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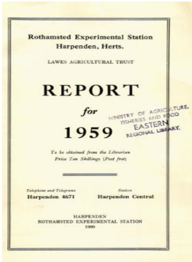
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The Exhaustion Land Site : an Account of Experiments Made Before and During the Period of Soil Exhaustion

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THE EXHAUSTION LAND SITE

An Account of Experiments made before and during the Period of Soil Exhaustion

By

R. G. Warren & A. E. Johnston

The Exhaustion Land site is a strip of $2\frac{1}{2}$ acres of arable land at the north end of Hoosfield and derived its name from the unmanured cereal cropping which began in 1902 to measure the residual effects of manures that had been applied in previous experiments. From 1852 to 1902 Lawes and Gilbert used the site for a succession of three experiments. The first, which lasted only 4 years, was a test of the Lois Weedon system of husbandry and was followed by a 20-year wheat experiment consisting of a few of the Broadbalk fertiliser treatments. In the last 26 years before the exhaustion period began there was a manurial experiment on potatoes.

The " Lois Weedon " Plots at Rothamsted, 1852–55

In 1849, during an agricultural depression, the Rev. Samuel Smith promised, in a pamphlet entitled *A Word in Season to the Farmer*, a profit of £4–£6/acre to those who adopted his system of growing wheat year after year without manure. The system, devised and employed by Mr. Smith on the heavy land portion of his 12-acre farm at Lois Weedon, Towcester, Northants, was not continuous wheat as on Broadbalk (until 1925), but was a succession of wheat and fallow strips across the field so that only half the area was in wheat each year. Each strip was 3 feet wide, was sown with three widely spaced rows of wheat at the low seed rate of 1–2 pecks (15–30 lb.)/acre and was cropped and fallowed in alternate years. An essential feature of the system was the intensive cultivation of the strips when they were in fallow, during which the subsoil was broken up and allowed to weather before it was mixed with the surface soil. The results from this system of growing wheat on the heavy land part of the Lois Weedon farm are summarised by Mr. Smith in his book *Lois Weedon Husbandry* (London, James Ridgway, 1856):

> " The ten years' average from this moiety of the acre has been thirty-four bushels; a very high average on any plan from a whole acre. And here, too, therefore, the proverb holds good —The half is more than the whole."

Lawes is most widely known in connexion with superphosphate and experiments testing the effects of different manures on individual crops grown continuously on the same land. However, Lawes and Gilbert were also interested in crop rotations, and in 1851 they began preparations for some " Lois Weedon " plots at Rothamsted on the site at the north end of Hoosfield. At the same time they also started on 1 acre of land adjoining the " Lois Weedon " plots a comparison of wheat after fallow for which normal methods of cultivation were to be used and the crop grown without manure. This comparison developed into a long-term experiment, known as the Alternate Wheat and Fallow Experiment. On the " Lois Weedon " plots Lawes and Gilbert followed the operational details as published by Mr. Smith. The fallow strips were, in fact, trenched to 14 or 15 inches.

The " Lois Weedon " plots failed to give the good results that Mr. Smith obtained on his own farm. Not only were yields lower than on the Alternate Wheat and Fallow Experiment but also lower than those of the continuously cropped unmanured plot on Broadbalk. The " Lois Weedon " experiment on Hoosfield was ended after the harvest of 1855. During the course of the experiment half the land had been trenched once and the other half twice.

Winter Wheat Experiment 1856–74

Lawes and Gilbert were sure that the low yields on the " Lois Weedon " plots at Rothamsted were caused by the low seed rate prescribed for the system, but nevertheless they began a search for the reasons that would explain the success of the system at Lois Weedon and the failure at Rothamsted. Smith suggested that a deficiency of minerals was one of the causes of the failure on Hoosfield at Rothamsted, but Lawes and Gilbert thought that the amount of assimilable nitrogen in the soil was more important. Broadbalk up to this time had demonstrated the greater importance of nitrogen for wheat. To confirm this for the Hoosfield soil they started in 1856 to test some of the Broadbalk manurial treatments on the site of the Lois Weedon strips. There were four plots, each containing an equal proportion of the trenched fallow and stubble ground, and the four treatments selected were unmanured, ammonium salts only, minerals only and ammonium salts with minerals; the fertiliser rates were the same as those of plots 5, 10 and 16 on Broadbalk, 1855. The land was prepared in the autumn of 1855 in the normal way, manures including the ammonium salts were applied in the autumn, and winter wheat sown at about 2 bushels/acre. On the north side of the plots there was another unmanured strip. This was narrower than each of the four plots and later formed part of plots 1 and 2 of the potato experiment, 1876–1901.

The results of the first year of this wheat experiment were similar to those for the comparable plots on Broadbalk and led Lawes and Gilbert to make the following statement in their account of the Lois Weedon System (*J. R. agric. Soc.* **17** (1st Series), 1856, p. 591):

> " Hundreds of other experiments, and the whole range of recorded agricultural experience, conspire to show, that in ordinarily cropped and cultivated soils, the available mineral supplies are generally in excess relatively to the available supply of nitrogen of the soil and season, in the case of the wheat crop: in fact that, excepting in cases of very special and unusual exhaustion of the mineral or soil-proper constituents, the direct supply of them by manure for wheat does not increase the crop in any practicable and agricultural degree, unless there be a liberal provision of *available and assimilable nitrogen in the soil.*"

The results showed that a supply of " available " nitrogen was more important than deep cultivation on the Hoosfield soil but did not explain the success of the system at Lois Weedon. Lawes and Gilbert never offered a satisfactory solution to this problem, for they drew no conclusions from their figures for total nitrogen in the soil and did not supply any figures to indicate the amount of " assimilable " nitrogen in the soil. It can be said now that, as the land at Lois Weedon had been old grassland it probably contained more " available " nitrogen than the Rothamsted soil. The turf had been pared off and used on other land for root crops, but the remaining soil evidently contained ample mineralisable nitrogen, because Smith made the following comment in his book:

> " This fresh-broken up land for several years produced over-luxuriant crops and very frequently the usual evil results."

The wheat experiment on Hoosfield continued until 1874. The results for the first 6 years (*J. R. agric. Soc.* **25** (2nd Series), 1864, p. 449) continued to resemble those on Broadbalk, but in later years the yields of wheat in the Hoosfield experiment were lower and the response to nitrogen less. The average yields for 5-year periods from 1856 to 1870 for Hoosfield and Broadbalk are given in Table 1.

TABLE 1

Yields of wheat on Hoosfield and Broadbalk, 1856–70

Five-year averages of dressed grain, bushels/acre

Years	Treatment: Unmanured		Ammonium salts		Minerals		Ammonium salts and minerals	
	H *	B	H	B	H	B	H	B
1856–60 ...	16	16	29	24	18	20	37	36
1861–65 ...	10	15	18	28	14	16	36	42
1866–70 ...	10	13	13	24	13	15	20	32

Fertiliser Dressings per acre:
Ammonium salts—
200 lb. ammonium sulphate
200 lb. ammonium chloride

Minerals—
200 lb. potassium sulphate †
100 lb. sodium sulphate
100 lb. magnesium sulphate
Superphosphate prepared from 200 lb. calcined bone and 150 lb. sulphuric acid.

* H = Hoosfield; B = Broadbalk.

† 300 lb. potassium sulphate, 200 lb. sodium sulphate in the three years 1856–58; the quantities were then reduced as they were on Broadbalk.

Lawes and Gilbert did not comment on the difference between the behaviour of the Broadbalk and Hoosfield wheat plots during the years 1861–70. A note in the record book of the Hoosfield experiment, however, stating that the land was very foul with weeds in 1870, may partially explain the lower yields. The site was fallowed in 1871 and 1872 and was again cropped with wheat in 1873 and in 1874, the first of the two crops was unmanured. For the 1874 crop the minerals were not given and the ammonium salts were *withheld until the spring* and then applied at only *half the usual rate.*

The yields were higher than those on the corresponding plots on Broadbalk and the response to nitrogen greater. It is worth noting here that the time of applying ammonium salts on Broadbalk, except Plot 15, was changed from autumn to spring for the 1878 crop and altered again for the 1884 crop to a divided dressing, part being given in autumn and part in spring. Starting in 1873, Plot 15 received all its ammonium salts in spring, then for the 1878 crop all the nitrogen was applied in autumn, the current practice. The Hoosfield experiment ended with the 1874 crop, and the land was fallowed in 1875.

Potato Experiment 1876–1901

In 1873, after a virulent attack of potato disease in the previous year, a special committee of the Council of the Royal Agricultural Society initiated investigations on the potato crop. As a part of these investigations a questionnaire on the cultivation of the crop was sent to leading growers. In the report on the questionnaire by Jenkins (*J. R. agric. Soc.* **10** (2nd Series), 1874, p. 475) one feature which must have interested Lawes and Gilbert was the considerable variation in the manuring of the crop, though many growers did use farmyard manure. A few years earlier Voelcker had published the results of several experiments on the manuring of potatoes in the *Journal of the Royal Agricultural Society* [**3** (2nd series), 1867, 500; **6** (2nd Series), 1870, 392; **7** (2nd Series), 1871, 365]. Voelcker concluded that good crops of potatoes could be grown on light land comparatively cheaply by using fertilisers consisting of ammonium sulphate, superphosphate and potassium sulphate. On heavy land " in good agricultural condition " he considered that ammonium sulphate could be omitted or less used and that, on this type of land, sodium nitrate may be more effective than ammonium sulphate.

Lawes and Gilbert began their manurial experiment on potatoes in 1876, and although one of the objects was to find whether the type of manuring was related to the amount of disease in the crop, the main purpose of the experiment was to obtain information on the nutrient requirements of the potato crop. The wheat site was extended about 12 links on the north side to make the fifth strip nearly the same width as the remainder, and the five strips were then halved. The new plot numbers of the potato experiment and the corresponding wheat plot numbers, together with the manurial treatments, are shown opposite one another in Table 2.

TABLE 2

Wheat Experiment	Potato Experiment	
Plot 1 (P, K, Na, Mg)	Plot 9 (P)	Plot 10 (P, K, Na, Mg)
2 (N, P, K, Na, Mg)	7 (N, P, K, Na, Mg)	8 (N*, P, K, Na, Mg)
3 (N)	5 (N)	6 (N*)
4 (O)	3 (dung, P)	4 (dung, N*, P)
5 (O)	1 (O)	2 (dung)

N = Ammonium salts.
N* = Sodium nitrate.

The fertiliser treatments from the wheat were continued in the potato experiment, and new treatments with farmyard manure and sodium nitrate were added.

The results of the first 12 years of the experiment were given in a lecture by Gilbert at the Royal Agricultural College, Cirencester, in 1888 and published in the *Agricultural student gazette*, New Series, **4**, part 2. The average yields during the first and second 6-year periods are given in Table 3, together with the average yields during the remaining years of the experiment, 1888–1901.

TABLE 3

Average annual yields of potatoes grown continuously on Hoosfield 1876–1901

Plot	Treatment	Years 1876–81	1882–87	1888–1901
1	Unmanured	2·28	1·69	0·84
5	N	2·51	2·07	1·19
6	N*	3·20	2·04	1·69
9	P	3·98	3·35	1·91
10	P, K, Na, Mg	4·14	3·39	2·17
7	N, P, K, Na, Mg	7·52	5·94	4·12
8	N*, P, K, Na, Mg	7·78	5·52	4·38
2	F.Y.M.§	5·23	3·05	1·48
3	F.Y.M., P †	5·58	4·25	4·62
4	F.Y.M., N*, P ‡	7·11	4·01	4·74

Fertiliser rates per acre:

N	200 lb. ammonium sulphate + 200 lb. ammonium chloride
N*	550 lb. sodium nitrate
P	1876–1896 3½ cwt. of superphosphate
	1897–1901 400 lb. basic slag
K	300 lb. potassium sulphate
Na	100 lb. sodium sulphate
Mg	100 lb. magnesium sulphate
F.Y.M.	Farmyard manure 14 tons

§ 1876–81, farmyard manure: 1882–1901, unmanured.
† 1876–82, farmyard manure and superphosphate, 1883–1901, farmyard only.
‡ 1876–81, farmyard manure, sodium nitrate and superphosphate; 1882, farmyard manure and superphosphate: 1883–1901, farmyard manure only.

Yields from different treatments must be compared only in the same period, as the variety of potato grown changed during the experiment. Changes were also made in the three farmyard manure treatments. Further, in this experiment with only a few plots and with each treatment represented by one plot, the results from the single nutrient tests (plots 5, 6 and 9) do not give useful information on the requirements of the potato crop. It is also necessary to mention that the yields of plot 9 (P) may be misleading, at least for the early years, because it received P and K fertilisers each year during the preceding experiment on wheat. The wheat crops probably used not more than one-quarter of the added K and left appreciable residues in the soil. The best information is derived from comparing the yields on the plot which received minerals only (10) with those of plots that had minerals and nitrogen (7 and 8) or had farmyard manure (2, 3 and 4). In the first 6 years of the experiment the full complement of fertilisers gave yields above the average for the country and above the yield obtained by farmyard manure alone. Both forms of fertiliser nitrogen, ammonium sulphate and sodium nitrate, at 86 lb. N/acre on plots 7 and 8 did equally well and produced about 3·5 tons more tubers per acre than the minerals alone (plot 10). The yields on the three farmyard manure plots for the same period indicate that the farmyard manure contained much less available nitrogen than was supplied by the complete fertiliser treatments. Adding superphosphate to the farmyard manure increased the yield by only ⅓ ton, whereas adding superphosphate and sodium nitrate gave nearly 2 tons more tubers per acre. Although the experiment showed that the 14 tons of farmyard manure was more deficient in nitrogen than phosphorus, it provided no evidence on the potassium status of the manure. In the second 6-year period the complete fertilisers continued to give higher yields than farmyard manure, but in the last 14 years the average yield from farmyard manure was 0·4 ton/acre more than from the complete fertilisers.

The determination of the amounts of nitrogen, phosphorus and potassium in agricultural crops was an important part of Lawes' and Gilbert's investigations. The large differences they found between the N, P and K contents of a crop and the amounts in the manures applied to the crop led them to make single plot tests to measure the effect of the unused nutrients on succeeding crops. In several of their experiments (e.g., Broadbalk, Hoosfield barley and Park Grass) a manurial treatment was discontinued but the land was cropped as usual. The three farmyard manure treatments in the Hoosfield potato experiment were modified to produce further information on the effect of residues, and they published several papers on the valuation of unexhausted manure, their principal concern being with the cash value of manurial residues from different feeding-stuffs. In the last paper (*J. R. agric. Soc.* **8** (3rd Series), 1897, 674) they gave the following conclusions from the Rothamsted experiments on the effect of manurial residues on succeeding crops:

1. Heavy and repeated dressings of organic manures must be given before effective residues are built up in the soil. Plant nutrients are released only slowly from the residues, more slowly in heavy soils than in light ones. Three-quarters of the increased yield of barley given by the farmyard manure comes from nitrogen in the residues.
2. The use of inorganic N fertilisers over long periods may give residual effects because the crop residues left in the soil are increased. For wheat the effect is small.
3. A considerable portion of the P and K added as fertilisers is fixed in the soil and is only slowly available to subsequent crops.

The Exhaustion Land Experiment 1902–58

After Lawes died in 1900 and Gilbert in 1901, Hall decided to end the potato experiment because the physical condition of the soil that had not received farmyard manure was poor and unsuitable for potatoes.

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At the end of the wheat and potato experiments the plots on the Exhaustion Land site had received the following treatments:

Number of dressings each plot received, 1856–1901*

Plot no.	1	2	3	4	5	6	7	8	9	10
Treatment:										
Farmyard manure	—	6	26	26	—	—	—	—	—	—
PK	—	—	—	—	—	—	42	42	17	42
P...	—	—	7	7	—	—	—	—	25	—
N...	—	—	—	6	44	44	44	44	—	—

Average dressing per acre: farmyard manure 14 tons, superphosphate 3 cwt., ammonium salts $3\frac{1}{2}$ cwt. or sodium nitrate 5 cwt., potassium sulphate $2\frac{1}{2}$ cwt.

* The number of dressings given in *Proc. Fertil. Soc.* 1956, No. 37, have been corrected here to allow for the omission of N in 1 year and PK in 3 years.

The amounts of nitrogen, phosphorus and potassium removed in the wheat and potato crops cannot be estimated precisely, because only a few of the crops were analysed, but a large part of the P and K applied was left in the soil.

After the potato experiment the site was cropped from 1902 to 1940 without manure to measure the duration of the residual effects of the previous manures. The crops were cereals, mainly barley, except on plots 5–10, where there was a soil inoculation trial on clover, 1905–11. The yields of the cereals were recorded regularly only till 1922. Beginning in 1941 the cereals received $2\frac{1}{2}$ cwt./acre of ammonium sulphate each year, and from 1949 the yields were again recorded. Table 4 gives the yields of cereals for three periods, 1902–4, 1917–22 and 1949–53. In 1902, the first year after manuring had ended, barley yielded well (28–34 cwt. grain/acre) on the plots that had previously received farmyard manure or N fertilisers, and the residues from these treatments increased yield by 18 cwt. and 14 cwt. of grain/acre over the unmanured plots. Only the farmyard manure plots, however, continued to yield well in the next 2 years. Hall (*The Book of the Rothamsted Experiments*, 1905) considered that the large 1-year residual effects on the N fertiliser plots came from the increases in crop residues in the soils of these plots rather than from any accumulation of unchanged fertiliser ammonium or nitrate. By 1917 the yields of all plots were very low and the farmyard manure residues gave only small increases in the years 1917–22. The yields of the fertiliser plots, including those which had not received N in the wheat and potato experiments, were also a little higher than those of the unmanured plots, but clover residues probably still remained in these plots and provided a little nitrogen for the cereal crops.

The method of measuring residual effects so far adopted, without new additions of any of the three nutrients N, P, K, gave no information on the contribution to yield of any one of the nutrients contained in the residues; nor did it indicate whether one nutrient in the residues was limiting the effects of the others. In the last period, 1949–53, for which yields are given in Table 4, the effects were restricted to the combined effects of the P and K residues by applying a basal N dressing. The increases in yield were large and were similar for the PK fertiliser residues (10 cwt. barley grain/acre)

TABLE 4

Exhaustion Land 1902–58

Yields of grain cwt./acre 85% dry matter

Plot	Year: / Crop: / Treatment 1856–1901	1902 Barley	1903 Barley	1904 Oats	1917 Barley	1918 Barley	1919* Barley	1921 Wheat	1922 Barley	1949 Barley	1950 Barley	1951 Barley	1952 Barley	1953 Barley
1	Nil	16·0	4·6	11·1	2·2	3·9	2·2	6·1	5·8	7·6	11·3	13·6	12·9	15·8
2	Nil †	17·1	7·3	10·4	4·3	5·1	3·5	10·1	7·0	10·0	15·1	12·7	10·1	11·8
5	N	28·5	9·2	11·6	2·5	5·6	3·5	10·9	7·8	8·7	12·5	15·2	16·5	17·4
6	N * ‡	30·3	9·0	10·9	3·4	7·6	3·6	12·4	7·9	13·0	14·7	11·2	13·1	14·6
9	P §	16·9	6·4	10·9	3·0	6·9	4·2	15·7	7·5	23·4	24·4	23·4	19·7	20·0
10	PK	12·0	6·2	9·9	3·2	7·1	5·1	15·2	7·0	27·0	26·6	26·4	21·8	21·8
7	NPK	31·0	13·9	14·9	5·6	10·1	5·7	14·1	7·8	23·0	22·2	24·1	21·3	21·4
8	N*PK ‡	32·3	12·6	15·7	5·4	9·2	4·4	14·7	7·8	27·9	26·3	23·8	21·4	20·2
3	F.Y.M.‖	34·2	22·6	26·8	3·5	7·9	5·4	14·1	9·6	26·8	24·2	22·9	23·2	22·4
4	F.Y.M.¶	34·9	21·6	29·6	4·7	7·7	6·0	15·7	9·7	25·9	29·0	25·1	22·8	22·8

* Land fallowed in 1920.
N Ammonium salts.
N* Sodium nitrate.
† Farmyard manure 1876–81, unmanured, 1882–1901.
‡ As ammonium salts, 1856–75; as sodium nitrate, 1876–1901.
§ PK, 1856–75; P, 1876–1901.
‖ Farmyard manure and superphosphate, 1876–1882; farmyard manure only, 1883–1901.
¶ Farmyard manure, sodium nitrate and superphosphate, 1876–81; farmyard manure and superphosphate, 1882; farmyard manure only, 1883–1901.

and the farmyard manure residues (11 cwt./acre). From the large increases on the old farmyard manure plots from 1949 to 1953, compared with the small ones from 1917 to 1922, it was concluded that after a long period of cereal cropping the organic manure residues supplied very little N and that the amounts of available P and K they contained were much more important. Lawes' conclusion that N caused three-quarters of the effect of farmyard manure residues was derived from the results of barley grown on new and relatively new residues. Although the large effects of the farmyard manure and PK fertiliser residues could, when basal N was given, result from the combined effects of P and K, Warren (*Proc. Fertil. Soc.* 1956, No. 37) concluded from the analysis of the crops that the increases with barley resulted almost entirely from P. The analyses of the barley crops also showed that 4–5 lb. more P/acre was removed each year from the PK fertiliser and farmyard manure residue plots than from the unmanured plots. This extra P is a small annual recovery and is equal to only 0·5% of the total P applied either as superphosphate or farmyard manure in the years before 1902. For K the extra amount removed was 15–19 lb./acre, which also represents only a small annual recovery of the K residues.

In 1953 parts of the plots in the west half of the experiment were found to be acid. Differential chalk dressings were applied to the acid area in the winter 1954–55. The whole site continued in barley during the period 1954–56, but in 1957 six crops (barley, spring wheat, potatoes, sugar beet, swedes and kale) were grown in strips across the plots (1, 3, 5, 7 and 9) in the east half of the experiment. The crops were separated by fallow strips which were used for the crops in the next year. Each strip was divided into microplots, and new additions of P and K were superimposed on the old treatments. All plots received a basal dressing of N fertiliser, basal P fertilisers were given when K was being tested and basal K was given where test dressings of P were applied. All fertilisers were applied broadcast except for potatoes where they were put in the bouts. Table 5 shows increases in yields produced by new additions of P and K for the six crops grown in each year.

TABLE 5

The increases in yields given by fresh additions of P and K fertilisers in the Exhaustion Land experiment

	Increase from new dressing of 1·0 cwt. P_2O_5/acre				Increase from new dressing of potassium fertiliser *			
Manuring in 1856–1901 period	No phosphate		Phosphate		No potassium		Potassium	
Year	1957	1958	1957	1958	1957	1958	1957	1958
Barley (cwt. of grain) ...	6	15	0	5	1	0	0	1
Wheat (cwt. of grain) ...	2·5	10	0	2	0	1	0	0·5
Potatoes (tons of tubers) ...	8	8	4	5·5	6·5	5	4	3
Sugar beet (tons of roots) ...	3·5	4·5	0	2	0	3·5	0	0
Swedes (tons)	5	13	0·5	3	0	2	0	0
Kale (tons)	6	6	2·5	2	1	0	2·5	0

* 1·2 cwt. K_2O/acre for potatoes, sugar beet and kale; 0·6 cwt. K_2O/acre for cereals and swedes.

Potatoes, sugar beet and kale responded similarly in both years to new dressings of phosphate where the crops were grown on soil that had received no phosphate from 1856 to 1901 (and none since). The mean yield of sugar beet in 1958 was 50% and of kale 25%

greater than in 1957; potatoes gave similar mean yields in the 2 years. On the same soil the response of swedes to new dressings of phosphate was much greater in 1958 (13 tons/acre) than in 1957 (5 tons/acre); the mean yield of swedes in 1958 was double that obtained in 1957. The phosphate residues from the old manuring were sufficient for full crops of barley, wheat, sugar beet and swedes in 1957, but not in 1958. In 1958 the phosphate residues were equivalent to about one-half to four-fifths of the value of the new phosphate fertiliser dressing for these crops. For potatoes and kale the phosphate residues were inadequate in both years: each year the extra yield of potatoes from the residues was only half as great as the increase given by a new dressing of 1 cwt./acre P_2O_5. For kale the corresponding extra yields in the 2 years were about two-thirds as great as the responses to new dressings.

On soil that received no potassium manuring between 1856 and 1901 (and none since) fresh dressings of potassium fertiliser greatly increased yields of potatoes in both years. In 1957 yield of the other crops was little increased by the fresh dressings of potassium; in 1958, however, new dressings of potassium also increased the yields of sugar beet and swedes, but not of cereals or kale. On the plots that had received potassium between 1856 and 1901 barley, wheat, sugar beet and swedes obtained enough potassium in both years from the residues left in the soil. Potatoes, however, responded well to fresh dressings of potassium in both years, kale gave a moderate increase in yield in 1957 only.

The amount of nitrogen mineralised each year from the farmyard manure residues was not measured. It is thought to have been small in recent years, as the average increase in yield from the residues was only 3 cwt. grain/acre in the years 1917–22, when the residues were supplying adequate amounts of P and K for cereals. The experiments have also not assessed the value of the farmyard manure and PK fertiliser residues for crops such as beans, clover, grass and lucerne. Because the annual rates of extraction of P and K from the residues by crops was determined over a short period only, the total amounts of P and K that may still be taken up from the residues cannot be estimated. The experiments indicate, however, that the percentage recoveries in crops of the P and K added as farmyard manure or fertilisers are greater than is commonly supposed.