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Special Groups of Experiments

Rothamsted Research

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REPLICATED EXPERIMENTS ON MALTING BARLEY, 1927-1933.

Summary of Average Responses and Interactions

Grain : cwt. per acre

Place.	Year.	Mean Yield.	Average Responses.				1st order Interactions.				2nd order Interaction		
			N	St. Error for N	P	K	St. Error for P&K	N x P	N x K	K x P	Standard Error.	N x P x K	Standard Error.
Rothamsted	1927	16.6	+5.2	±1.21	+1.6	—	±1.21	+0.4	—	—	±2.42	—	—
Rothamsted	1928	16.6	+3.4	±0.84	+0.8	—	±0.84	+1.1	—	—	±1.68	—	—
Woburn	1928	18.2	+1.0	±1.45	-1.2	+2.2	±1.45	-4.1	-6.6	-3.8	±2.90	+7.2	±5.79
Woburn	1929	28.8	+1.2	±0.98	-1.4	+2.8	±0.98	-1.6	-6.0	-0.6	±1.96	-3.9	±3.92
Wellingore	1929	20.2	+3.3	±0.63	+0.7	+1.2	±0.63	+6.0	+1.4	-0.6	±1.26	+4.5	±2.52
Rothamsted	1929	22.9	+3.5	±1.08	+0.7	-0.5	±1.08	+0.8	-1.6	-1.4	±1.71	+4.0	±3.42
Wellingore	1930	14.7	+6.1	±0.71	+0.4	+0.5	±0.71	+1.5	+2.7	+1.4	±1.40	+1.6	±2.79
Sparsholt	1930	13.9	+1.5	±0.74	+1.4	+0.2	±0.74	-0.3	-1.2	+0.3	±1.12	+0.2	±2.25
Wellingore	1931	29.8	-0.3	±0.65	-0.6	+0.3	±0.65	-0.3	-1.0	+1.3	±1.75	-8.2	±3.50
Wye	1931	22.6	+3.6	±0.61	+0.9	+0.5	±0.61	+0.3	-1.9	-1.9	±0.92	+3.2	±1.85
Sparsholt	1931	17.2	+1.0	±0.62	+0.2	+0.6	±0.62	0.0	-1.0	-0.3	±0.86	+1.0	±1.72
Wellingore	1932	30.1	+1.8	±1.18	-1.5	0.0	±1.18	+2.3	+0.5	+0.3	±1.96	+2.0	±3.92
Wye	1932	28.7	+2.8	±1.64	+1.4	-3.0	±1.64	-2.6	+0.6	+0.2	±2.69	+3.5	±5.38
Sparsholt	1932	24.9	+3.8	±1.64	+0.6	-0.4	±1.64	-0.4	-0.9	+1.1	±2.77	+2.4	±5.54
Wellingore	1933	23.6	+3.2	±0.76	+1.8	—	±0.76	+0.5	—	—	±1.53	—	—
Wye	1933	26.4	+5.0	±1.46	+2.2	—	±1.46	+1.1	—	—	±2.92	—	—
Weighted Mean*	..	—	—	—	+0.64	+0.25	—	+0.28	-0.78	-0.29	—	+1.21	—
	..	—	—	±0.21	±0.22	—	±0.22	±0.42	±0.45	±0.45	—	±0.89	—
Unweighted Mean*	..	23.16	+2.91	—	+0.68	-0.20	—	+0.26	-0.42	+0.11	—	+1.08	—

* 1930-33 and Rothamsted 1929.

The responses to nitrogen are either those to sulphate of ammonia or the mean responses to sulphate of ammonia and nitrate of soda.

The dressings per acre in cwt. were as follows :

1927-28 and Wellingore 1929 : 0.2N, 0.486 P₂O₅, 0.75K₂O.

1930-33 and Rothamsted and Woburn 1929 : 0.2N, 0.4 P₂O₅, 0.6K₂O.

Other particulars are given in this and previous reports under the reports of the separate experiments.

CONCLUSIONS

Woburn differs significantly from the other centres in response to phosphate and potash and in the strong negative interaction between nitrogen and potash. The other first order interactions are also negative (though the differences are not significant).

Excluding Woburn and the early experiments having different levels of manuring, the remaining experiments show a significant response to nitrogen, significantly different for the different experiments (though showing no correlation with year or place). They also show a small but definitely significant general response to phosphate, not significantly different in the different experiments. The general response to potash and the interactions are not significant. The significant depression of yield with potash at Wye in 1932, therefore, and the significant interactions at Wellingore and Wye in 1931 appear to be due to chance and may be ignored.

An earlier series of single plot experiments was carried out in the years 1922-26. There were 51 experiments in which the yields were recorded, carried out at 18 centres. All experiments (with one or two minor exceptions) contained the treatments O, NPK, NP, NK, PK, the levels of manuring being the same as in the replicated experiments 1927-28. The experiments are reported in detail in (1). The mean responses were as follows :

	Grain cwt. per acre.*	Standard Error.†
To Complete Fertiliser (NPK—O)	+2.66	±0.385
To Nitrogen (NPK—PK)	+1.82	±0.424
To Phosphate (NPK—NK)	+0.19	±0.344
To Potash (NPK—NP)	-0.11	±0.316

* Dressed grain converted from bushels per acre.

† Computed from the variation in the response under consideration from experiment to experiment.

The average responses to nitrogen and the complete fertiliser are significant. There are indications of a significant variation in response to nitrogen and complete fertiliser from experiment to experiment. The difference in response between the complete fertiliser and the sum of its components does not approach significance (the standard errors shown are not appropriate for testing this difference).

¹ E. J. Russell and L. R. Bishop, "Investigations on Barley. Report on the Ten Years of Experiments under the Institute of Brewing Research scheme, 1922-1931." Supplement to the *Journal of the Institute of Brewing*, Vol. XXXIX., No. 7 (Vol. XXX., new series), 1933.

EXPERIMENTS ON POULTRY MANURE AND AMMONIUM BICARBONATE

Centres	Type of Expt.	No. of Plots
Rothamsted (See pp. 146-7 for details)	1a	48
Woburn (See pp. 154-5 for details)	1	24
Lady Manner's School, Bakewell (A)	2	16
Lady Manner's School, Bakewell (B)	2	16
Grammar School, Burford	2	16
Dartington Hall, Totnes, Devon (A)	1b	36
Dartington Hall, Totnes, Devon (B)	1b	36
Fakenham School, Norfolk	2	16
County School, Godalming, Surrey	2	16
Messrs. Spencer Thomas, Honeydon, Beds. J. W. Dallas, Esq., County Organiser	1	32
The High School, Newcastle, Staffs.	2	16
Sailors' Orphan Homes School, Newlands, Hull	2	16
Hertfordshire Farm Institute, Oaklands, St. Albans	1	32
T. H. Ream, Esq., Portobello Farm, nr. Potton	1	32
Church of England School, Staindrop, Co. Durham	2	16
The Horticultural College, Swanley (A)	2b	25
The Horticultural College, Swanley (B)	1	16
County School, Welshpool, Montgomeryshire (A)	2	16
County School, Welshpool, Montgomeryshire (B)	2	16
South-Eastern Agricultural College, Wye, Kent (A)	2a	16
South-Eastern Agricultural College, Wye, Kent (B)	1	32
Oundle School, Peterborough	2	16

Experimental Arrangements

- (1) All combinations of $\left\{ \begin{smallmatrix} O \\ P.M \end{smallmatrix} \right\} \times \left\{ \begin{smallmatrix} O \\ S/A \end{smallmatrix} \right\} \times \left\{ \begin{smallmatrix} O \\ Super. \end{smallmatrix} \right\}$
 Randomised blocks, second order interaction confounded.
- (1a) All combinations of $\left\{ \begin{smallmatrix} O \\ P.M \end{smallmatrix} \right\} \times \left\{ \begin{smallmatrix} O \\ \frac{1}{2}S/A \\ S/A \end{smallmatrix} \right\} \times \left\{ \begin{smallmatrix} O \\ Super. \end{smallmatrix} \right\}$
 Randomised blocks.
- (1b) All combinations of $\left\{ \begin{smallmatrix} O \\ Wet P.M \\ Dry P.M \end{smallmatrix} \right\} \times \left\{ \begin{smallmatrix} O \\ S/A \end{smallmatrix} \right\} \times \left\{ \begin{smallmatrix} O \\ Super. \end{smallmatrix} \right\}$
 Randomised blocks, one interaction degree of freedom confounded.
- (2) No N, S/A, B/A, P.M. }
 (2a) O, S/A, wet and dry P.M. } Latin Squares.
 (2b) O, $\frac{1}{2}$ S/A, S/A, P.M., Guano. }

Rates of Manuring

Sulphate of ammonia at the rate of 0.6 cwt. N except for Rothamsted (0.6 and 0.3 cwt. N), Dartington Hall (0.57 cwt. N), Oaklands (0.3 cwt. N), Potton (0.4 cwt. N), Swanley (A) (0.6 and 0.229 cwt. N). Superphosphate at the rate of approximately 0.5 cwt. P_2O_5 in types 1, 1a, 1b, except for Oaklands (0.25 cwt.), i.e., the equivalents of the P_2O_5 in the poultry manure. In types 2, 2a, 2b a basal dressing was given, at the rate of 0.6 cwt. P_2O_5 except for Oundle (0.64 cwt.), Swanley (2.0 cwt.) and Wye (0.44 cwt.).

Place.	Area Acres.	Soil.	Variety.	Manures Applied.	Seed Sown.	Harvested.	Previous Crop.	Basal Manuring (per acre).
Bakewell (A) ..	1/102	Limestone	Garton's yellow globe	April 10th	May 9th	Oct. 20th-27th	Potatoes	2½ cwt. Sulph. Pot. 4 cwt. Salt
Bakewell (B) ..	1/102	Limestone	Scotch King Edward	May 16th-19th	May 16th-19th	Sept. 20th	Swedes	2½ cwt. Sulph. Pot.
Burford ..	1/200	Brashy Loam	King George	April 28th	April 27th	Sept. 19th-21st	Perm. Grass	2½ cwt. Sulph. Pot.
Dartington Hall (A) ..	1/109	Shale loam	Roskoff	July 14th	July 14th	April 12th-30th	Seeds	Nil
Dartington Hall (B) ..	1/99	Shale loam	Marrow stem	May 16th	May 30th	Nov. 13th, 20th & 27th	Seeds	Nil
Fakenham ..	1/302	Sandy loam	Majestic	April 4th	April 5th	Oct. 10th	Potatoes	2½ cwt. Sulph. Pot.
Godalming ..	1/290	Sandy	Field Marshal	April 24th	April 24th	Sept. 1st	Potatoes	2½ cwt. Sulph. Pot.
Honeydon ..	1/50	Boulder clay	—	April 5th & July 5th & 17th	May 7th	Nov. 2nd	Brussel sprouts	Nil
Newcastle ..	1/455	Heavy	Majestic	April 8th	April 10th	March 16th	Waste land	2½ cwt. Sulph. Pot.
Newlands ..	1/223	Heavy alluvium	Arran banner	April 11th-12th	April 11th	Oct. 10th	Vegetables	2½ cwt. Sulph. Pot.
Oaklands ..	1/56	Gravel loam	King Edward	April 9th	April 11th	Sept. 27th	Silage	2 cwt. Sulph. Pot. 15 tons F.Y.M.
Oundle ..	1/60	Heavy loam	Garton's Incomparable	July 3rd	June 8th	Nov. 28th	Wheat	Nil
Petton ..	1/50	Poor light sand	—	April 27th	April 27th	Sept. 25th	Runner beans	2 cwt. Sulph. Pot.
Staindrop ..	1/162	Loam	Great Scott	May 18th	April 28th	Nov. 3rd	Potatoes	2½ cwt. Sulph. Pot.
Swanley (A) ..	1/90	Light calcareous loam	Boswells R L	July 27th	May 18th	Dec. 29th	Brussel sprouts	2 cwt. Sulph. Pot.
Swanley (B) ..	1/50	Gravelly over chalk	King Edward	April 10th	April 20th	Oct. 16th	Strawberries	10 tons dung 2 cwt. Sulph. Pot.
Welshpool (A) ..	1/200	Medium loam on Wenlock shale	Great Scott	April 9th	April 9th	Sept. 21st	Mangolds	2½ cwt. Sulph. Pot.
Welshpool (B) ..	1/160	Medium loam on Wenlock shale	Lord Derby	May 16th	May 20th	Nov. 8th	Potatoes	2½ cwt. Sulph. Pot.
Wye (A) ..	1/50	Silt loam	Golden Tankard	April 12th	April 22nd	Oct. 9th	Spring wheat	2 cwt. Mur. Pot.
Wye (B) ..	1/100	Loam	Ronsham park Hero	April 7th	April 12th	Sept. 5th	Cauliflowers	3 cwt. Sulph. Pot.

Yields of Separate Treatments. Type 1

Place.	Crop.	Sub-blocks A						Sub-blocks B				Mean.	Standard Error.
		None.	Sulph. Amm., Super.	Poul. Man., Super.	Poul. Man., Sulph. Amm.	Poul. Man.	Sulph. Amm.	Super.	Poul. Man., Sulph. Amm.				
Oaklands Swanley (B)	Potatoes : tons	5.16	4.86	4.93	5.00	5.07	4.88	5.28	5.13	5.04	±0.360		
	" "	8.94	8.74	8.36	8.52	8.15	9.32	8.19	7.72	8.49	±0.816		
Wye (B)	Onions : tons	7.16	6.42	8.09	7.79	7.64	7.76	7.50	8.77	7.64	±0.470		
Potton	Sprouts : cwt.*												
	1st harvesting	1.06	2.06	2.57	3.46	2.84	1.78	2.06	2.73	2.32			
	2nd "	4.69	5.47	4.02	5.02	5.69	3.68	4.35	4.35	4.66			
	3rd "	9.26	11.83	10.94	11.16	11.05	11.83	10.82	10.16	10.88			
	4th "	6.70	7.92	6.36	6.58	6.47	7.03	7.70	6.25	6.88			
	Total saleable	21.71	27.28	23.89	26.22	26.05	24.32	24.93	23.49	24.74	±2.03		
	Total weight including blown	26.78	35.44	30.69	34.82	32.09	31.53	30.24	30.92	31.56			
Honeydon	Sprouts : cwt.												
	1st harvesting	3.94	8.66	9.34	7.31	5.29	4.16	8.78	9.90	7.17			
	2nd "	10.13	15.98	18.12	14.52	12.38	10.02	12.04	14.74	13.49			
	3rd "	7.76	9.68	10.92	10.46	7.43	7.09	7.65	12.72	9.21			
	4th "	7.65	9.45	9.45	10.35	13.28	8.89	12.94	11.37	10.42			
	Total saleable	29.48	43.77	47.83	42.64	38.38	30.16	41.41	48.73	40.29	±1.54		
	Total weight including blown	35.22	52.55	56.27	50.87	44.90	37.59	49.40	57.84	48.08			

* Nitrate of soda used instead of sulphate of ammonia.

Average Effects and Interactions. Type 1

Place.	Crop.	Mean yield.	N	P	P.M.	St. Error.	N × P	N × PM	P × PM	St. Error.
Oaklands	Potatoes : tons per acre	5.04	-0.14	+0.02	-0.01	±0.254	+0.06	+0.42	-0.06	±0.509
Swanley (B)	" " " "	8.49	+0.16	-0.48	-0.61	±0.577	-0.42	-0.60	+0.37	±1.154
Wye (B)	Onions : tons per acre	7.64	+0.09	+0.11	+0.86	±0.332	-0.58	+0.66	+1.22	±0.664
Potton	Sprouts : Total saleable—									
	cwt. per acre	24.74	+1.18	+0.32	+0.35	±1.436	-0.42	-2.60	-5.54	±2.870
Honeydon	" " " "	40.29	+2.05	+10.27	+8.19	±1.089	-0.84	+1.06	-5.00	±2.178

Yields of Separate Treatments. Type 1b

Place.	Crop.	O	Sub-blocks A			Sub-blocks B			Mean.	Stan- dard Error.		
			Dry PM, P	Wet PM, P	Dry PM, N	Wet PM, N	Dry PM, N, P	Wet PM, N, P				
Dartington Hall (A)	Broccoli— Centres : tons per acre	1.50	1.97	1.35	1.68	1.26	1.42	1.69	1.21	1.53	1.56	±0.168
	Outsides : " "	7.04	8.29	6.46	7.93	6.75	6.78	7.74	6.34	7.36	7.28	±0.758
	No. of plants per acre	5813	5850	5268	5886	5741	5741	5922	5704	6104	5838	±230
	Change of yield with time*	+0.071	-0.011	+0.050	+0.042	+0.028	+0.025	-0.025	+0.006	+0.022	+0.022	±0.032
Dartington Hall (B)	Kale—tons per acre	21.31	23.75	21.03	26.60	23.74	20.94	25.12	21.44	26.31	24.04	±0.619

*Increase of centres in tons per week ; pickings on April 12, 16, 19, 25, 30.

Main Effects. Type 1b

Place.	Crop.	N	P	St. Error.	Dry PM	Wet PM	St. Error.
Dartington Hall (A)	Broccoli : Centres—tons per acre	+0.22	-0.03	±0.097	+0.16	-0.02	±0.119
" (B)	Kale—Tons per acre	+4.00	+0.02	±0.357	+1.80	+0.54	±0.438

Interactions. Type 1b

Place.	Crop	N × P	N × Dry PM	P × Dry PM	N × Wet PM	P × Wet PM	St. Error.
Dartington Hall (A)	Broccoli : Centres—tons per acre	*	-0.20	+0.34	-0.10	+0.06	±0.238
" (B)	Kale—Tons per acre	*	-1.13	-0.14	+1.86	-0.02	±0.876

*Partially confounded.

Comparison of Poultry Manure with Equivalent Artificials. Types 1, 1a and 1b

Place	Crop	No Manure	Poultry Manure	S/A and Super.	P.M.—(N + P)		
					Actual	Per cent. of yield	Per cent. of mean response
Oaklands	Potatoes : tons	5.21	5.02	4.91	+0.11	+2.2 ±8.8	—
Swanley	" " "	8.80	8.29	8.60	-0.31	-3.7 ±11.8	—
Wye	Onions : tons	7.44	7.36	6.70	+0.66	+8.7 ±7.4	—
Potton	Sprouts : Total saleable : cwt.	21.67	26.09	27.24	-1.15	-4.7 ±10.1	23.0
Honeydon	" " " "	28.85	39.01	43.14	-4.13	-10.3 ±4.7	33.8
Dartington Hall	Broccoli—Centres tons	1.39	1.37	1.54	-0.17	-10.9 ±13.2	—
" " "	Kale : tons	21.30	23.75	25.14	-1.39	-5.8 ±3.1	44.3
Rothamsted	Sprouts—Total saleable : cwt.	30.95	27.50	31.20	-3.70	-12.5 ±10.3	—
Woburn	" " "	33.76	40.63	42.94	-2.31	-5.7 ±8.1	28.8

In constructing this table the second order interactions are assumed to be negligible except at Rothamsted where there was no confounding.

Conclusions

Sulphate of ammonia and superphosphate give significantly greater yields on the average than poultry manure, there being no significant differences in response (considered as a percentage of mean yield) at the four stations where there was clear response to fertilisers.

Summary
Types 2, 2a and 2b

Place	Crop	No Nitrogen	$\frac{1}{2}$ Sulph. Amm.	Sulph. Amm.	Amm. Bicarb.	Poultry Manure	Mean	Standard Error
Godalming	Potatoes : tons per acre	7.83		10.15	9.45	9.44	9.22	0.323
Staindrop	" " " "	10.62		11.90	11.63	11.56	11.43	0.507
Welshpool (A)	" " " "	7.63		8.95	8.86	8.70	8.53	0.250
Burford	" " " "	6.81		7.25	6.67	7.59	7.08	0.155
Newcastle	" " " "	12.15		12.36	12.28	12.18	12.24	0.925
Fakenham	" " " "	8.61		9.27	9.32	9.50	9.17	0.304
Bakewell (B)	" " " "	6.65		8.29	7.77	7.70	7.60	0.287
Newlands	" " " "	11.57		12.09	11.67	12.23	11.89	0.633
<i>Mean of Potato Experiments</i>		8.98		10.03	9.71	9.86	9.64	0.172
Welshpool (B)	Swedes : Roots : tons per acre	8.50		10.32	10.64	9.68	9.78	0.612
	Tops : " "	2.39		3.43	3.64	4.09	3.39	0.263
Oundle	Swedes : Roots ,,	7.41		10.03	8.53	6.84	8.20	0.491
Bakewell (A)	Mangolds : Roots tons per acre	24.91		28.19	27.35	26.46	26.73	0.557
Wye (A)	" " " "	24.29		28.54	WetP.M. 23.62	26.27	25.68	0.542
Swanley (A)	Brussel Sprouts : cwt. per acre				Guano			
	1st and 2nd pickings*†	3.11	2.58	2.17	2.87	3.91	2.93	0.665
	Total of all pickings†	25.16	22.19	19.50	21.95	23.43	22.45	1.299
	Total of blown sprouts	8.88	7.38	7.90	9.06	9.34	8.51	

*First picking October 5th, second picking October 18th. After this eleven more pickings were made, but most of the individual pickings did not cover the whole experiment and are not worth considering separately.

†Saleable sprouts.

Conclusions

Most of the experiments show a significant response to nitrogen. The yields of potatoes with poultry manure and ammonium bicarbonate are less, but not significantly so, than with sulphate of ammonia. Swedes and mangolds give significantly smaller yields with poultry manure than with sulphate of ammonia; the difference with ammonium bicarbonate is not significant. Wet poultry manure at Wye produced no response. Sulphate of ammonia depressed the yields of sprouts at Swanley significantly whereas the depression with poultry manure was small and not significant, being significantly less than the depression with sulphate of ammonia; guano occupied an intermediate position.

SUGAR BEET FERTILISER EXPERIMENTS

FACTORY SERIES

Treatments : All combinations of sulphate of ammonia at the rate of 0.4 cwt. N, superphosphate at the rate of 0.4 cwt. P_2O_5 , and muriate of potash at the rate of 0.5 cwt. K_2O per acre.
 System of replication : 6 randomised blocks of 4 plots each (the second order interaction being confounded) at each of 14 centres.
 Area of each plot : 1/10 acre. (Ipswich : 0.0684. Newark : 0.0975. Felstead : 0.0485. Poppleton : 0.0905. Wissington : 0.0875. King's Lynn : 0.0981. Ely : 0.0833. Cantley : 0.0978.)
 Varieties : Ely and Peterborough, Kuhn P. ; King's Lynn, Marsters ; Poppleton, Dobrovic ; remainder, Kleinwanzleben E.
 Mechanical and chemical analyses of soil samples from each experiment have been carried out.

Factory	Soil	Previous Crop	Date of Sowing	Date of Harvesting	Farming notes
1. Balderton (Newark)	Sandy loam	—	—	—	Very acid, crop failed.
2. Ipswich	Sandy loam	Beet	April 25th	Oct. 16-23rd	Dung for 1932 beet, tops folded by sheep in autumn.
3. Colwick	Sandy loam	Oats	May 10th	Nov. 16-21st	10 cwt. lime per acre a few days before sowing.
4. Newark	Sandy loam	Wheat (dunged)	April 24th & May 1st	Nov. 2-6th	Not highly farmed recently.
5. Felstead	Heavy loam on clay.	Beet	May 5th	Nov. 1st	6 tons chalk per acre for beet.
6. Brigg	Sandy loam	Wheat	April 25th	Oct. 16-17th	Held out well against drought but not up to standard of district.
7. Poppleton	Sandy loam	Kale	April 28-29th	Sept. 30th- Oct. 3rd.	Poorish land very highly farmed. Previous crop kale sheeped with cake.
8. Bardney	Sandy loam	Barley	May 9th	Nov. 14-16th	Dunged in Dec., 1932, at 10 loads per acre. Wireworm damage.
9. Allscott	Sandy loam	Clover Hay	May 8th.	Nov. 9th.	Field naturally poor but highly farmed.
10. Wissington	Sandy loam	Barley	May 11th	Nov. 15-20th	Poor land well cultivated.
11. Peterboro'	Heavy fen	Peas (dunged)	May 12th	Dec. 1-14th	
12. King's Lynn	Fine sandy Loam	Early potatoes	April 14th	Oct. 20-21st	Rich soil, with fairly high water table. $\frac{1}{2}$ cwt. Nitrate of soda given in June.
13. Ely	Rich clay fen	Beet	April 11th	Nov. 25-28th	After 2 beet crops.
14. Cantley	Sandy loam	Potatoes	April 27th	Dec. 18-19th	5 tons waste lime in Jan., 1933. Poor soil very well farmed. Crop so damaged by wireworm that in June it was proposed by the grower to abandon the experiment as a failure. The soil is on a terrace which may receive water and nutrients by seepage from higher ground.

Plant Density (Mean Values)

Centre	Yield in tons per acre.	Plants in thousands per acre.	Distance in inches between rows	Weight of roots in lbs. per plant.	Increase in yield for one additional beet	S.E. per plot t.p.a. Adjusting for plant number	
						Before	After
3. Colwick	7.2	32	19½	0.5	—	±1.12	—
5. Felstead	9.1	22	23	0.9	1.918	±0.70	±0.62
6. Brigg	10.7	25	18	1.0	1.942	±0.93	±0.91
8. Bardney	12.3	19	21	1.4	-0.748	±1.73	±1.81
9. Allscott	12.4	22	20	1.3	-0.008	±0.68	±0.71
12. King's Lynn	14.4	37	18	0.9	—	±0.81	—
14. Cantley	16.4	25	17	1.5	1.850	±1.70	±1.50

Sampling errors in Sampling for Sugar Content

(10 Roots in Each Sample)

Centre	No. of samples analysed per plot	Standard Error Per Sample
4. Newark	2	0.37
6. Brigg	2	0.27
9. Allscott	2	0.52*
10. Wisington	4	0.36
13. Ely	4	0.48
14. Cantley	2	0.32

* Estimate of S.E. between plots is lower (but not significantly so) than 0.52 and probably 0.46 is the best estimate of sampling error.

Summary Tables

See following pages.

Conclusions

The responses of roots to sulphate of ammonia and potash are significantly different at the different centres, and there is a significant negative interaction between them, though this interaction does not differ significantly from centre to centre.

The sugar percentages are significantly decreased by sulphate of ammonia, and increased by potash, the variations in these effects from centre to centre not being significant.

The tops on those experiments where they were weighed show significantly different responses to sulphate of ammonia at the different centres, but show no potash effects.

The responses to superphosphate are not significant when considered as a whole, nor are there any significant interactions involving superphosphate.

It is difficult to offer any explanation of the complex significant effects on plant number at Allscott.

Yields of Individual Treatments

Centre.	Mean of all Treatments.		Sub-blocks A.					Sub-blocks B.					Standard Error	S.E. Per Plot	
	O	NP	NK	PK	N	P	K	NPK							
	Roots (washed) tons per acre :														
2. Ipswich	5.17	5.4	5.1	5.0	5.2	4.9	5.2	5.0	5.2	4.9	5.2	5.0	±0.25	±0.43	
3. Colwick	7.17	8.2	7.4	6.6	7.9	6.5	6.9	6.6	6.9	6.5	6.9	8.2	±0.65	±1.12	
4. Newark	8.29	8.7	9.0	9.6	7.9	8.0	7.2	9.6	7.9	8.0	7.2	7.7	±0.51	±0.88	
5. Felstead	9.09	8.8	9.3	9.5	9.0	8.9	9.1	9.5	9.0	8.9	9.1	9.5	±0.41	±0.70	
6. Brigg ..	10.74	11.3	12.9	10.5	11.9	9.2	9.3	10.4	11.9	9.2	9.3	10.4	±0.54	±0.93	
7. Poppleton	11.71	11.1	11.0	12.0	12.4	11.4	11.6	12.3	12.4	11.4	11.6	12.3	±0.53	±0.92	
8. Bardney	12.32	12.9	13.8	11.3	12.1	12.2	11.8	12.9	12.1	12.2	11.8	12.9	±1.00	±1.73	
9. Allscott	12.38	12.9	12.8	13.3	12.1	10.5	13.3	12.5	12.1	10.5	13.3	12.5	±0.39	±0.68	
10. Wissington	13.82	14.9	14.0	14.2	13.3	12.9	12.8	13.4	13.3	12.9	12.8	13.4	±0.40	±0.69	
11. Peterborough	14.06	14.4	14.3	15.2	14.2	13.8	13.9	12.8	14.2	13.8	13.9	12.8	±0.37	±0.63	
12. King's Lynn	14.36	14.3	13.8	14.1	14.9	14.6	14.6	13.7	14.9	14.6	14.6	13.7	±0.47	±0.81	
13. Ely ..	14.74	15.5	14.6	15.3	14.6	14.7	14.6	14.7	14.6	14.7	14.6	14.7	±0.52	±0.90	
14. Cantley	16.36	16.7	15.5	16.9	14.9	16.4	17.1	16.7	14.9	16.4	17.1	16.7	±0.98	±1.70	
Mean ..	11.53	11.92	11.78	11.78	11.55	11.06	11.32	11.50	11.55	11.06	11.32	11.50			
	Sugar Percentage														
2. Ipswich	15.92	15.0	15.9	16.4	15.6	16.0	16.6	15.5	15.6	16.0	16.6	15.5	±0.45	±0.78	
3. Colwick	15.10	14.8	15.0	15.0	15.2	15.2	15.7	15.2	15.2	15.2	15.7	15.2	±0.46	±0.79	
4. Newark	16.23	15.8	16.2	16.5	16.3	16.3	16.5	15.9	16.3	16.3	16.5	15.9	±0.17	±0.29	
5. Felstead	16.72	16.4	16.5	17.4	16.2	17.1	16.8	16.4	16.2	17.1	16.8	16.4	±0.18	±0.32	
6. Brigg ..	17.74	17.6	17.7	17.8	17.5	17.8	18.1	17.5	17.5	17.8	18.1	17.5	±0.14	±0.23	
7. Poppleton	17.94	17.7	18.3	18.1	17.6	18.0	18.1	17.8	17.6	18.0	18.1	17.8	±0.37	±0.64	
8. Bardney	16.15	16.0	16.1	16.3	15.4	16.5	16.7	15.9	15.4	16.5	16.7	15.9	±0.40	±0.70	
9. Allscott	15.93	15.8	16.2	17.0	15.5	15.8	16.2	15.8	15.5	15.8	16.2	15.8	±0.16	±0.28	
10. Wissington	16.40	16.2	16.5	17.0	15.7	16.7	16.6	16.0	15.7	16.7	16.6	16.0	±0.23	±0.41	
11. Peterborough	14.84	14.6	14.8	15.5	14.8	14.8	14.6	14.9	14.8	14.8	14.6	14.9	±0.31	±0.54	
12. King's Lynn	16.69	17.3	16.8	17.0	16.3	17.1	15.8	16.6	16.3	17.1	15.8	16.6	±0.42	±0.72	
13. Ely ..	15.89	15.8	15.9	15.7	15.9	16.2	15.9	15.8	15.9	16.2	15.9	15.8	±0.27	±0.46	
14. Cantley	15.70	15.3	15.7	15.8	15.3	16.0	15.7	15.8	15.3	16.0	15.7	15.8	±0.30	±0.52	
Mean ..	16.25	16.02	16.28	16.52	15.95	16.42	16.41	16.08	15.95	16.42	16.41	16.08			

Centre.	Mean of all Treatments	Sub-blocks A.					Sub-blocks B.					Standard Error.	S.E. Per Plot
		O	NP	NK	PK	N	P	K	NPK				
Plant Number : thousands per acre													
5. Felstead	22.4	20.9	21.9	22.7	23.0	21.9	23.9	21.5	23.8	±0.71	±1.22		
6. Brigg ..	24.7	23.5	25.2	24.3	24.9	24.3	25.6	24.2	25.6	±1.11	±1.92		
8. Bardney	18.8	17.1	19.0	19.2	19.1	19.0	19.2	18.9	19.0	±0.62	±1.07		
9. Allscott	22.4	20.3	25.4	22.1	20.5	21.8	21.4	26.7	21.4	±1.08	±1.88		
14. Cantley	25.4	25.8	25.7	25.4	24.8	24.9	-25.1	26.2	25.6	±0.63	±1.09		
Mean	22.77	21.53	23.44	22.74	22.46	22.37	23.05	23.51	23.08				
Tops : tons per acre													
4. Newark	6.05	6.3	6.4	6.7	6.7	5.9	5.4	4.7	6.2	±0.43	±0.74		
6. Brigg ..	6.56	5.1	7.8	8.2	5.7	8.2	5.3	5.1	7.0	±0.42	±0.73		
7. Poppleton	9.59	8.6	10.1	9.6	8.0	11.0	8.1	10.3	11.1	±0.87	±1.52		
9. Allscott	10.99	9.9	10.5	11.5	10.2	11.9	11.8	10.6	11.4	±1.08	±1.88		
13. Ely ..	21.96	21.4	22.6	21.1	23.6	21.3	21.1	22.0	22.7	±0.83	±1.44		
Mean	11.03	10.26	11.48	11.42	10.84	11.66	10.34	10.54	11.68				
Percentage Purity													
12. King's Lynn	90.4	90.3	90.6	89.8	90.8	90.0	90.7	90.3	90.5	±0.10	±0.18		

Mean responses and interactions

* 5 per cent Significance. ** 1 per cent. Significance.

Centre.	Mean Yield.	Mean response to			Standard Error.	Interactions			Standard Error.
		N	P	K		N × P	N × K	P × K	
Roots (washed) : tons per acre									
2. Ipswich	5.17	+0.02	-0.17	-0.15	±0.17	+0.44	-0.12	+0.06	±0.35
3. Colwick	7.17	+1.53**	+0.36	+0.21	±0.46	+0.28	-0.92	-0.30	±0.93
4. Newark	8.29	+0.10	+0.39	+0.20	±0.36	-1.28	-0.26	+0.24	±0.72
5. Felstead	9.09	+0.17	+0.26	+0.56	±0.29	-0.44	-0.16	+0.18	±0.58
6. Brigg	10.74	+1.76**	-0.74	+0.10	±0.38	-1.65	-0.06	+0.19	±0.76
7. Poppleton	11.71	+0.02	-0.02	+0.04	±0.38	-0.04	-0.27	+1.66*	±0.75
8. Bardney	12.32	+1.26	+0.01	+0.30	±0.71	-0.14	+1.10	-1.48	±1.42
9. Allscott	12.38	+0.38	-0.16	+1.16**	±0.28	+0.84	-2.08**	0.00	±0.55
10. Wisington	13.82	+0.20	+0.08	-0.39	±0.28	+0.82	+0.09	+0.61	±0.56
11. Peterborough	14.06	-0.29	-0.33	-0.03	±0.26	-1.26*	-1.44*	-0.10	±0.52
12. King's Lynn	14.36	-0.39	-0.33	-0.65	±0.33	+0.06	-0.38	+0.16	±0.66
13. Ely	14.74	+0.24	+0.63	+0.12	±0.36	-0.21	-1.00	-0.53	±0.73
14. Cantley	16.36	-0.83	+0.62	+0.36	±0.69	+1.70	-0.08	-0.26	±1.38
Mean	11.53	+0.32	+0.07	+0.14		-0.07	-0.43	+0.03	
Sugar Percentage									
2. Ipswich	15.92	-0.84*	-0.38	+0.34	±0.320	-0.20	+0.10	+0.14	±0.640
3. Colwick	15.10	-0.13	-0.12	+0.22	±0.322	+0.10	-0.30	-0.26	±0.643
4. Newark	16.23	-0.38**	-0.22	+0.12	±0.119	-0.32	-0.15	+0.14	±0.238
5. Felstead	16.72	-0.66**	+0.22	+0.14	±0.129	-0.35	+0.02	-0.01	±0.258
6. Brigg	17.74	-0.36**	-0.14	+0.09	±0.096	+0.18	-0.01	-0.17	±0.191
7. Poppleton	17.94	-0.15	-0.05	+0.25	±0.263	-0.24	+0.24	-0.30	±0.526
8. Bardney	16.15	-0.62*	+0.01	+0.21	±0.286	+0.32	+0.18	-0.68	±0.573
9. Allscott	15.93	-0.19	+0.02	+0.39**	±0.113	-0.08	-0.08	-0.28	±0.226
10. Wisington	16.40	-0.62**	+0.12	+0.24	±0.166	-0.23	+0.22	-0.33	±0.331
11. Peterborough	14.84	-0.15	+0.22	+0.20	±0.222	-0.53	-0.16	+0.63	±0.444
12. King's Lynn	16.69	+0.14	+0.63*	-0.24	±0.294	-0.48	+0.32	-0.32	±0.587
13. Ely	15.89	-0.07	-0.04	-0.13	±0.189	-0.14	+0.14	-0.26	±0.378
14. Cantley	15.70	-0.33	+0.07	+0.14	±0.212	-0.06	+0.68	+0.14	±0.424
Mean	16.25	-0.34	+0.03	+0.15		-0.16	+0.09	-0.12	

Centre	Mean Yield	Mean response to			Standard Error.	Interactions			Standard Error.
		N	P	K		N × P	N × K	P × K	
Total Sugar : cwt. per acre									
2. Ipswich	16.46	-0.80	-0.94	-0.12	+1.20	-0.28	+0.34		
3. Colwick	21.66	+4.44	+0.92	+0.94	-4.68	-3.20	-1.28		
4. Newark	26.90	-0.30	+0.90	+0.84	-2.02	-1.10	+1.00		
5. Felstead	29.46	-0.62	+1.22	+2.06	-5.46	-0.50	+0.56		
6. Brigg ..	38.10	+5.48	-2.92	+0.54	-0.70	-0.24	+0.30		
7. Poppleton	42.02	-0.28	-0.18	+0.72	+0.34	-0.40	+5.26		
8. Bardney	39.80	+2.54	+0.06	+1.48	+2.48	+4.00	-6.46		
9. Allscott	39.44	+0.74	-0.46	+4.66	+2.06	-6.82	-0.70		
10. Wissington	45.32	-1.06	+0.60	-0.62	+5.24	+0.90	+1.08		
11. Peterborough	41.72	-1.28	+0.52	+0.48	-1.18	-4.72	+1.48		
12. King's Lynn	47.94	-0.90	+0.70	-2.86	-1.08	-0.34	-0.38		
13. Ely ..	46.84	+0.56	+1.88	0.00	+5.14	-2.76	-2.44		
14. Cantley	51.36	-3.68	+2.18	+1.58	-0.63	+1.98	-0.36		
Mean ..	37.46	+0.37	+0.34	+0.75	-0.63	-1.04	-0.12		
Plant Number : thousands per acre									
5. Felstead	22.45	+0.25	+1.40*	+0.60	+1.70	+1.50	-0.20		±1.00
6. Brigg ..	24.70	+0.30	+1.25	+0.13	-0.22	+0.22	-0.42		±1.57
8. Bardney	18.81	+0.48	+0.52	+0.48	-1.25	-0.75	-1.05		±0.87
9. Allscott	22.45	+0.45	-0.55	+0.45	+4.00*	-4.60*	-5.80**		±1.53
14. Cantley	25.44	-0.08	-0.28	-0.12	+1.55	+0.15	-0.65		±0.89
Mean ..	22.77	+0.28	+0.47	+0.36	+0.48	-0.70	-1.62		
Tops : tons per acre									
4. Newark	6.05	+0.51	+0.28	+0.05	-0.58	+0.46	+0.92		±0.61
6. Brigg ..	6.56	+2.51**	-0.20	-0.10	-1.21	-0.57	-0.18		±0.60
7. Poppleton	9.59	+1.76*	-0.55	+0.28	+1.70	-1.04	+0.28		±1.24
9. Allscott	10.99	+0.70	-0.03	-0.11	-1.44	+0.66	-0.50		±1.53
13. Ely ..	21.96	-0.10	+1.03	+0.78	+0.85	-1.59	+1.09		±1.18
Mean ..	11.03	+1.08	+0.11	+0.18	-0.14	-0.42	+0.32		
Percentage Purity.									
12. King's Lynn ..	90.40	-0.32**	+0.56**	-0.06	+0.17	-0.21	+0.04		±0.15