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The Value of Residues from Long-period Manuring at Rothamsted and Woburn
V. The Value to Arable Crops of Residues Accumulated from Potassium Fertilisers

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These experiments were made on the Exhaustion Land at Rothamsted during 1957–58 and at Woburn on the Permanent Wheat and Barley Sites during 1960–62. Paper III (page 22) gives the histories of the sites and the experimental details, including amounts of K tested and basal N and P fertilisers. For the reasons given in the fourth paper (page 40), the yields of crops grown on both plots 8 at Woburn are given only in the Appendix Tables.

Yields

Cereals. Appendix Table 1 shows the yields of barley and spring wheat on the Exhaustion Land during 1957–58, and of barley at Woburn during 1960–62. New K increased grain yields by 1·4 to 2·5 cwt/acre on the starved soils but did not affect yield on the enriched soils (Table 1). There were also small increases in straw yields when new K was given.

TABLE 1

Effect of a new dressing of 56 lb K/acre on the yield of barley grown on soils with and without K residues at Rothamsted and Woburn, 1957–62

Grain, cwt/acre

	Rothamsted Exhaustion Land mean 1957 & 1958	Woburn	
		Wheat Site mean 1960 & 1962	Barley Site mean 1960 & 1961
Starved soil			
Without new K	26·6	26·7	23·2
With new K	28·4	29·2	24·6
Response to new K[1]	1·8	2·5	1·4
Enriched soil			
Without new K	28·2	26·4	26·6
With new K	28·4	26·4	26·3
Response to new K[1]	0·2	0	−0·3

[1] New K at 56 lb K/acre applied broadcast to the seedbed.

Table 2 shows the yields on starved and enriched soils without new K. Residues slightly increased the yield of barley at Rothamsted and on the Barley Site at Woburn, but barley on the Wheat Site at Woburn and spring wheat on the Exhaustion Land yielded slightly less with than without residues.

TABLE 2

Effect of K residues in the soil on the yields of cereals given no new K at Rothamsted and Woburn, 1957–62

	Grain, cwt/acre			
	Rothamsted Exhaustion Land mean 1957 & 1958		Woburn	
			Wheat Site mean 1960 & 1962	Barley Site mean 1960 & 1961
	Barley	Spring wheat	Barley	Barley
Soil given no new K and with:				
No residues	26·6	26·4	26·7	23·2
K residues	28·2	23·8	26·4	26·6
Increase due to K residues in the soil	1·6	−2·6	−0·3	3·4

The response curves to new K on both starved and enriched soils show the residues cannot be valued in terms of a new dressing of K, because the responses to new K fertiliser were too small and the yields on starved and enriched soils were too variable (Fig. 1).

Ploughed in and seedbed applications of new K fertiliser were compared in the experiments at Woburn in 1961–62. Yields (Table 3) show that the method of applying the new K had little effect.

TABLE 3

Effect of new K, ploughed in or broadcast on the seedbed, on barley yields at Woburn, 1961–62

		Grain, cwt/acre			
		Wheat Site 1962		Barley Site 1961	
K given lb/acre		Plot 9 with K residues	Plot 7 no K residues	Plot 9 with K residues	Plot 7 no K residues
0		28·5	28·9	28·1	25·9
14	Seedbed	—[1]	31·9	27·3	25·6
56	Seedbed	26·5	32·1	25·7	26·2
0		25·6	32·5	22·1	25·6
14	Ploughed in	29·9	34·8	25·4	27·6
56	Ploughed in	27·1	34·9	26·3	27·0

[1] No yield recorded because of extensive bird damage.

Potatoes. New K fertiliser was applied in different ways on the two sites. On the Exhaustion Land it was placed in the bottom of the furrows before the potatoes were set by hand, at Woburn it was either ploughed in or applied to the flat seedbed before the chitted seed was planted by machine. Appendix Table 2 shows the yields on the Exhaustion Land and at Woburn.

Table 4 shows that on both starved *and* enriched soils at Rothamsted and Woburn potatoes responded to new K at the largest amount tested, a striking contrast to the lack of response to K by cereals. Potatoes on the Exhaustion Land responded less to K than to P, but at Woburn the response to K was much larger than to P. On the starved soil at Rothamsted, the

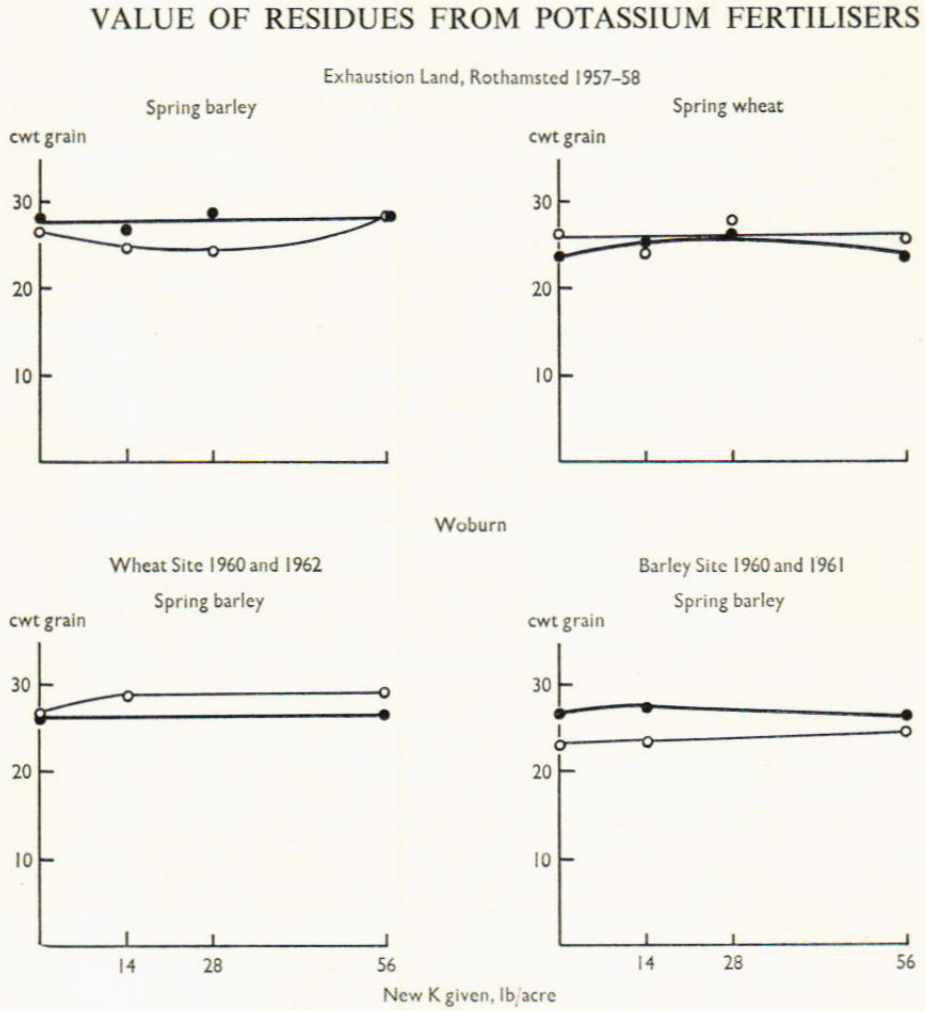

FIG. 1. Effect of K residues and new K on the average yield per acre of cereal grain, Rothamsted and Woburn, 1957–62.

(With ● and without ○ K residues.)

TABLE 4

Effect of a new dressing of 112 lb K/acre on the yield of potatoes grown on soils with and without K residues at Rothamsted and Woburn, 1957–62

	Tubers, tons/acre		
	Rothamsted Exhaustion Land mean 1957 & 1958	Woburn	
		Wheat Site 1960	Barley Site 1960
Starved soil			
Without new K	6·8	11·9	14·3
With new K	12·4	17·0	18·2
Response to new K[1]	5·6	5·1	3·9
Enriched soil			
Without new K	11·0	16·3	16·4
With new K	14·6	19·3	18·2
Response to new K[1]	3·6	3·0	1·8

[1] New K at 112 lb K/acre given along the bottoms of the furrows before hand planting on the Exhaustion Land, on the flat seedbed before machine planting at Woburn.

yield was only 6·8 tons/acre and giving 112 lb K increased it by 5·6 tons. A Woburn, yield on the starved soil was double that at Rothamsted, 11·9 tons/acre on the Wheat Site, 14·3 tons/acre on the Barley Site, but the increases in yield from 112 lb of new K were about the same as at Rothamsted, on the Wheat Site 5·1 tons and less on the Barley Site, 3·9 tons.

Table 5 shows the yields on starved and enriched soils without new K. The residues gave large increases in yield, about three-quarters of the extra yield given by the fresh dressing of 112 lb K to the starved soil.

TABLE 5

Effect of K residues in the soil on the yields of potatoes given no new K at Rothamsted and Woburn, 1957–62

Tubers, tons/acre

	Rothamsted Exhaustion Land mean 1957 & 1958	Woburn	
		Wheat Site 1960	Barley Site 1960
Soil given no new K and with			
No residues	6·8	11·9	14·3
K residues	11·0	16·3	16·4
Increase due to K residues in the soil	4·2	4·4	2·1

Fig. 2 gives the response curves to new K on starved and enriched soils. On both the Exhaustion Land and at Woburn the residues can be valued in terms of a new broadcast dressing of K having the same effect on yield. The residues were worth:

	lb new K/acre
Exhaustion Land, Rothamsted	56
Wheat Site, Woburn	75
Barley Site, Woburn	16

Both on the Wheat Site at Woburn and on the Exhaustion Land, the response curves did not show a maximum and, with any amount of new K tested, yield on the enriched soil always exceeded that on the starved soil.

When ploughed in and seedbed dressings of fertiliser were compared at Woburn in 1961–62, the amount of new K applied was increased to see whether this would decrease the difference between the yield on soils with and without residues. Table 6 shows the yields with 42 and 168 lb K, but unfortunately one of the two plots without new K on plot 9 on the Wheat Site yielded very badly. On the starved soil on both sites, only the largest amount of new K ploughed in increased yield to equal that on the enriched soil without new K. However, giving new K to the enriched soils increased yield still further.

Sugar beet. This crop was grown on the Exhaustion Land in 1957–58, at Woburn on the Barley Site in 1961 and on the Wheat Site in 1962. Table 7 shows the yields of sugar on the Exhaustion Land with new K broadcast on the seedbed and Table 8 yields at Woburn when seedbed dressings and

VALUE OF RESIDUES FROM POTASSIUM FERTILISERS

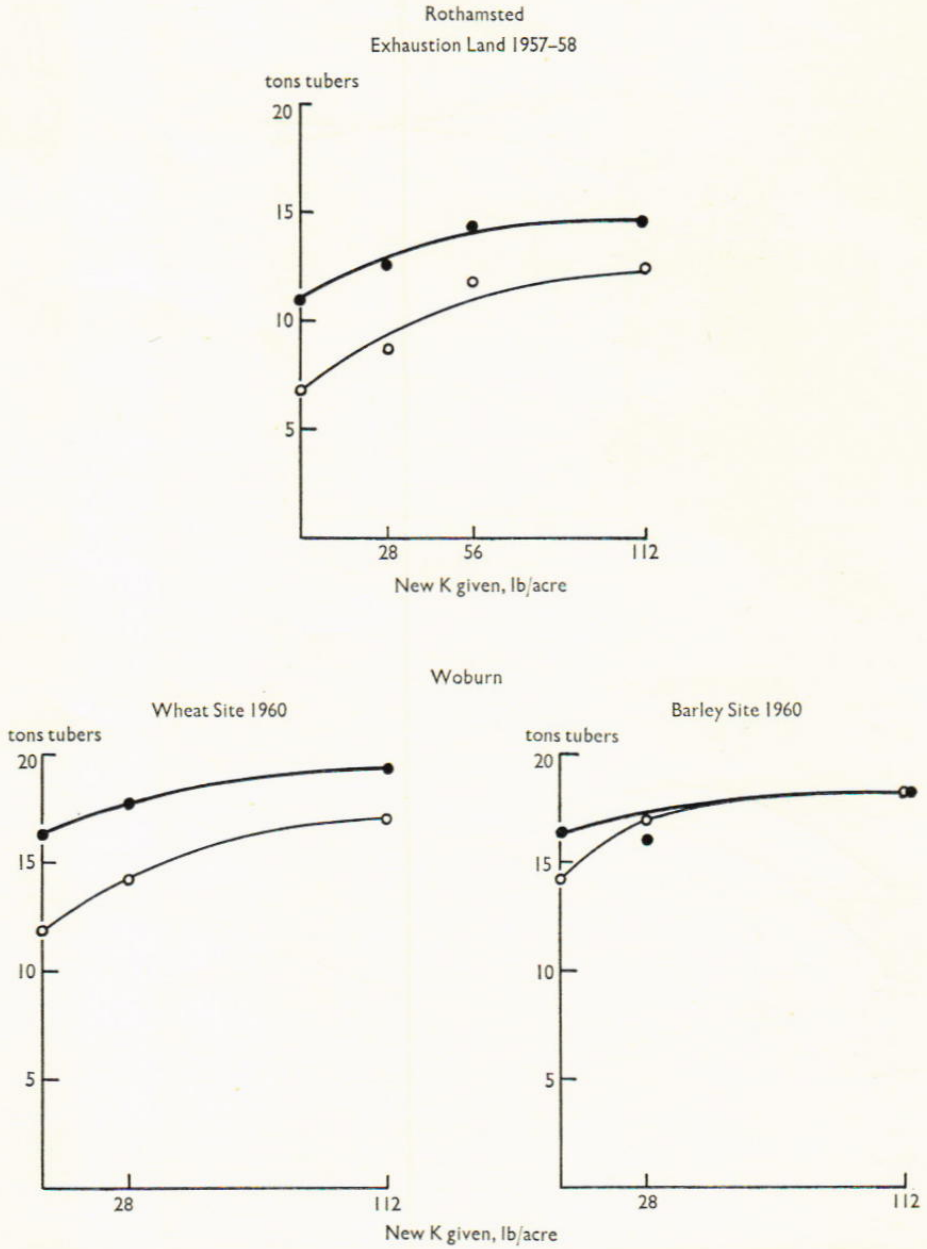

FIG. 2. Effect of K residues and new K on the average yield per acre of potato tubers, Rothamsted and Woburn, 1957–60.

(With ● and without ○ K residues.)

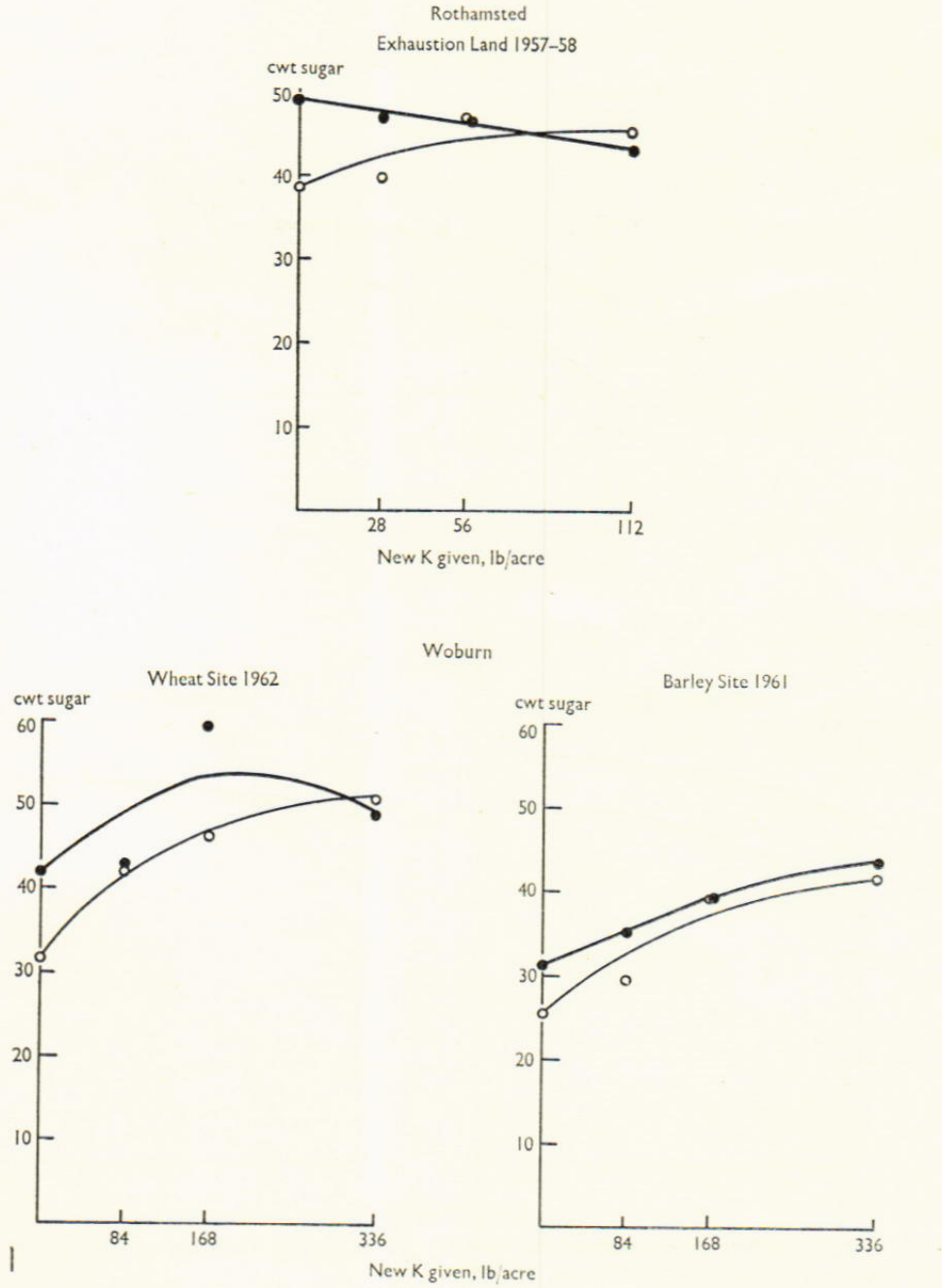

FIG. 3. Effect of K residues and new broadcast dressings of K on the average yield per acre of sugar at Rothamsted and Woburn.
(With ● and without ○ K residues.)

VALUE OF RESIDUES FROM POTASSIUM FERTILISERS

TABLE 6

Effect of new K, ploughed in or broadcast on the seedbed, on potato yields at Woburn, 1961–62

Tubers, tons/acre

K given lb/acre		Wheat Site 1962		Barley Site 1961	
		Plot 9 with K residues	Plot 7 no K residues	Plot 9 with K residues	Plot 7 no K residues
0		13·2	10·8	12·0	8·6
42	Seedbed	12·8	12·4	11·8	10·4
168	Seedbed	14·5	11·8	15·0	10·2
0		8·1	9·1	13·0	8·3
42	Ploughed in	12·3	12·4	12·5	11·1
168	Ploughed in	13·5	13·3	14·6	12·7

TABLE 7

Effect of new broadcast dressings of K on the yields of sugar from beet grown on soils with and without K residues on the Exhaustion Land, Rothamsted, 1957–58

Sugar, cwt/acre

Classical Experiment plot	K given lb/acre	1957	1958	Mean	Response
1 no K residues	0	25·9	51·8	38·8	—
	28	20·8	58·6	39·7	0·9
	56	30·7	63·2	47·0	8·2
	112	26·3	64·2	45·2	6·4
7 with K residues	0	31·2	66·7	49·0	—
	28	30·5	62·8	46·6	−2·4
	56	30·6	65·2	47·9	−1·1
	112	27·9	58·7	43·3	−5·7

TABLE 8

Effect of new K, ploughed in or broadcast on the seedbed, on sugar yields at Woburn, 1961–62

Sugar, cwt/acre

K given lb/acre	Wheat Site 1962		Barley Site 1961	
	Plot 9 with K residues	Plot 7 no K residues	Plot 9 with K residues	Plot 7 no K residues
To seedbed				
0	42·0	31·6	31·4	25·5
84	42·5	41·9	35·2	29·7
168	59·7	46·2	39·6	39·3
336	48·8	50·8	43·7	41·8
Ploughed in				
0	45·5	38·0	29·1	18·2
84	43·2	40·9	42·0	34·1
168	50·2	43·7	36·6	33·1
336	45·3	52·5	43·6	33·0

ploughed-in new K were tested in amounts up to 336 lb K/acre. On the Exhaustion Land beet yielded less in 1957 than in 1958, partly because of a severe attack by virus yellows. On the starved soil in 1957 the position of the microplots within the old Classical Experiment plot had a larger effect on yield than the new dressings of K. The microplots dressed with 28 and 112 lb/acre of new K, which were on the south side of the plot, gave a smaller mean yield than the other pair on the north, which had 0 and 56 lb new K. However, in 1958, yields were more consistent because the arrangement of the microplots was improved, and on the starved soil new K increased yield by 12 cwt of sugar/acre. On the enriched soil there was no response to new K.

Table 7 also shows that, without new K the effect of the residues was to increase sugar yield by 10 cwt/acre on the Exhaustion Land. At Woburn the residues increased yield by between 5 and 10 cwt/acre without new K (Table 8). The yield of sugar was the same on starved and enriched soils with new K at the largest amount tested. The residues on the Exhaustion Land could not be valued in terms of a new dressing of K (Fig. 3), but at Woburn they were worth between 75 and 85 lb of fresh K/acre.

TABLE 9

Effect of new broadcast dressings of K on the yields of swedes and kale grown on soils with and without K residues on the Exhaustion Land, Rothamsted, 1957–58

Classical Experiment plot	K given lb/acre	tons/acre 1957	1958	Mean	Response
		Swede roots			
1 no K residues	0	10·7	19·4	15·0	—
	14	11·9	21·9	16·9	1·9
	28	11·8	20·9	16·4	1·4
	56	11·5	20·6	16·0	1·0
7 with K residues	0	12·4	24·9	18·6	—
	14	12·7	25·3	19·0	0·4
	28	12·9	24·8	18·8	0·2
	56	12·9	25·0	19·0	0·4
		Swede tops			
1 no K residues	0	2·6	3·8	3·2	—
	14	2·5	4·3	3·4	0·2
	28	2·2	4·4	3·3	0·1
	56	2·4	4·1	3·2	0·0
7 with K residues	0	2·3	4·0	3·2	—
	14	2·2	4·4	3·3	0·1
	28	2·5	4·3	3·4	0·2
	56	2·2	4·2	3·2	0·0
		Kale			
1 no K residues	0	17·3	23·1	20·2	—
	28	16·5	21·1	18·8	−1·4
	56	19·8	22·6	21·2	1·0
	112	17·4	19·1	18·2	−2·0
7 with K residues	0	18·0	24·2	21·1	—
	28	18·4	23·3	20·8	−0·3
	56	18·4	23·0	20·7	−0·4
	112	20·9	24·6	22·8	1·7

Swedes and kale. These two crops were grown only on the Exhaustion Land in 1957–58 and Table 9 gives yields of both. Swede roots responded to new K only on the starved soil, and maximum response (2 tons/acre) was to the smallest amount (14 lb/acre) of new K. However, the soil with residues yielded consistently more than the soil without, by about 3 tons/acre. The residues could not be valued in terms of a fresh dressing because the yield on starved soil with new K was less than on enriched soil without new K. The yields of swede tops were not increased by residues in the soil or by fresh K. Kale did not respond to new K on the starved soil, but on the enriched soil, the largest amount of K tested gave an extra 1·7 tons. The average yield was 2 tons/acre more with residues.

Discussion of the potassium tests

On the starved soils on the Exhaustion Land cereals without new K gave the same yield in both seasons. However, potatoes, sugar beet, kale and swedes all yielded more in 1958 than in 1957. 1958 was wetter, but less virus yellows in the sugar beet and less mildew on the swedes contributed to better yields in 1958.

Table 10 summarises the responses of the crops to the largest amount of new K applied as a seedbed dressing. At both Rothamsted and Woburn new K increased yield of barley on starved soil by 1 to 2 cwt grain but had no effect on enriched soil. Spring wheat on the Exhaustion Land did not respond to new K, on either the starved or enriched soil. In all years, and at both Rothamsted and Woburn, new K greatly increased potato yields on both starved and enriched soils. Sugar beet yields were usually increased by new K on starved and enriched soils, but not on the enriched soil of the Exhaustion Land, where the yield with new K was less than might have been expected. Swedes at Rothamsted gave small increases in yield with new K especially on starved soils, but yields of kale did not always increase with new K.

When the fertiliser K residues are valued by the difference in yield on soils with and without residues but with adequate N and P, they have considerable value at both Rothamsted and Woburn, except perhaps for cereals. Table 11 summarises the increases in yield from the presence of residues in the enriched soil.

The large crops currently being grown on many well fertilised soils take up much K, and it is not known whether K is accumulating in soils as is P. The section on K uptake shows that much K goes into the straw of cereals and the tops of sugar beet and how much K is removed from the soil depends on what happens to these parts of the crop. The accumulation of K is also related to the release of native soil K by weathering and the equilibrium between readily soluble and 'fixed' K. The rates of weathering and fixation of K differ considerably in different soils. Recent work at both Rothamsted and Woburn shows that change in the amount of K soluble in 1*N*-ammonium acetate is a good indication of the depletion or accumulation of readily soluble soil K during a cropping cycle. Current work is examining the release of K from reserves of 'fixed' K accumulated from fertiliser dressings.

TABLE 10

Effect of a broadcast dressing of K as potassium sulphate on the yields of crops grown on soils with and without K residues at Rothamsted and Woburn, 1957–62

	Rothamsted			Woburn				
		Exhaustion Land mean 1957 & 1958			Wheat Site mean 1960 & 1962[1]		Barley Site mean 1960 & 1961[1]	
	New K given lb/acre	No K residues	With K residues	New K given lb/acre	No K residues	With K residues	No K residues	With K residues
Barley grain, cwt	0	26·6	28·2	0	26·7	26·4	23·2	26·6
	56	28·4	28·4	56	29·2	26·4	24·6	26·3
	56 minus 0	1·8	0·2	56 minus 0	2·5	0·0	1·4	−0·3
Spring wheat grain, cwt	0	26·4	23·8	—	—	—	—	—
	56	25·7	23·8	—	—	—	—	—
	56 minus 0	−0·7	0·0	—	—	—	—	—
Potatoes tubers, tons	0	6·8	11·0	0	11·9	16·3	14·3	16·4
	112	12·4	14·6	112	17·0	19·3	18·2	18·2
	112 minus 0	5·6	3·6	112 minus 0	5·1	3·0	3·9	1·8
Sugar beet sugar, cwt	0	38·8	49·0	0	31·6	42·0	25·5	31·4
	112	45·2	43·3	336	50·8	48·8	41·8	43·7
	112 minus 0	6·4	−5·7	336 minus 0	19·2	6·8	16·3	12·3
Swedes roots, tons	0	15·0	18·6	—	—	—	—	—
	56	16·0	19·0	—	—	—	—	—
	56 minus 0	1·0	0·4	—	—	—	—	—
Kale tons	0	20·2	21·1	—	—	—	—	—
	112	18·2	22·8	—	—	—	—	—
	112 minus 0	−2·0	1·7	—	—	—	—	—

[1] No sugar beet at Woburn in 1960.

TABLE 11

Effect of old residues of fertiliser K dressings at Rothamsted and Woburn, 1957–62

Yields/acre

Crop	Site	Years	No K residues	With K residues	Increase due to K residues
Barley grain, cwt	Exhaustion Land	1957 & 1958	26·6	28·2	1·6
	Wheat Site, Woburn	1960 & 1962	26·7	26·4	−0·3
	Barley Site, Woburn	1960 & 1961	23·2	26·6	3·4
Spring wheat grain, cwt	Exhaustion Land	1957 & 1958	26·4	23·8	−2·6
Potatoes tubers, tons	Exhaustion Land	1957 & 1958	6·8	11·0	4·2
	Wheat Site, Woburn	1960 & 1962	11·4	14·8	3·4
	Barley Site, Woburn	1960 & 1961	11·4	14·4	3·0
Sugar beet sugar, cwt	Exhaustion Land	1957 & 1958	38·8	49·0	10·2
	Wheat Site, Woburn	1962	34·8	43·8	9·0
	Barley Site, Woburn	1961	21·8	30·2	8·4
Swedes roots, tons	Exhaustion Land	1957 & 1958	15·0	18·6	3·6
Kale tons	Exhaustion Land	1957 & 1958	20·2	21·1	0·9

Potassium concentration in the crops

Tables 12, 13 and 14 give the percentages of potassium in the dry matter of the crops.

Cereals. Johnston (1969) showed that the mineral composition of the grain and straw of winter wheat grown recently on Broadbalk confirmed Lawes and Gilbert's view that fully ripened grain has a consistent mineral composition whereas the composition of the straw varies considerably. Table 12 shows that the concentration of K in the grain grown on the starved soils on the Exhaustion Land and on the Barley Site at Woburn was 0·50%, slightly less than in the barley on the Hoosfield Continuous Barley plots. Barley on the Wheat Site at Woburn contained much less K (0·40%) for unknown reasons. K residues in the soil increased the concentration of K in the grain, but less on the Wheat Site than on the other two sites. On the enriched Exhaustion Land soil, the % K in the grain almost equalled that in the grain from the Hoosfield Continuous Barley Experiment. Dressings of fresh K did not increase the % K in grain from either the starved or enriched soils. The K concentration in the straw from the Exhaustion Land (1·16% in the enriched soil without new K) was nearly equal to that in the straw from the Hoosfield Continuous Barley Experiment, but the straw at Woburn contained only about half as much. Both the residual K in the soil and new dressings increased the % K in the straw by about the same amount, 0·1 to 0·3%.

Potatoes. Table 13 shows that the % K in dry matter of potato tubers from the Exhaustion Land was affected much more by new K than by K residues in the soil. However, the effect of the residues was not lessened by new K. At Woburn, in 1960, with larger concentrations of K in the

TABLE 12

Effect of K residues and new K on the percentage of K in the grain and straw of cereals grown at Rothamsted and Woburn, 1957–62

% K in dry matter

	Rothamsted Exhaustion Land mean 1957 & 1958 K to seedbed				Woburn							
					Wheat Site 1962				Barley Site 1961			
	Barley		Spring wheat		K to seedbed Barley		K ploughed in Barley		K to seedbed Barley		K ploughed in Barley	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
No new K given to soil with												
No residues	0·48	0·84	0·37	0·40	0·43	0·50	0·39	0·34	0·50	0·40	0·50	0·46
K residues	0·54	1·16	0·42	0·48	0·39	0·52	0·41	0·49	0·53	0·61	0·52	0·61
Effect of residues	0·06	0·32	0·05	0·08	−0·04	0·02	0·02	0·15	0·03	0·21	0·02	0·15
56 lb new K given to soil with												
No residues	0·50	1·12	0·38	0·45	0·40	0·42	0·40	0·47	0·49	0·50	0·48	0·59
K residues	0·54	1·32	0·40	0·53	0·41	0·64	0·41	0·60	0·53	0·65	0·53	0·62
Effect of residues	0·04	0·20	0·02	0·08	0·01	0·22	0·01	0·13	0·04	0·15	0·05	0·03
Effect of 56 lb new K in the												
Absence of residues	0·02	0·28	0·01	0·05	−0·03	−0·08	0·01	0·13	−0·01	0·10	−0·02	0·13
Presence of residues	0·00	0·16	−0·02	0·05	0·02	0·12	0	0·11	0	0·04	−0·01	0·01

TABLE 13

Effect of K residues and new K on the percentage of K in potatoes grown at Rothamsted and Woburn, 1957–62

% K in tuber dry matter

	Rothamsted Exhaustion Land mean 1957 & 1958	Woburn		Woburn			
		Wheat Site 1960	Barley Site 1960	Wheat Site 1962		Barley Site 1961	
	K in furrows	K to seedbed	K to seedbed	K to seedbed	K ploughed in	K to seedbed	K ploughed in
No new K given to soil with							
No residues	1·08	1·28	1·33	1·26	1·19	1·13	1·30
K residues	1·16	1·42	1·69	1·49	1·43	1·65	1·52
Effect of residues	0·08	0·14	0·39	0·23	0·24	0·32	0·22
New K[1] added to soil with							
No residues	1·40	1·68	1·82	1·85	1·61	1·74	1·59
K residues	1·50	1·92	2·20	1·92	1·79	2·04	2·04
Effect of residues	0·10	0·24	0·38	0·07	0·18	0·30	0·45
Effect of new K in the							
Absence of residues	0·32	0·40	0·49	0·59	0·42	0·41	0·29
Presence of residues	0·34	0·50	0·48	0·43	0·36	0·39	0·52

[1] 112 lb new K Exhaustion Land and Woburn 1960; 168 lb new K Woburn 1961–62.

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dry matter, the residues increased the % K more than at Rothamsted. Also at Woburn, 112 lb/acre of new K increased the % K more than the same dressing did at Rothamsted. This was true even though at Woburn the dressing was applied on the flat seedbed whereas at Rothamsted it was applied in the furrows. This again suggests that potato roots grow more easily and further in Woburn soil than in Rothamsted soil. This suggestion was supported when, in 1961–62, more K was tested at Woburn and seedbed dressings and ploughed-in new K increased the % K in dry matter similarly.

Sugar beet, swedes and kale. On the soil without residues or new K, swede tops and roots, sugar beet tops, and kale, all had nearly the same K concentration in the dry matter, but the sugar beet roots had much less (Table 14). K residues in the soil increased the % K in swede tops and roots

TABLE 14

Effect of K residues and new K on the percentage of K in sugar beet, swedes and kale grown on the Exhaustion Land, Rothamsted, 1957–58

	Swedes		Sugar beet		
	Tops	Roots	Tops	Roots	Kale
No new K given to soil with					
No residues	1·68	1·90	1·71	0·63	1·78
K residues	2·54	2·36	3·55	0·77	2·41
Effect of residues	0·86	0·46	1·84	0·14	0·63
New K[1] given to soil with					
No residues	2·19	2·21	2·30	0·74	2·31
K residues	2·62	2·55	3·66	0·90	2·54
Effect of residues	0·43	0·34	1·36	0·16	0·23
Effect of new K in the					
Absence of residues	0·51	0·31	0·59	0·11	0·53
Presence of residues	0·08	0·19	0·11	0·13	0·13

[1] 56 lb K to swedes, 112 lb K to sugar beet and kale.

and in kale by much the same amounts, but much less than in sugar-beet tops; however residues had little effect on the % K in sugar beet roots. New K increased the % K of all crops on starved soil much more than in the presence of residues.

Potassium content of the crops

Tables 15, 16, 17 and 18 give the uptakes of potassium by the harvested parts of the crops.

Cereals. Barley at Woburn and spring wheat at Rothamsted took up little more than 30 lb/acre K but the maximum uptake by barley at Rothamsted was twice as much (Table 15). More K was taken up from enriched than from starved soils and much of this extra K was in the straw. More K was taken up from newly applied K without than with residues, except for barley at Rothamsted, the uptake never exceeded 10% of the 56 lb/acre K newly applied.

TABLE 15

Effect of K residues and new K on the amount of K in the grain and straw grown at Rothamsted and Woburn, 1957–62

lb K/acre/year

	Rothamsted Exhaustion Land mean 1957 & 1958 K to seedbed						Woburn											
							Wheat Site 1962						Barley Site 1961					
	Barley			Spring wheat			K to seedbed Barley			K ploughed in Barley			K to seedbed Barley			K ploughed in Barley		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
No new K given to soil with																		
No residues	12	25	37	9	16	25	12	6	18	12	9	21	12	12	24	12	13	25
K residues	14	37	51	10	19	29	10	14	24	10	11	21	14	19	33	11	20	31
Effect of K residues	2	12	14	1	3	4	−2	8	6	−2	2	0	2	7	9	−1	7	6
56 lb new K given to soil with																		
No residues	13	36	49	10	20	30	12	12	24	13	15	28	12	15	27	12	18	30
K residues	15	42	57	9	22	31	10	18	28	11	15	26	13	18	31	13	19	32
Effect of K residues	2	6	8	−1	2	1	−2	6	4	−2	0	−2	1	3	4	1	1	2
Effect of 56 lb new K in the																		
Absence of residues	1	11	12	1	4	5	0	6	6	1	6	7	0	3	3	0	5	5
Presence of residues	1	5	6	−1	3	2	0	4	4	1	4	5	−1	−1	−2	2	−1	1

TABLE 16

Effect of residues and new K on the amount of K in potato tubers grown at Rothamsted and Woburn, 1957–62

lb K/acre/year

	Rothamsted Exhaustion Land mean 1957 & 1958	Woburn					
		Wheat Site 1960	Barley Site 1960	Wheat Site 1962		Barley Site 1961	
	K in furrows	K to seedbed	K to seedbed	K to seedbed	K ploughed in	K to seedbed	K ploughed in
No new K given to soil with							
No residues	34	73	90	72	57	58	56
K residues	64	111	130	104	59	101	108
Effect of K residues	30	38	40	32	2	43	52
New K[1] given to soil with							
No residues	86	133	154	107	109	94	105
K residues	106	168	173	136	121	147	149
Effect of K residues	20	35	19	29	12	53	54
Effect of new K in the							
Absence of residues	52	60	64	35	52	36	49
Presence of residues	42	57	43	32	62	46	41

[1] 112 lb new K Exhaustion Land and Woburn 1960; 168 lb new K Woburn 1961–62.

VALUE OF RESIDUES FROM POTASSIUM FERTILISERS

Potatoes. Uptake of K by potatoes on both sites (Table 16) varied very considerably, from 34 to 173 lb K/acre. Without new K, potato tubers from the starved soil on the Exhaustion Land contained about as much K as did the barley (grain plus straw), but tubers from the enriched soil contained more K than barley. At Woburn without new K, the potatoes took up more K than from the Exhaustion Land. The amount was about twice that taken up by the barley. Very much more K was taken up from the residues by potatoes than by barley. About 50% of the 112 lb/acre K tested on the Exhaustion Land and at Woburn in 1960 was taken up by potatoes. Increasing the dressings of new K to 168 lb K/acre at Woburn in 1961–62 did not increase K uptake from the fertiliser, so the apparent recovery of the added K by potatoes was only about 30% in 1961–62.

Sugar beet, swedes and kale. Without new K, sugar beet on the Exhaustion Land and at Woburn took up much the same amount of K (Table 17). By contrast potatoes took up less K on the Exhaustion Land than at Woburn, suggesting that they make less use of nutrients in Rothamsted soil than do sugar beet. From the starved soil without new K on the Exhaustion Land, sugar beet took up more than 100 lb K/acre and much more (180 lb) from the richer soil. Of the new K applied to the starved soil, the sugar beet took up 30 lb K (25%) but apparently none was taken up from the enriched soil. At Woburn the whole crop took up a maximum of 270 lb K. Possibly because the amount of new K tested was much more than at Rothamsted, more was taken up from the starved soil with new K than from the enriched soil without new K. However, maximum uptake was always with new K and residues. Apparent recoveries of added K were 30% from starved soils and 15% from enriched soils.

Swedes and kale on Exhaustion Land both resembled sugar beet, and took up much more K from the residues than from starved soil with fresh K fertiliser (Table 18). Without new K, kale extracted 13 lb more K from the

TABLE 18

Effect of K residues and new K on the amount of K in swedes and kale grown on the Exhaustion Land, Rothamsted, 1957–58

lb K/acre/year

	Swedes			
	Tops	Roots	Total	Kale
No new K added to soil with				
No residues	16	63	79	121
K residues	22	98	120	171
Effect of K residues	6	35	41	50
New K[1] added to soil with				
No residues	20	76	96	145
K residues	24	103	127	197
Effect of K residues	4	27	31	52
Effect of new K in the				
Absence of residues	4	13	17	24
Presence of residues	2	5	7	26

[1] 56 lb K to swedes; 112 lb K to kale.

TABLE 17

Effect of K residues and new K on the amount of K in sugar beet grown at Rothamsted and Woburn, 1957–62

lb K/acre/year

	Rothamsted Exhaustion Land mean 1957 & 1958 K to seedbed			Woburn Wheat Site 1962 K to seedbed			Woburn Wheat Site 1962 K ploughed in			Woburn Barley Site 1961 K to seedbed			Woburn Barley Site 1961 K ploughed in		
	Tops	Roots	Total	Tops	Roots	Total	Tops	Roots	Total	Tops	Roots	Total	Tops	Roots	Total
No new K added to soil with															
No residues	75	33	108	80	30	110	94	38	132	93	34	127	68	20	88
K residues	133	49	182	143	54	197	137	50	187	157	46	203	132	45	177
Effect of K residues	58	16	74	63	24	87	43	12	55	64	12	76	64	25	89
New K[1] added to soil with															
No residues	91	46	137	159	61	220	161	65	226	160	65	225	165	51	216
K residues	130	51	181	181	72	253	167	67	234	160	69	229	190	77	267
Effect of K residues	39	5	44	22	11	33	6	2	8	0	4	4	25	26	51
Effect of new K in the															
Absence of residues	16	13	29	79	31	110	67	27	94	67	31	98	97	31	128
Presence of residues	−3	2	−1	38	18	56	30	17	47	3	23	26	58	32	90

[1] 112 lb new K on Exhaustion Land; 336 lb new K at Woburn.

starved soil than did sugar beet and swedes 29 lb less. However, sugar beet extracted more K from the residues than did either kale or swedes. Apparent recovery of new K by swedes was altered by the residues; without them, 30% was taken up, with them, 12%. However, kale apparently recovered 20% of the new K from soils with and without residues.

Summary of the effects of K residues and new dressings of K fertiliser on K uptake

On the Exhaustion Land without new K, total uptake on the starved soil ranged from 25 lb by spring wheat to 121 lb/acre by kale, and on the enriched soil from 29 lb by spring wheat to 182 lb/acre by sugar beet. Thus, the recoveries from the residues ranged widely, from 4 lb by spring wheat to 74 lb by sugar beet. At Woburn there was a similar wide range of uptakes, 18 lb K by barley to 132 lb/acre K by sugar beet from the starved soil, and 21 lb K by barley to 203 lb/acre K by sugar beet from the enriched soil. In one comparison, barley obtained no extra K from the residues but sugar beet took up 89 lb K/acre. A large proportion of this extra K went into the straw of cereals, the tops of sugar beet and the roots of swedes. Except for potatoes and kale, the uptake from the residues was always decreased by new K fertiliser. Apparent recovery of new K was always less with than without residues, except for potatoes and kale. Apparent recoveries of the newly applied K ranged considerably, but the amounts of K tested were not the same in all experiments.

Summary

All crops tested gave larger yields on soils enriched with many past dressings of K fertilisers than on starved soils, when new K was not given but N and P fertilisers were.

Potatoes consistently responded well to new K on both starved and enriched soils, much more than the other crops.

All crops from soils enriched with residues contained more K than crops from starved soils. Thus, as for P, residues provide the growing plant with K throughout the cultivated soil. Except for potatoes, the concentration of K in each crop was increased more by residues than by the new dressings of fertiliser K. Much of the extra K taken up by cereals and sugar beet went into the straw and tops respectively.

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Reference

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APPENDIX TABLE 1

Yields of cereals grown on the Exhaustion Land at Rothamsted and on the Wheat and Barley Sites at Woburn, 1957–62

cwt/acre at 85% dry matter

Exhaustion Land, Rothamsted

Classical Experiment plot	New K dressing to seedbed lb/acre	Barley grain				Barley straw			
		1957	1958	Mean	Response	1957	1958	Mean	Response
1 no K residues	0	26·7	26·4	26·6	—	22·4	37·5	30·0	—
	14	22·7	26·8	24·8	−1·8	19·6	40·2	29·9	−0·1
	28	22·2	26·5	24·4	−2·2	21·3	38·6	30·0	0·0
	56	30·2	26·5	28·4	1·8	27·0	39·8	33·4	3·4
7 with K residues	0	29·3	27·0	28·2	—	25·0	39·5	32·2	—
	14	27·5	26·3	26·9	−1·3	22·9	42·7	32·8	0·6
	28	28·9	28·6	28·8	0·6	25·3	39·2	32·2	0·0
	56	28·4	28·3	28·4	0·2	23·1	41·3	32·2	0·0
		Spring wheat grain				Spring wheat straw			
		1957	1958	Mean	Response	1957	1958	Mean	Response
1 no K residues	0	25·6	27·1	26·4	—	36·0	43·6	39·8	—
	14	21·4	26·7	24·0	−2·4	32·4	44·3	38·4	−1·4
	28	28·8	26·8	27·8	1·4	43·8	46·1	45·0	5·2
	56	23·6	27·8	25·7	−0·7	33·7	50·9	42·3	2·5
7 with K residues	0	22·5	25·0	23·8	—	31·2	45·0	38·1	—
	14	24·4	25·9	25·2	1·4	32·9	49·3	41·1	3·0
	28	24·7	27·2	26·0	2·2	35·2	49·4	42·3	4·2
	56	20·5	27·0	23·8	0·0	28·8	50·1	39·4	1·3

VALUE OF RESIDUES FROM POTASSIUM FERTILISERS

Wheat Site, Woburn

Classical Experiment plot	New K dressing to seedbed lb/acre	Barley grain 1960	Barley grain 1962	Barley grain Mean	Barley grain Response	Barley straw 1960	Barley straw 1962	Barley straw Mean	Barley straw Response
7 no K residues	0	24·5	28·9	26·7	—	27·8	13·5	20·6	—
	14	25·9	31·9	28·9	2·2	26·0	27·7	26·8	6·2
	56	26·2	32·1	29·2	2·5	30·6	30·7	30·6	10·0
8 with K residues	0	19·0	26·9	23·0	—	24·2	21·1	22·6	—
	14	18·7	26·4	22·6	−0·4	26·5	23·7	25·1	2·5
	56	17·9	27·4	22·6	−0·4	27·1	24·5	25·8	3·2
9 with K residues	0	24·2	28·5	26·4	—	28·5	28·0	28·2	—
	14	24·5	—	—	—	29·9	—	—	—
	56	26·4	26·5	26·4	0·0	32·4	29·6	31·0	2·8

Barley Site, Woburn

Classical Experiment plot	New K dressing to seedbed lb/acre	Barley grain 1960	Barley grain 1961	Barley grain Mean	Barley grain Response	Barley straw 1960	Barley straw 1961	Barley straw Mean	Barley straw Response
7 no K residues	0	20·6	25·9	23·2	—	21·9	30·1	26·0	—
	14	21·3	25·6	23·4	0·2	22·0	29·1	25·6	−0·4
	56	23·0	26·2	24·6	1·4	23·9	31·8	27·8	1·8
8 with K residues	0	23·4	25·3	24·4	—	24·4	33·3	28·8	—
	14	24·0	27·9	26·0	1·6	23·9	31·5	27·7	−1·1
	56	23·8	25·7	24·8	0·4	26·4	33·5	30·0	1·2
9 with K residues	0	25·0	28·1	26·6	—	27·1	33·1	30·1	—
	14	27·3	27·3	27·3	0·7	28·1	30·4	29·2	−0·9
	56	26·9	25·7	26·3	−0·3	28·7	29·7	29·2	−0·9

APPENDIX TABLE 2

Yields of potatoes grown on the Exhaustion Land at Rothamsted and on the Wheat and Barley Sites at Woburn, 1957–62

Tubers, tons/acre

Classical Experiment plot	New K dressing to seedbed lb/acre	Exhaustion Land, Rothamsted 1957	1958	Mean	Response
1 no K residues	0	4·7	8·8	6·8	—
	28	7·9	9·7	8·8	2·0
	56	11·5	12·1	11·8	5·0
	112	10·9	13·9	12·4	5·6
7 with K residues	0	10·0	12·1	11·0	—
	28	11·4	13·8	12·6	1·6
	56	14·0	14·9	14·4	3·4
	112	14·1	15·2	14·6	3·6

		Woburn Wheat Site 1960	Barley Site 1960	Mean	Response
7 no K residues	0	11·9	14·3	13·1	—
	28	14·2	17·0	15·6	2·5
	112	17·0	18·2	17·6	4·5
8 with K residues	0	15·2	16·9	16·0	—
	28	14·9	17·2	16·0	0·0
	112	16·2	18·8	17·5	1·5
9 with K residues	0	16·3	16·4	16·4	—
	28	17·7	16·0	16·8	0·4
	112	19·3	18·2	18·8	2·4