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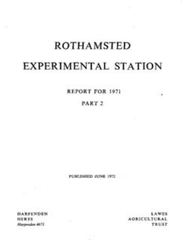

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Long-term Effects of Fertilisers at Broom's Barn, 1965–70

A. P. DRAYCOTT, M. J. DURRANT and D. J. WEBB

Introduction

The fertiliser dressings recommended as being most profitable for sugar beet are based on conclusions from many experiments done on commercial farms since 1930 by the staff of Rothamsted and Broom's Barn Experimental Stations, in co-operation with the British Sugar Corporation. Although there is no reason to doubt that the recommendations are well founded, they can be adversely criticised inasmuch as they are based on results of annual experiments. Perhaps partly for this reason many growers use more fertiliser than recommended, believing that what is not used will increase soil fertility and eventually increase yield.

The experiment explored the value of doubling the amounts of fertiliser nitrogen, phosphorus and potassium recommended for Broom's Barn soil for each crop in a three-course rotation of sugar beet, winter wheat and barley. The other objects were to obtain information about the ability of the soil to release plant nutrients, to measure the value of farmyard manure and the effect of using sodium chloride.

Field details

Soil. The experiment was on a local variant of the Ashley Series (Hodge & Seale, 1966) formed from glacial drift overlying chalk at variable depth. The plough layer is a grey-brown sandy loam with coarse sand overlying sandy clay and chalk at 150–200 cm. Table 1 shows some chemical characteristics of samples of the plough layer (0–25 cm) before the experiment began. Phosphorus fertiliser was not expected to increase yield as the soil contained 40 ppm $NaHCO_3$-soluble P but the small potassium concentration (65 ppm exchangeable K) indicated a probable response to potassium (and sodium) fertiliser by sugar beet.

TABLE 1

Analysis of soil samples (0–25 cm) taken before the experiment (October 1964)

(For methods of analysis, see text)

	pH	Nitrogen (%)	Bicarbonate-soluble phosphorus (ppm)	Organic carbon (%)
Mean	7·0	0·102	40	0·91
Range	6·7–7·2	0·090–0·113	34–48	0·84–1·04

	Exchangeable			
	Potassium (ppm)	Sodium (ppm)	Calcium (ppm)	Magnesium (ppm)
Mean	65	30	1780	36
Range	60–75	25–33·5	1400–2450	35–40

Crops. All the plots were in a three-course rotation of sugar beet (var. Sharpe's Klein 'E'), winter wheat (var. Cappelle Desprez) and barley (var. Impala). Table 2 shows the amounts of fertiliser applied and the 18 treatment combinations tested. Two replicates of each crop were grown every year. The same fertiliser treatment combination was

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applied to each plot every year. The residual herbicide 'Pyramin' was band-sprayed at 2·8 kg/ha to control weeds in the sugar beet, which was also sprayed with 13·5 kg/ha 'Solubor' to prevent boron deficiency and with 1680 ml/ha 'Metasystox R' to kill aphids. Herbicides used in the cereal crops were either 'Cambilene' (5·6 litres/ha) or 'Actril C' (8·4 litres/ha).

Harvesting procedure and plant sampling. Each year an area four rows (51 cm apart) by 12·45 m of sugar beet was harvested by hand. Roots from each plot were counted, the tops weighed in the field, and the roots were washed and weighed in the laboratory. Samples of the brei were shaken with lead acetate solution to extract sugar, potassium, sodium and α-amino nitrogen; others were used to estimate purity of the juice or to measure the dry matter and nutrient content of the roots. About 10 kg tops were selected at random, subsampled to measure dry matter and nutrient contents. The remaining tops were distributed evenly over the plot and ploughed in. Fresh yields of the cereal crops were measured by weighing the produce from an area 3·05 $\times$ 13·28 m combine harvested. Both grain and straw were removed from the plot. Dry matter percentage was determined by drying a subsample of plant material at 85°C for at least 14 hours.

Soil sampling. During the spring before applying inorganic fertilisers (but after applying FYM), soil samples 0–25 cm deep were taken from plots to be cropped with sugar beet. These were air-dried, ground to pass a 2 mm round-hole sieve and stored until analysed in 1970/71.

Chemical analysis

Plant samples. After drying at 105°C for at least 4 hours, a subsample was ashed at 450°C and phosphorus and cations extracted with dilute hydrochloric acid. This solution was analysed for phosphorus colorimetrically, potassium by flame emission and for sodium, calcium and magnesium by atomic absorption. Total nitrogen was measured in another subsample, using a micro Kjeldahl technique with a Cu/Se catalyst.

Soil samples. pH was measured in a 1 : $2\frac{1}{2}$ w/v of soil : water suspension. Phosphorus was extracted by shaking 1 g soil with 20 ml 0·5*M* sodium bicarbonate solution and determined colorimetrically (Olsen *et al.*, 1954). Potassium, sodium, calcium and magnesium were extracted by shaking 2 g soil with 40 ml normal ammonium nitrate solution and measured as already described. Soil nitrogen was measured using a micro Kjeldahl technique and organic carbon by refluxing soil with potassium dichromate/sulphuric acid and titrating the excess dichromate with ferrous ammonium sulphate solution (Tinsley, 1950).

Yields

Yields of crops from four treatments are dealt with first: $N_0P_0K_0Na_0$—which illustrates the effect of no fertiliser (F_0); $N_1P_1K_1Na_1$—found to be enough for maximum yield in many annual experiments on commercial farms (F_1); $N_2P_2K_2Na_1$—enough to leave large nutrient residues (F_2) and $N_2P_2K_2Na_1$ plus FYM (F_2 + FYM). The amounts of fertiliser used are shown in Table 2. Yields of the three crops each year are in *Rothamsted Reports for 1965–70*, pp. 279, 293, 287, 293, 334 and 270 respectively.

Mean yields, 1965–70. Table 3 gives the effect of the four fertiliser treatments on the mean yield of sugar beet, winter wheat and barley. Compared with F_0, F_1 significantly increased the yield of all crops. Giving F_2 further increased sugar and barley yields but

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had no effect on wheat yield. When F_2 + FYM was used, only sugar beet responded to the FYM.

TABLE 2

Amounts of each element tested

Crop	N_1 (kg/ha)	N_2 (kg/ha)	P_1 (kg/ha)	P_2 (kg/ha)	K_1 (kg/ha)	K_2 (kg/ha)	Na_1 (kg/ha)	FYM (t/ha)
Sugar beet	100	200	22	44	83	167	148	30
Winter wheat	75	150	22	44	42	83	0	0
Barley	50	100	22	44	42	83	0	0

(Plots also received 5 t/ha lime in November 1967)

Fertiliser treatments

N	P	K	Na	N	P	K	Na	N	P	K	Na
0	0	0	0	0	1	1	0	1	1	0	1
1	0	0	0	1	1	1	0	1	1	1	1
0	1	0	0	2	1	1	0	2	2	2	1
0	0	1	0	1	2	1	0	0	0	0	0 + FYM
1	1	0	0	1	1	2	0	1	1	1	1 + FYM
1	0	1	0	2	2	2	0	2	2	2	1 + FYM

(Sodium and FYM applied for sugar beet only)

TABLE 3

Effect of four fertiliser treatments on crop yield, 1965–70

	1965	1966	1967	1968	1969	1970	Mean
Sugar beet				Sugar (t/ha)			
F_0	5·54	6·14	6·98	4·61	5·01	4·63	5·50
F_1–F_0	+2·14	+2·57	+1·42	+2·06	+1·48	+1·79	+1·90
F_2–F_1	+0·56	−0·64	−0·38	+0·83	+0·46	+0·58	+0·23
(F_2 + FYM)–F_2	−0·28	+0·62	+0·18	+0·06	+0·68	+0·76	+0·34
s.e.	±0·339	±0·306	±0·350	±0·309	±0·323	±0·404	±0·178
Winter wheat				Grain at 85% DM (t/ha)			
F_0	2·42	3·84	3·35	2·10	3·05	2·67	2·91
F_1–F_0	+1·33	+0·18	+1·82	+0·97	+1·56	+0·64	+1·08
F_2–F_1	−1·33	+0·87	−0·21	+0·04	−0·28	−0·54	−0·24
(F_2 + FYM)–F_2	+0·20	−0·13	−0·22	−0·31	−0·04	+0·12	−0·06
s.e.	±0·380	±0·271	±0·153	±0·220	±0·163	±0·168	±0·141
				Straw at 85% DM (t/ha)			
F_0	4·32	5·61	4·09	3·41	3·75	2·67	3·98
F_1–F_0	+2·60	+1·84	+2·95	+1·64	+2·45	+1·33	+2·13
F_2–F_1	−0·81	−0·33	+0·03	+0·59	+0·23	−0·32	−0·10
(F_2 + FYM)–F_2	+0·18	+0·35	+0·42	−0·22	+0·45	+0·40	+0·27
s.e.	±0·589	±0·601	±0·270	±0·230	±0·253	±0·267	±0·211
Barley				Grain at 85% DM (t/ha)			
F_0	2·13	3·95	1·81	2·07	2·80	1·82	2·43
F_1–F_0	+1·67	+0·23	+2·32	+1·00	+1·58	+1·03	+1·31
F_2–F_1	+1·11	+0·68	+0·20	+0·10	−0·39	+0·43	+0·35
(F_2 + FYM)–F_2	−0·25	+0·15	−0·23	+0·29	−0·04	+0·02	−0·01
s.e.	±0·285	±0·264	±0·235	±0·266	±0·181	±0·198	±0·129
				Straw at 85% DM (t/ha)			
F_0	3·18	1·42	1·78	2·13	2·18	1·10	1·97
F_1–F_0	+1·24	+1·42	+2·12	+1·35	+2·07	+0·91	+1·52
F_2–F_1	+0·96	+0·99	+1·07	+0·79	+0·83	+0·60	+0·86
(F_2 + FYM)–F_2	−0·49	+0·37	+0·01	+0·19	+0·24	+0·13	+0·08
s.e.	±0·322	±0·398	±0·187	±0·301	±0·222	±0·183	±0·115

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Yields each year. Table 3 gives the yield of sugar beet each year. Neither F_2 nor $F_2 + FYM$ produced significantly more yield than F_1 during the first three years. In the fourth and later years, the increase in yield from F_2 although not significant was consistent; the increase from $F_2 + FYM$ compared with F_1 was significant and became progressively larger. Sugar yields generally decreased between 1967 and 1970 because of seasonal effects but decreased least with $F_2 + FYM$.

Table 3 gives the yield of winter wheat each year. In contrast to sugar beet, more fertiliser than F_1 (with or without FYM) was not justified even after five years' cropping. The difference in straw yield between F_0 and the other three treatments was similar each year. All grain and straw yields were small in 1970 when prolonged drought caused the crop to ripen early.

Table 3 gives the yields of barley each year. Although F_2 was clearly needed in 1965 and 1966 to give maximum grain yields, increases over F_1 were small in the other four years. For maximum straw yields F_2 was needed every year. FYM given to beet slightly increased straw yields between 1968 and 1970.

Response to individual elements

Yields from other fertiliser treatments included in the experiment indicate possible reasons for the response to the double dressing (F_2) compared with the recommended dressing (F_1).

Sugar beet. Table 4 shows the effect of three amounts of each element and of FYM on sugar yield each year. N_1 sufficed for maximum yield every year and there was no indication that giving more benefited the crop in the later years. Phosphorus never gave a significant increase in yield. In contrast, potassium given without sodium consistently increased sugar yield, especially in 1969 and 1970. However, when sodium was given

TABLE 4

Effect of individual nutrients on sugar yield, 1965–70

	1965	1966	1967	1968	1969	1970	Mean
				Sugar (t/ha)			
Nitrogen (P_1K_1 given)							
N_0	5·69	6·63	7·18	5·13	5·79	5·90	6·059
N_1–N_0	+2·11	+0·94	−0·14	+1·16	+1·03	+0·04	+0·86
N_2–N_1	−0·69	−0·58	+0·35	−0·03	−0·33	+0·37	−0·15
Phosphorus (N_1K_1 given)							
P_0	7·76	7·61	7·55	6·39	6·60	5·55	6·91
P_1–P_0	+0·04	+0·04	−0·51	−0·10	+0·22	+0·39	+0·01
P_2–P_1	+0·05	−0·50	+0·29	+0·24	−0·59	+0·13	−0·06
Potassium ($N_1P_1Na_0$ given)							
K_0	7·26	6·21	6·53	5·36	5·13	4·95	5·94
K_1–K_0	+0·54	+1·36	+0·51	+0·96	+1·69	+0·99	+1·00
K_2–K_1	−0·40	+0·29	+0·23	−0·22	+0·27	+1·02	+0·29
Potassium ($N_1P_1Na_1$ given)							
K_0	8·36	7·96	7·71	6·34	7·05	6·57	7·53
K_1–K_0	−0·68	+0·75	+0·69	+0·43	−0·56	−0·15	+0·07
(F_0 + FYM)–F_0	+1·79	+1·07	0	+1·93	+0·99	+1·49	+1·20
(F_1 + FYM)–F_1	+0·58	+0·35	0	+1·08	+1·02	+1·75	+0·79
(F_2 + FYM)–F_2	−0·28	+0·62	+0·18	+0·06	+0·68	+0·76	+0·34
s.e.	±0·339	±0·306	±0·350	±0·309	±0·323	±0·404	±0·178

Sugar yields for F_0, F_1 and F_2 are given in Table 3.

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(as in F_1) there was little response to even the small dressing of potassium. It is not clear why F_2 consistently increased yield more than F_1. As the experiment did not include factorial combinations of the double dressing of each element, the contribution of an interaction to the increase in yield from F_2 compared with F_1 could not be determined.

Wheat and barley. Table 5 shows that the double dressing of nitrogen, phosphorus or potassium never gave more yield of wheat grain than the recommended dressing, confirming that F_1 was enough. However, yield of barley grain was greatest with the double dressing of nitrogen every year but the recommended dressing of phosphorus and potassium was sufficient. Probably the barley yielded more from F_2 than from F_1 simply because F_1 supplied too little nitrogen.

TABLE 5

Effect of individual nutrients on grain yield, 1965–70

	1965	1966	1967	1968	1969	1970	Mean
Winter wheat			Grain at 85% DM (t/ha)				
Nitrogen (P_1K_1 given)							
N_0	2·66	3·45	4·44	1·91	2·87	2·80	3·02
N_1–N_0	+1·31	+1·56	+1·22	+1·79	+1·40	+0·35	+1·27
N_2–N_1	−1·26	+0·11	−0·51	−0·60	−0·03	−0·36	−0·44
Phosphorus (N_1K_1 given)							
P_0	3·07	4·68	5·40	2·95	4·39	3·06	3·93
P_1–P_0	+0·90	+0·33	+0·26	+0·75	−0·12	−0·09	+0·36
P_2–P_1	+0·11	−0·52	+0·04	−0·22	+0·16	+0·05	−0·06
Potassium (N_1P_1 given)							
K_0	3·97	5·02	5·75	3·12	4·32	2·97	4·19
K_1–K_0	0	−0·01	−0·0	+0·58	−0·05	+0·18	+0·10
K_2–K_1	−0·81	−0·43	−0·36	−0·60	+0·17	−0·51	−0·40
s.e.	±0·380	±0·271	±0·153	±0·220	±0·163	±0·168	±0·141
Barley							
Nitrogen (P_1K_1 given)							
N_0	3·16	3·63	2·41	2·38	3·01	2·27	2·81
N_1–N_0	+0·88	+1·06	+1·14	+1·20	+1·46	+0·40	+1·02
N_2–N_1	+0·78	+0·14	+0·70	+0·70	+0·27	+0·35	+0·49
Phosphorus (N_1K_1 given)							
P_0	3·91	4·49	3·79	3·31	4·17	2·56	3·70
P_1–P_0	+0·13	+0·20	−0·24	+0·27	+0·30	+0·11	+0·13
P_2–P_1	+0·35	−0·35	+0·47	+0·03	−0·01	+0·30	+0·13
Potassium (N_1P_1 given)							
K_0	4·04	4·46	3·75	3·73	4·37	2·67	3·84
K_1–K_0	0	+0·23	−0·20	−0·15	+0·10	0	0
K_2–K_1	−0·33	−0·25	+0·40	−0·15	−0·14	+0·10	−0·06
s.e.	±0·285	±0·264	±0·235	±0·266	±0·181	±0·198	±0·129

Nutrient concentration and uptake

Sugar beet. Table 6 gives the average amount of each element in sugar-beet tops and roots at harvest. The differences largely reflect changes in root and top dry matter yields. Without fertiliser (F_0), the soil supplied on average more than 107 kg/ha N, 20 kg/ha P, 130 kg/ha K and 52 kg/ha Na for each crop at harvest.

Winter wheat. Table 7 shows the total amount of each nutrient in wheat grain plus straw. Crops without fertiliser contained 66 kg/ha N, 13 kg/ha P, 33 kg/ha K and

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TABLE 6

Nutrient composition of sugar beet—Mean 1965–70

The concentration (%) in dry matter

	Nitrogen		Phosphorus		Potassium		Sodium	
	Tops	Roots	Tops	Roots	Tops	Roots	Tops	Roots
F_0	2·24	0·56	0·32	0·14	2·68	0·69	1·59	0·07
F_1	2·34	0·63	0·31	0·14	3·11	0·70	1·61	0·08
F_2	2·92	0·88	0·34	0·15	3·13	0·80	1·64	0·12
F_2 + FYM	2·98	0·92	0·33	0·15	3·49	0·96	1·66	0·11

Amount in the sugar-beet crop at harvest (kg/ha)

	Nitrogen			Phosphorus			Potassium			Sodium		
	Tops	Roots	Total	Tops	Roots	Total	Tops	Roots	Total	Tops	Roots	Total
F_0	66	41	107	10	10	20	79	51	130	47	5	52
F_1	96	64	160	13	14	27	127	70	197	66	8	74
F_2	163	92	255	19	16	35	175	83	258	92	13	105
F_2 + FYM	168	98	266	19	16	35	197	102	299	94	12	106

0·5 kg/ha Na. Wheat grown on plots receiving sodium for sugar beet showed small but consistent increases in the concentration of Na in grain and straw. The increased total amount of Na in the wheat may have come from either fertiliser or decaying sugar beet tops and fibrous roots.

TABLE 7

Total amount of nutrients (kg/ha) in cereals at harvest—Mean 1965–70

	N	P	K	Na	Ca	Mg
Winter wheat						
F_0	66	13	33	0·5	12	5·7
F_1	89	16	47	0·6	18	6·4
F_2	106	15	50	0·7	19	6·2
F_2 + FYM	112	17	56	0·9	22	6·7
Barley						
F_0	41	10	22	1·7	10	3·6
F_1	65	13	30	3·0	16	5·1
F_2	95	15	32	4·4	22	5·9
F_2 + FYM	90	15	33	3·7	25	5·6

Barley. Table 7b shows the total amount of each nutrient in barley grain plus straw. Crops without fertiliser contained 41 kg/ha N, 10 kg/ha P, 22 kg/ha K and 1·7 kg/ha Na. The sodium fertiliser given for sugar beet increased the amount of sodium in barley more than in wheat. The rainfall of two winters would probably have leached any sodium fertiliser residues so the sodium in the barley probably came from wheat roots (grain and straw were both removed) or the plant residues from the sugar beet grown two years before.

Nutrient balance

Complete rotation. Fig. 1 shows the cumulative effect of three treatments (F_0, F_1 and F_2) on nutrient balance (i.e. amount applied–amount removed by crops) between spring 1965 and harvest 1970. Without fertiliser, a total of 300 kg/ha N, 65 kg/ha P, 210 kg/ha K and 18 kg/ha Na was removed in two complete rotations. With F_1, the amount of nitrogen and potassium applied was very similar to that removed by the crops. P_1 more than balanced P offtake for all crops, so small amounts of P were added to soil reserves each year. On average of all crops, the total amount of Na applied greatly exceeded Na

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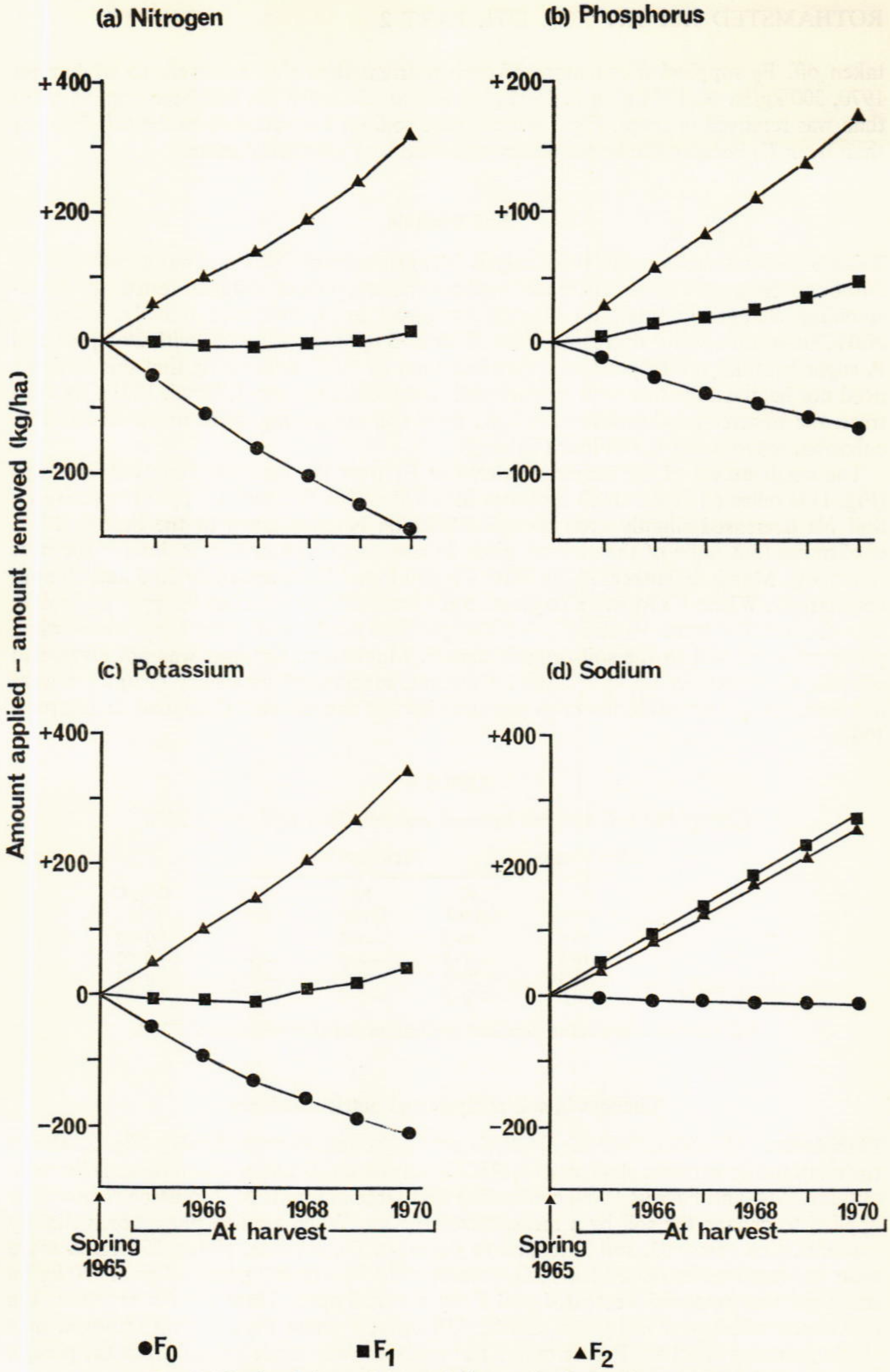

FIG. 1. Nutrient balance. Means of all crops in the rotations 1965–70.

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taken off. F_2 supplied much more of each nutrient than was removed, so by harvest 1970, 300 kg/ha N, 175 kg/ha P, 350 kg/ha K and 250 kg/ha Na had been applied more than was removed in crops. Fig. 1 shows more sodium was returned to the soil from F_1 than from F_2 because the larger plants produced by F_2 removed more.

Soil analysis

Table 8 shows the change in soil analysis between autumn 1964 and early spring 1970. Although there were large differences between the amounts of nitrogen tested, the corresponding changes in total soil N were too small to be measured reliably. With F_0, $NaHCO_3$-soluble soil P decreased from 35 to 29·5 ppm. As expected with 29·5 ppm soil P, sugar beet did not respond to P fertiliser even by 1970, confirming that this fertiliser need not be given for this crop on such soil (Draycott, Durrant & Boyd, 1971). By contrast, the progressive decrease in soil K, on a soil containing small amounts initially, enhanced response to K fertiliser (Table 4).

The small excess of the major nutrients in F_1 over the amounts removed by crops (Fig. 1) is reflected in the small increases in soil P and K (0·5 and 1·5 ppm respectively). Soil Na decreased slightly even though 148 kg/ha Na was given to the beet in 1967, confirming that none of the sodium given to one sugar beet crop remains for the next (Draycott, Marsh & Tinker, 1970). With F_2, soil P and K increased by 13·5 and 20 ppm respectively. Where FYM was also given, soil P increased by a further 0·5 ppm and soil K by a further 58·5 ppm. F_2 and F_2 + FYM produce plants with large tops, which when ploughed back add to the soil organic matter. Magnesium fertiliser was not given and soil Mg decreased by up to 7·5 ppm. However, magnesium deficiency symptoms were not seen, so it is probable the crop was not short of this element (Draycott & Durrant, 1969).

TABLE 8

Changes in soil analysis between autumn 1964 and spring 1970

	Bicarbonate soluble P (ppm)	Exchangeable K (ppm)	Exchangeable Na (ppm)	Exchangeable Mg (ppm)	Org. C (%)
F_0	−5·5	−8·5	−7·0	−2·5	+0·02
F_1	+0·5	+1·5	−8·5	−5·0	+0·02
F_2	+13·5	+20·0	0	−7·5	+0·23
F_2 + FYM	+14·0	+78·5	−2·5	−2·5	+0·09

Soil samples taken before fertiliser application but after addition of FYM.

Changes in soil analysis and nutrient balance

Phosphorus. ($N_1P_0K_1$, $N_1P_1K_1$, $N_1P_2K_1$ or P_0, P_1 and P_2 respectively). Fig. 2a shows the relationship between changes in $NaHCO_3$-soluble soil P and nutrient balance between autumn 1964 and harvest 1969, confirming that large amounts of P must be removed or applied to change the soil by a measurable amount. When applied phosphorus slightly exceeded that removed, soil P tended to decrease. On average, giving 150 kg/ha more than was removed increased $NaHCO_3$-soluble soil P by about 8 ppm and giving 50 kg/ha less than was removed decreased soil P by about 5 ppm. These results represent the cumulative effect over five years. Giving 150 kg/ha P more than a crop removed in a single year may affect soil P differently. The analyses were made on soil from the plough layer and take no account of changes at depth.

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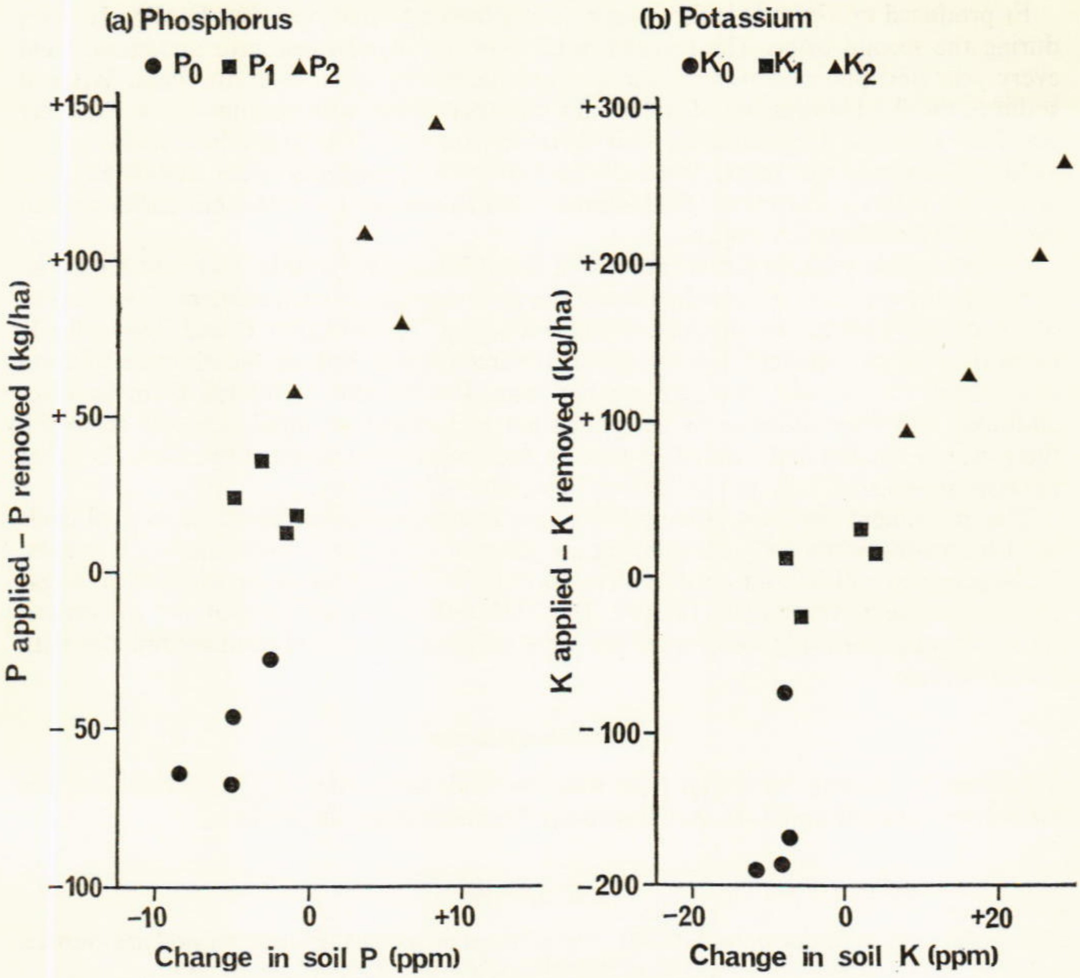

FIG. 2. The relationship between changes in soil analysis and nutrient balance.

Potassium ($N_1P_1K_0$, $N_1P_1K_1$, $N_1P_1K_2$ or K_0, K_1 and K_2 respectively). Fig. 2b shows the relationship between changes in exchangeable soil K and nutrient balance. In agreement with Warren and Johnson (1962) and Mattingly, Johnson and Chater (1970), exchangeable soil K did not increase or decrease at the same rate as calculated from the nutrient balance, so either some was 'fixed' and/or some lost by leaching. On average, giving 100 kg/ha more K than was removed increased exchangeable soil K by about 10 ppm. When more than 75 kg/ha K had been removed, there were only small further decreases in exchangeable soil K, suggesting either that crops were using 'non-exchangeable' soil K or exchangeable K was being used from below the plough layer.

Summary and conclusions

Results are reported from the first six years of a long-term experiment testing 18 fertiliser treatments on yield and composition of crops in a three-course rotation of sugar beet, winter wheat and spring barley. The main object was to see whether the fertiliser recommendation (F_1, Table 2) based on many annual experiments on commercial farms was sufficient for a rotation at Broom's Barn or whether a larger dressing (F_2) might give larger yields after several years of testing.

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F_1 produced maximum yield of sugar during the first three years but F_2 slightly more during the second three. The recommended dressing of nitrogen gave maximum yield every year and phosphorus fertiliser was not needed by sugar beet any year. Without sodium, the double dressing of potassium was needed but with sodium (as in F_1) there was little response to potassium. It is therefore not clear why sugar beet with F_2 outyielded F_1 in the later years. Nor is it clear why FYM increased yield slightly in most years even with F_2. The cereal yields showed that F_1 sufficed for wheat but barley needed the double dressing of nitrogen.

Crops on plots without fertiliser removed about 300 kg/ha N, 60 kg/ha P and 220 kg/ha K during the six years. F_1 supplied about the same amount of each element as was taken off in crops, whereas F_2 supplied about 300 kg/ha N, 160 kg/ha P and 350 kg/ha K more than crops removed. Soil phosphorus extracted with sodium bicarbonate solution was related to, but always much smaller than, the amount calculated from fertiliser additions and crop offtakes. When potassium was added or small amounts removed, there was a smaller but related change in soil potassium; when more than 75 kg/ha potassium was removed, soil potassium decreased only slightly.

The experiment provides little evidence that recommendations based on annual trials need increasing when the yields during six years of cropping are considered. However, the experiment will be continued unchanged in 1971–73 in order to see whether the sugar beet does respond more to F_2 than F_1. In 1974–76 the plots will be split and the experiment cropped uniformly to compare the value of the accumulated fertiliser residues with fresh fertiliser.

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REFERENCES

DRAYCOTT, A. P. & DURRANT, M. J. (1969) The effects of magnesium fertilizers on yield and chemical composition of sugar beet. *Journal of Agricultural Science, Cambridge* **72**, 319–324.

DRAYCOTT, A. P., DURRANT, M. J. & BOYD, D. A. (1971) The relationship between soil phosphorus and response by sugar beet phosphate fertilizer on mineral soils. *Journal of Agricultural Science, Cambridge* **77**, 117–121.

DRAYCOTT, A. P., MARSH, J. A. P. & TINKER, P. B. H. (1970) Sodium and potassium relationships in sugar beet. *Journal of Agricultural Science, Cambridge* **74**, 568–573.

HODGE, C. A. H. & SEALE, R. S. (1966) The soils of the district round Cambridge. [Sheet 188.] *Memoirs of the Soil Survey of Great Britain*, 183 pp.

MATTINGLY, G. E. G., JOHNSON, A. E. & CHATER, M. (1970) The residual value of farmyard manure and superphosphate in the Saxmundham Rotation II Experiment. *Rothamsted Experimental Station. Report for 1969*, Part 2, 91–112.

OLSEN, S. R., COLE, C. V., WATANABE, F. & DEAN, L. A. (1954) Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *U.S. Department of Agriculture. Circular* No. 939.

TINSLEY, J. (1950) The determination of organic carbon in soils by dichromate mixtures. *Transactions of the 4th International Congress Soil Science, Amsterdam* **1**, 161–164.

WARREN, R. G. & JOHNSON, A. E. (1962) The accumulation and loss of soil potassium in long-term experiments, Rothamsted and Woburn. *The Fertiliser Society Proceedings* **72** 5–24.

https://doi.org/10.23637/ERADOC-1-6