sulphate of potash, cwt. per acre	No Sulphate of ammonia	Sulphate of ammonia		Mean ±0.204	No Sulphate of ammonia	Sulphate of ammonia		Mean ±0.560
		1½ cwt.	3 cwt.			1½ cwt.	3 cwt.	
0	12.3	14.5	15.8	14.2	5.0	5.9	9.5	6.8
1½	13.2	15.4	16.0	14.8	7.9	8.2	8.4	8.1
3	13.1	15.0	16.4	14.8	7.5	8.8	9.5	8.6
Mean ±0.204	12.9	14.9	16.0	14.6				
Mean ±0.560					6.8	7.6	9.1	7.8

The contrast is shown perhaps more clearly in Table XXXV when all levels of nitrogen are grouped together so as to show only the potash and phosphate effects :—

TABLE XXXV

	Yields, tons per acre ±0.354 Heavy Soil (Little Downham, 1934) Phosphate response				*Yields, tons per acre* ±0.970 Light Soil (Thorney, 1934) Potash response			
Sulphate of potash, cwt. per acre	No Super-phosphate	Super-phosphate		Mean ±0.204	No Super-phosphate	Super-phosphate		Mean ±0.560
		4½ cwt.	9 cwt.			4½ cwt.	9 cwt.	
0	11.3	14.8	16.5	14.2	7.0	6.5	6.9	6.8
1½	12.1	16.0	16.4	14.8	8.0	8.1	8.2	8.1
3	11.8	15.6	17.1	14.8	7.8	8.4	9.6	8.6
Mean ±0.204	11.7	15.5	16.6	14.6				
Mean ±0.560					7.6	7.7	8.2	7.8

Interactions. It not infrequently happens that a fertilizer acts better in presence of another than when it is used alone. Occasionally the reinforcement is very pronounced as in the following experiments on potatoes at Thorney, Isle of Ely, in **1933** :—

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TABLE XXXVI

Mean yield, tons per acre	Addition given by sulphate of ammonia, tons per acre		Mean yield, tons per acre	Addition given by sulphate of ammonia, tons per acre	
	Used alone	With potassic fertilizer		Used alone	With phosphatic fertilizer
9.00	0.43	1.72	14.52	1.05	4.00
10.17	0.41	1.86	14.11	0.47	3.33

The figures in the upper line are in presence of farmyard manure: those in the lower line in absence of farmyard manure.

The total number of interactions of this kind obtained up to the present (1925-1937 inclusive) is shown in Table XXXVII.

TABLE XXXVII

	Nitrogen and potash interaction	Nitrogen and phosphate interaction	Phosphate and potash interaction
Total number of experiments	55	40	39
Positive interactions ..	35	29	27
No interaction or negative	20	11	12

Most of the interactions, however, are not statistically significant but all significant results are positive.

The proportion of ware. Mr. Garner has recently collected all the results relating to the percentage of ware and finds that fertilizers have a very marked effect in raising the proportion of ware in cases where the percentage without manure is low, but not where it is high.

TABLE XXXVIII

Percentage Ware

Mean Effects of Nutrients and Organic Manures Grouped according to Initial Percentage Ware

Initial percentage ware (no manure)	Increase due to						Total expts.
	N	P	K	Organic	Dung	NPK	
Over 90 ..	−0.4	−1.1	+0.6	−0.3	—	—	9
80 ..	+1.2	−1.1	+1.5	+0.7	—	—	34
70 ..	+2.6	+3.6	+8.7	−1.0	+5.5	+4.0	29
60 ..	+0.7	+6.8	+8.4	+2.8	+15.2	+4.4	29
50 ..	+16.8	+5.9	+15.8	—	+25.9	+22.4	9
Under 50 ..	—	—	+20.3	—	+34.2	—	3
Weighted mean	+2.0	+2.1	+7.6	+1.2	+15.3	+6.9	113

Kale

Marrow stem kale is one of the most useful of fodder crops and one of the best converters of cheap fertilizer nitrogen into valuable

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protein food for animals. Numerous experiments on the manuring of kale have been recorded in previous Reports : for convenience they are collected in Table XXXIX : they show that responses continue even up to 6 cwt. fertilizer per acre and whether dung is given or not. One of the experiments (Woburn 1932) shows that a dressing of 15 tons of dung had about the same effect as 2 cwt. sulphate of ammonia per acre.

TABLE XXXIX

Effect of Nitrogenous Fertilizers on Kale

Year	Yield, tons No nitrogen	Increase, tons per acre[1]						Standard error ±	Form of nitrogen
		1	2	3	4	5	6		
ROTHAMSTED									
1932	12.6		2.8					0.54	Sulphate of ammonia
1933	9.0					2.5([2])		0.39	Sulphate of ammonia
1936	11.3		1.5		2.4			0.65	Sulphate of ammonia
WOBURN									
1932	18.3		1.3					0.92	Sulphate of ammonia
1932	13.3	4.5	6.4		11.1			1.01	Sulphate of ammonia
1932	19.2	2.0	4.5		9.6			1.01	Sulphate of amm. (3).
1936	8.2		2.0		6.4			0.66	Sulphate of ammonia
MIDLAND COLL.									
1931	15.3	2.9	3.8		7.1			0.95	Nitrate of soda (3).
1932	22.8		1.6		3.8			0.81	Nitrochalk (3).
1933	27.5			5.4			8.5	1.10	Nitrochalk (3).
1934	30.7			2.4			4.5	1.32	Nitrochalk (3).
1935	33.4			1.3			4.0	1.15	Nitrochalk (3).
1936	30.1			2.8			6.7	1.54	Nitrochalk (3).
DERBY									
1935	8.2		4.0		7.9			0.67	Sulphate of ammonia
WINCHESTER									
1933	12.1		0.3		−1.6			0.64	Sulphate of ammonia

(1) The headings 1, 2, 3, etc., refer to the number of cwt. per acre of nitrogenous fertilizers supplied.
(2) Other plots received respectively 10 and 15 cwt. per acre sulphate of ammonia and gave increases over no nitrogen of 2.6 and 2.5 tons per acre.
(3) All plots received farmyard manure.

TABLE XL

Kale (*tons per acre*)

	No sulphate of ammonia	Sulphate of ammonia		
		1 cwt.	2 cwt.	4 cwt.
No dung	13.3	17.8	19.7	24.4
15 tons dung	19.2	21.2	23.7	28.7
Increase for sulphate of ammonia (no dung)	—	4.5	6.4	11.1
Further increase for 15 tons farmyard manure	—	3.4	4.0	4.3

No farmyard manure is given except where stated.

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Beans

Field beans have not formed the subject of many experiments and yet they have considerable value as fodder. During the past four years (1934-1937) several manuring experiments have been made, and in them were included comparisons of narrow and of wide spacing respectively.

The effects of the fertilizer treatments are shown in Table XLII : the summary is shown in Table XLI.

TABLE XLI

Beans grain (cwt. per acre)

Responses to treatments

Year	Dung (10 tons per acre)	Nitro-chalk (0.4 cwt. nitrogen per acre)	Muriate of potash (1 cwt. K_2O per acre)	Super-phosphate (0.6 cwt. P_2O_5 per acre)	Standard error	Mean yield
1934	+1.9(1)	+1.1	+0.5	—	±0.91	18.7
1935	+5.6(1)	+1.2	+2.7(1)	−2.0	±1.20	21.0
1936	−0.1	−2.2(1)	−0.3	+0.3	±0.61	16.8
1937	+2.0	+0.4	+2.4	+3.3(1)	±1.34	29.0

(1) Significant effect.

In 1936 the crop was weedy and the yields were poor—only 16 to 18 cwt. grain per acre. There were no treatment effects except a significant depression of yield on plots receiving nitrochalk, which may have been due to a stimulation of the weeds.

In each of the other years dung has given an increased yield, though only in 1935 was the effect large. Nitrochalk has had little effect in the other years, while potash gave increases in 1935 and 1937, and superphosphate increased the yield in 1937.

The results suggest that the bean crop is not very responsive to fertilizers. While farmyard manure has given increases there seems no reason to invoke any special action beyond what is due to the nutrients present.

The narrow spacing (16-18 ins.) proved superior to the wide spacing (24 ins.) in both years (1935 and 1937) in which it was tested, giving increases of 2.8 cwt. in 1935 and 7.7 cwt. in 1937. The mean yield on the 1936 spacing experiment was only 14.8 cwt. ; the yields with the three spacings were :

8 ins.	15.4 cwt.
16 ins.	14.8 cwt.
24 ins.	14.2 cwt.

small differences, but in the same direction as above.

The narrow spacing might have been supposed more responsive to manures than the wide, on account of extra demand for nutrients : the results, however, tend rather in the opposite direction. The responses in cwt. per acre to treatments at the two spacings were :

D

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Response to	1935 Spacing		1937 Spacing	
	18 ins.	24 ins.	16 ins.	24 ins.
Dung	+3.8	+7.4	+2.5	+1.4
Nitrochalk	0.0	+2.4	−0.4	+1.2
Potash	−0.4	+5.8	+1.8	+3.1
Superphosphate	−3.0	−0.9	+2.7	+3.8
Standard error	±1.69		±1.89	

The standard errors per cent. per plot ranged from 10.3 to 18.4. Beans have proved more variable than most farm crops in our experiments.

TABLE XLII

Effect of Various Manures on the Yield of Beans (cwt. per acre). Rothamsted 1934-1937

Year	Dung			Nitrochalk			Superphosphate		Muriate of potash			Drill width		Standard error
	No dung	D_1	D_2	No nitrogen	N_1	N_2	No phosphate	P_1	No potash	K_1	K_2	18ins.	24 ins.	±
Grain :														
1934	17.2	18.9	20.1	18.2	18.7	19.3	—	—	18.7	17.8	19.4	—	—	0.647
1935	18.2	23.8	—	20.4	—	21.6	22.0	20.0	19.6	—	22.4	22.4	19.6	0.845
1936	16.8	16.8	—	17.9	—	15.7	16.6	16.9	16.9	—	16.6	—	—	0.430
1937	28.0	30.0	—	28.8	—	29.2	27.4	30.7	27.8	—	30.2	32.9	25.2	0.947
Straw :														
1934	13.4	14.6	16.7	14.9	14.7	15.3	—	—	15.2	14.3	15.3	—	—	0.549
1935	21.4	31.2	—	25.1	—	27.5	25.4	27.2	24.9	—	27.7	28.6	24.0	0.892
1936	31.2	34.5	—	32.0	—	33.8	32.6	33.1	32.0	—	33.8	—	—	—
1937	29.4	32.0	—	30.5	—	30.9	29.5	31.9	29.4	—	32.1	34.2	27.2	—

$D_1 = 7\frac{1}{2}$ tons 1934, 10 tons 1935-1937. $N_1 = 0.4$ cwt. Nitrogen. $K_1 = 1.0$ cwt. K_2O. $P_1 = 0.6$ cwt. P_2O_5 per acre.
D_2, N_2, K_2, applications double D_1, N_1, K_1. Narrow drill 16 inch in 1937.

POSSIBLE NEW CROPS: SOYA BEANS AND MAIZE

In 1934 experiments on the possibility of finding varieties of maize and soya beans suited to this country were begun at Rothamsted and Woburn by Prof. W. Southworth, who had been very successful in similar work at the Manitoba Agricultural College.

Maize

Seed of Manitoba Flint and Manalta were obtained from the Manitoba Agricultural College where they originated and sown both at Rothamsted and Woburn in the spring of 1934. The season was hot and sunny. The seed ripened well and was saved for 1935. This season also was sufficiently good to allow of ripening and by this time it was clear that Manalta was in our conditions earlier than Manitoba Flint. The latter, therefore, was discarded.

1936 was cloudy and wet; during July and September, two important months for both maize and soya beans, there were no less than 152 hours less sunshine than the normal; seeding was, therefore, not good. 1937 was better and at Woburn we obtained a good crop of well ripened Manalta seed.

Meanwhile two varieties of sweet corn, Golden Bantam, from the Manitoba Agricultural College, and Dorinni from the Central Experiment Farm, Ottawa were grown at Rothamsted in 1935. The former proved less suitable and was, therefore, discarded. The two varieties had been grown side by side and cross pollination took