ROTHAMSTED RESEARCH

# Report for 1937

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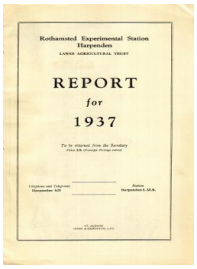


## Arable Land

### Rothamsted Research

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expected, the responses to both manures are greater on plots without manuring in the previous year than on plots which were then manured. The average differences between the increases to artificials and the increases to compost are 3.7 cwt. per acre on plots unmanured and 7.0 cwt. per acre on plots manured. This indicates that artificials are more effective relatively to compost at higher levels of yield.

TABLE III

*First Year Residual Effects of Artificials and Compost*

| | No manure in current year | | Manured in current year | |
|---|---|---|---|---|
| | Response to | | Response to | |
| | Artificials | Compost | Artificials | Compost |
| 1933 | +0.7 | +2.8 | −0.8 | −0.9 |
| 1934 | +9.8 | +21.7 | +8.1 | +7.8 |
| 1935 | +2.8 | +9.7 | −3.2 | +5.2 |
| 1936 | +7.5 | +10.2 | +1.4 | +3.4 |
| 1937 | +3.2 | +13.4 | −1.8 | −2.3 |

In most years there were also good responses to a previous year's dressing of manures on plots receiving no manure in the current year. The relative effectiveness of the two manures has, however, been reversed, compost giving about 6.7 cwt. per acre more than artificials. On plots manured in the current year, the residual effects were small or negligible except in 1934, in which the residual responses to the two manures were roughly equal; at these higher levels of yield compost has apparently little residual value, a result in accordance with that indicated above.

## ARABLE LAND

### The Liming Programme

Some of the results of the 1936-37 experiments have an important bearing on the liming programme of the Ministry of Agriculture. In many parts of England there is a dislike of magnesian limestone and of the lime prepared from it. We have made a number of experiments in different parts of the country but so far obtained no evidence that the magnesian limestones are detrimental. When used in the quantities indicated by the ordinary lime requirement methods they give fully as good results as the corresponding high-calcium products. In some pot experiments, indeed, magnesium proved beneficial, but not in any of the field experiments. No full survey has been made but there is no present evidence of widespread magnesium deficiency in English soils.

### Residual Effects of Chalk

The residual effects of chalk have been studied in three experiments, in two of which there were several dressings of chalk so as to determine the most effective amount to apply.

At Tunstall on an acid sandy soil, chalk was applied in 1932 but nothing was added afterwards. Sugar-beet was grown by Mr. A. W. Oldershaw, for the first four years, 1932-5.

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TABLE IV

*Sugar Beet : Tunstall. Root (tons per acre)*

| Chalk tons per acre (1932) | 1932 | | 1933 | | 1934 | | 1935 | |
|---|---|---|---|---|---|---|---|---|
| | | Increase | | Increase | | Increase | | Increase |
| None | 1.82 | | 2.94 | | Nil | | Nil | |
| 1 | 12.61 | +10.79 | 11.40 | +8.46 | 13.37 | +13.37 | 14.64 | +14.64 |
| 2 | 14.30 | + 1.69 | 13.23 | +1.83 | 16.36 | + 2.99 | 15.90 | + 1.26 |
| 3 | 14.27 | − 0.03 | 13.26 | +0.03 | 16.81 | + 0.45 | 15.43 | − 0.47 |
| 4 | 14.74 | + 0.47 | 13.91 | +0.65 | 17.26 | + 0.45 | 15.97 | + 0.54 |
| Standard Error | ± 0.432 | ± 0.611 | ± 0.437 | ±0.618 | ±0.332 | ±0.469 | ± 0.242 | ±0.342 |

The plots without chalk gave negligible yields throughout. The single dressing (1 ton chalk per acre) in 1932 raised the yield of roots to 12.6 tons per acre and continued to give good crops in subsequent years, with no indication of a decrease in effectiveness. The double dressing gave a further increase in yield each year of between 1.2 and 3 tons per acre. The 3 ton dressing proved no better than the 2 ton dressing in three years out of four. For this dressing, however, the choice of plots may have been unfortunate, since the highest dressing (4 tons) did not fail similarly but gave the best yields throughout, about half a ton per acre more roots than the 2 ton dressing.

The four levels of chalk produced no apparent differences in sugar percentage. The residual effects on the tops were similar to those on roots, except that the response fell off less sharply at the two highest dressings than with roots.

The experiment was continued with barley in 1936 and clover hay in 1937.

TABLE V

| Chalk : tons per acre (1932) | Barley : Grain 1936 | | Clover : Hay 1937 | |
|---|---|---|---|---|
| | | Increase | | Increase |
| None | Nil | | 5.0 | |
| 1 | 14.5 | +14.5 | 32.3 | +27.3 |
| 2 | 17.0 | +2.5 | 34.9 | +2.6 |
| 3 | 18.3 | +1.3 | 37.4 | +2.5 |
| 4 | 18.4 | +0.1 | 38.8 | +1.4 |
| Standard Error | — | — | ±1.04 | ±1.47 |

The residual effects persist and the results are similar to those with sugar beet, except that with both crops the 3 ton dressing has given higher yields than the 2 ton dressing.

The experiment has not yet proceeded long enough to tell how long the effects of the chalk will persist, but at least in the first five years there is little sign that the effects of the 1932 dressings are disappearing. It will also be interesting to see whether the effects of the largest dressings persist longer than those of the smaller ones.

A similar experiment has been carried out by Mr. H. W. Gardner, of the Herts. Farm Institute, at Stevenage on a gravelly loam soil with somewhat smaller dressings of chalk. The experiment started in 1933 with a crop of lucerne which failed owing to drought. Winter oats followed in 1934, but the yields were not

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recorded. The oats were undersown with a seeds mixture, which constitutes the 1935 crop, while mangolds were grown in 1936.

TABLE VI

| Chalk : cwt. per acre (1933) | 1935 Hay : cwt. per acre Yield | 1935 Hay : cwt. per acre Increase for each dressing | 1936 Mangolds roots : tons per acre Yield | 1936 Mangolds roots : tons per acre Increase for each dressing |
|---|---|---|---|---|
| None | 25.5 | | 17.22 | |
| 35 | 46.0 | +20.5 | 24.92 | +7.70 |
| 70 | 59.2 | +13.2 | 29.12 | +4.20 |
| 140 | 66.0 | +6.8 | 31.49 | +2.37 |
| 210 | 67.3 | +1.3 | 31.57 | +0.08 |
| Standard Error | ±2.70 | ±3.82 | ±1.42 | ±2.01 |

The effects of acidity are clearly much less marked than at Tunstall, moderate crops being obtained in both years even in the absence of chalk. The successive increases per 35 cwt. of chalk were 20.5, 13.2, 3.4 and 0.6 cwt. hay in 1935 and 7.70, 4.20, 1.18 and 0.04 tons mangolds in 1936. Thus the residual response falls off steadily at the higher levels of application; in particular, the highest dressing would not have proved economically efficient.

In a second experiment by Mr. Gardner, started in 1934, the residual effects on hay of chalk, potash salt, slag and Gafsa phosphate are studied alone and in combination. The phosphatic treatments have so far had no beneficial effect, while potash salt has produced only small increases which were not significant. The responses to 75 cwt. chalk applied in 1934 are shown in Table VII.

TABLE VII

*Responses to 75 cwt. chalk applied in 1934, Barnet, Herts*

| Hay cwt.per acre | Mean response | Potash: (applied in 1934) Absent | Potash: (applied in 1934) Present | Standard error | Mean yield |
|---|---|---|---|---|---|
| 1934 | +1.7 | +1.6 | +1.8 | ±0.806 | 16.1 |
| 1935 | +5.4 | +5.2 | +5.6 | ±1.17 | 28.8 |
| 1936 | +8.6 | +4.4 | +12.8 | ±1.55 | 35.7 |
| 1937 | +5.9 | +6.3 | +5.5 | ±1.38 | 25.7 |

As in the other experiments there is no sign that the effects of chalk are dying away, good responses being obtained in each of the last three seasons. In 1936 the effectiveness of chalk was increased by the presence of potash, the increase to chalk being 12.8 cwt. with potash present as against 4.4 cwt. with no potash. In the other years, however, the response to chalk has not been affected by potash.

## Organic Manures

The growing shortage of stable manure has seriously curtailed the supply of organic manure for the soil and alternative sources are being studied. More and more there is a tendency to divert waste products to other purposes but certain products, particularly sewage sludge and town refuse, still offer some possibilities. The manurial value of town refuse treated by a new process is being tested.

The experiments on the making of artificial farmyard manure from straw have been much facilitated and improved as a result of the erection of the new building at the farm.

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*Early Results with Farmyard Manure at Rothamsted*

On the Classical fields farmyard manure has been compared with artificial fertilisers for a long series of years under continuous cropping conditions.

TABLE VIII

| Field | Crop | Period | Average Yield | | |
|---|---|---|---|---|---|
| | | | No manure | Farmyard manure | Best artificial treatment |
| Broadbalk .. | Wheat | 1852–1925 | *Plot* 3. Grain 6.7 cwt. Straw 9.8 ,, | *Plot* 2B. Grain 19.4 cwt. Straw 34.2 ,, | *Plot* 8. Grain 20.1 cwt Straw 39.8 ,, |
| Hoosfield .. | Barley | 1852–1928 | *Plot* 1O. Grain 6.2 cwt. Straw 7.8 ,, | *Plot* 7-2. Grain 20.7 cwt. Straw 28.1 ,, | *Plot* 4A. Grain 18.2 cwt. Straw 23.6 ,, |
| Barnfield .. | Mangolds | 1876–1935 | *Plot* 8O. Roots 3.39 tons Tops 0.98 tons | *Plot* 1O. Roots 17.59tons Tops 3.06tons | *Plot* 4N. Roots 17.79tons Tops 3.86tons |

Farmyard manure used annually maintains a satisfactory level of yield, which is equalled in the case of wheat grain and mangolds roots and approached in the case of barley grain by a heavy complete annual dose of artificials.

Other classical plots showed that the cumulative effects of repeated dressings of farmyard manure were considerable and persisted for a long period after the manuring was stopped. Thus on Hoosfield the following yields were recorded in the past three seasons some 65 years since the dung on Plot 7-1 was discontinued :—

*Barley, cwt. per acre*

| Plot | 1935 | | 1936 | | 1937 | |
|---|---|---|---|---|---|---|
| | Grain | Straw | Grain | Straw | Grain | Straw |
| 1-0 Unmanured since 1852 | 5.2 | 11.1 | 5.9 | 12.4 | 2.3 | 6.1 |
| 7-1 14 tons dung 1852-71 then unmanured .. | 20.0 | 23.7 | 12.8 | 18.9 | 3.6 | 13.3 |
| 7-2 14 tons dung annually since 1852 .. .. | 33.9 | 59.3 | 28.1 | 42.2 | 15.2 | 31.7 |

Similar results appeared on Hoosfield when the permanent potato plots, which for 26 years (1876-1901) had received annual dressings of 14 tons of farmyard manure, were discontinued and cropped with cereals without further manure. In the last four crops for which yields were recorded the figures were :—

TABLE IX

| | Plot 1 | | Plot 3 | |
|---|---|---|---|---|
| | Unmanured since 1876 | | Dung 14 tons per acre annually for 26 years 1876-1901, afterwards unmanured | |
| | Grain | Straw | Grain | Straw |
| | bush. | cwt. | bush. | cwt. |
| 1918 Barley | 8.4 | 4.0 | 16.2 | 8.6 |
| 1919 Barley | 4.7 | 3.2 | 11.5 | 6.4 |
| 1921 Wheat | 10.5 | 9.1 | 24.3 | 24.6 |
| 1922 Barley | 13.0 | 7.4 | 21.6 | 11.3 |

The manner of storage of farmyard manure was studied in field experiments in 1915-16. The results showed the increase in crop producing power caused by keeping the dung heaps compact, and in particular by providing them with some shelter. *

* E. J. Russell and E. H. Richards, J. A. S. 1917, Vol. 8. pp. 495-563, and J. R. A. S. E. 1916, Vol. 77, pp. 1-36.

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Although dung is so widely used, its effects have seldom been measured in replicated experiments owing to the difficulty of applying this bulky material to scattered small plots.

*Modern Replicated Experiments on Farmyard Manure*

The material available consists of eleven experiments each on sugar beet and potatoes, four on beans (summarised on p. 49), five on mangolds (summarised on p. 43), two each on swedes and kale and one on wheat. The residual effects of the manure on the succeeding crop have also been studied in several experiments.

*Direct effects*

TABLE X

*Direct Effects of Farmyard Manure*
*Potatoes tons per acre*

| Year | Centre | Mean yield | Increase for dung | Quantity of dung tons/acre |
|---|---|---|---|---|
| 1915 | Rothamsted .. .. | 6.71 | +3.19 | 10 |
| 1916 | Rothamsted .. .. | 3.19 | +1.12 | 20 |
| 1920 | Rothamsted .. .. | 9.21 | +1.98 | 15 |
| 1932 | Rothamsted .. .. | 11.54 | +1.10 | 15 |
| 1934 | Rothamsted .. .. | 9.95 | +2.23 | 20 |
| 1935 | Rothamsted .. .. | 5.24 | +2.36 | 15 |
| 1936 | Rothamsted .. .. | 5.21 | +2.18 | 15 |
| 1937 | Rothamsted .. .. | 6.16 | +2.46 | 15 |
| 1934 | Wimblington .. .. | 7.81 | +5.00 | 8 |
| 1935 | Wimblington .. .. | 7.14 | +2.47 | 8½ |
| 1936 | Wimblington .. .. | 8.25 | +1.18 | 6½ |
| | *Sugar Beet Roots (tons per acre)* | | | |
| 1933 | Rothamsted .. .. | 6.46 | +2.34 | 20 |
| 1934 | Rothamsted .. .. | 14.03 | +1.26 | 10 |
| 1935 | Rothamsted .. .. | 11.57 | +1.23 | 10 |
| 1936 | Rothamsted .. .. | 14.84 | +1.68 | 10 |
| 1937 | Rothamsted .. .. | 14.14 | +1.04 | 10 |
| 1937 | Woburn .. .. .. | 16.06 | +0.74 | 10 |
| 1936 | Gainsborough .. .. | 12.76 | +0.08 | 10 |
| 1936 | Wragby .. .. .. | 12.21 | +0.74 | 10 |
| 1937 | Wragby .. .. .. | 13.45 | +0.74 | 10 |
| 1937 | Market Rasen .. .. | 10.63 | +0.11 | 10 |
| | *Mangolds Roots (tons per acre)* | | | |
| 1936 | Rothamsted .. .. | 25.50 | +4.20 | 10 |
| 1937 | Rothamsted .. .. | 21.40 | +2.04 | 10 |
| 1932 | Oakerthorpe .. .. | 31.20 | +8.13 | 15 |
| 1933 | Oakerthorpe .. .. | 20.58 | +4.21 | 15 |
| 1934 | Oakerthorpe .. .. | 19.56 | +9.75 | 15 |
| | *Beans Grain (cwt. per acre)* | | | |
| 1934 | Rothamsted .. .. | 18.7 | +1.9 | 10 |
| 1935 | Rothamsted .. .. | 21.0 | +5.6 | 10 |
| 1936 | Rothamsted .. .. | 16.8 | −0.1 | 10 |
| 1937 | Rothamsted .. .. | 29.0 | +2.0 | 10 |
| | *Swedes Roots (tons per acre)* | | | |
| 1922 | Rothamsted .. .. | 29.74 | +3.71 | 10 |
| 1923 | Rothamsted .. .. | 15.0 | +1.1 | 10 |
| | *Kale (tons per acre)* | | | |
| 1932 | Woburn .. .. .. | 20.99 | +4.44 | 15 |
| 1936 | Woburn .. .. .. | 13.11 | +2.42 | 10 |
| | *Wheat Grain (bushels per acre)* | | | |
| 1916 | Rothamsted .. .. | 34.8 | +3.1 | 10 |

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At Rothamsted the responses in potatoes varied from 1.1 to 3.2 tons per acre, the average response to a dressing of 15 tons being 2.1 tons per acre. At Wimblington, on a light fenland soil, dressings of about 8 tons proved very effective.

A dressing of 10 tons increased the yields of sugar beet roots by 1.3 tons per acre in the Rothamsted experiments; elsewhere the responses in roots were smaller. In most experiments dung produced a small decrease in sugar percentage.

The direct effect of 10 tons of farmyard manure is usually about equivalent to that of 2 cwt. of sulphate of ammonia. Calculated on a nitrogen basis one part of ammoniacal nitrogen is about equal to 3 parts of farmyard manure in the year of application.

In order to study the rate of exhaustion of the effects of normal dressings of dung in rotation practice an experiment on residual values was laid down in Little Hoosfield in 1904 and continued till 1926. The results showed that the dung made by cattle having a good cake ration was considerably more effective in its first year than dung made by animals on a store ration, but in the subsequent three seasons the effects of the two types of manure were very similar. The residual effects of dung of any kind were much more pronounced than those of commercial organic manures such as shoddy, guano and rape cake; but in the fourth season after application the residues of dung only increased production some 20 per cent. above the level of the continuously unmanured control plot. The design of the Little Hoos experiment was improved in the present Four-Course Rotation experiment commenced in Hoosfield in 1930. The results of the first three years of the complete cycle were summarised in the Station Report for 1936, p. 53. Dung, Adco compost, and straw with supplementary artificials are compared in direct effects and in residual action over a 5 year period. The three forms of straw manure behave in a similar manner and their residual effects are apparent at least three years after application. As the experiment proceeds the measurement of manurial effects will gain in precision.

*Methods of applying farmyard manure*

In the Rothamsted potato experiments in 1932 and 1934, dung ploughed in in autumn was compared with dung ploughed in shortly before planting in spring. In the 1934 experiment there was no appreciable difference between the effects of the two times of application, while in 1932 the spring application gave an extra increase of about one ton per acre, which was, however, not significant

In the later Rothamsted potato experiments dung ploughed in during December or January was compared with dung applied in the bouts.

TABLE XI

*Potatoes: tons per acre*

*Farmyard Manure (15 tons per acre)*

| | No dung | Ploughed in | In the bouts | Mean response | Advantage for application in bouts |
|---|---|---|---|---|---|
| 1935 | 5.24 | 7.15 | 8.06 | +2.36 | +0.91 |
| 1936 | 5.21 | 6.45 | 8.33 | +2.18 | +1.88 |
| 1937 | 6.16 | 7.64 | 9.60 | +2.46 | +1.96 |

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Application in the bouts proved definitely superior each year, giving an increase of between 1 and 2 tons per acre over the earlier application.

In the 1936 and 1937 experiments the effect of adding 2 tons of chaffed straw to the dung was also tested. With the earlier application of dung the straw was ploughed in, while with the later application the straw was mixed with the dung and stored until bouting. In both years the addition of straw produced small but not significant decreases in yield. In 1936, however, straw increased the yields on plots which also received sulphate of ammonia (applied in the bouts).

The addition of straw (1½ tons) to dung is also included in the new Woburn green manuring experiment. On plots receiving dung and 2 cwt. sulphate of ammonia, straw decreased the yield of kale by 1.0 tons per acre, while on plots receiving dung and 4 cwt. sulphate of ammonia the decrease was only 0.1 tons per acre. The difference between these figures is not significant, but it is in the same direction as in the 1936 potato experiment. In 1937 the kale crop was a very poor one and straw had no appreciable effect.

Only one experiment is available on the method of applying dung to sugar beet. At Rothamsted in 1931 dung was applied and spread three weeks before ploughing under or immediately before ploughing. The later application gave a significant increase of 0.7 tons roots over the earlier application.

TABLE XII

*Responses to Artificials*

*Potatoes (tons per acre)*

Responses to Sulphate of Ammonia

| | | Amount of sulphate of ammonia | Dung: Absent | Dung: Present | Difference Pres. minus Abs. | S.E. of difference |
|---|---|---|---|---|---|---|
| 1932 | Rothamsted . . | 0.4 cwt. N | +1.85 | +2.34 | +0.49 | ±0.471 |
| | | 0.8 cwt. N | +3.17 | +3.22 | +0.05 | ±0.471 |
| 1934 | Rothamsted . . | 0.4 cwt. N | +1.35 | +1.59 | +0.24 | ±0.476 |
| | | 0.8 cwt. N | +1.65 | +1.88 | +0.23 | ±0.476 |
| 1935 | Rothamsted . . | 0.8 cwt. N | +1.03 | +1.89 | +0.86 | ±0.329 |
| 1936 | Rothamsted . . | 0.4 cwt. N | +1.52 | +0.99 | −0.53 | ±0.612 |
| 1937 | Rothamsted . . | 0.4 cwt. N | +1.85 | +1.90 | +0.05 | ±0.366 |
| | | 0.8 cwt. N | +2.87 | +3.46 | +0.59 | ±0.366 |
| 1934 | Wimblington | 0.45 cwt. N | +0.29 | +0.83 | +0.54 | ±0.354 |
| 1935 | Wimblington | 0.5 cwt. N | +0.65 | +1.26 | +0.61 | ±0.404 |
| 1936 | Wimblington | 0.5 cwt. N | −0.01 | +0.88 | +0.89 | ±0.891 |

Responses to Sulphate of Potash

| | | Amount of sulphate of potash | | | | |
|---|---|---|---|---|---|---|
| 1932 | Rothamsted . . | 0.8 cwt. $K_2O$ | −0.15 | +0.16 | +0.31 | ±0.471 |
| | | 1.6 cwt. $K_2O$ | +0.15 | −0.10 | −0.25 | ±0.471 |
| 1937 | Rothamsted . . | 1.6 cwt. $K_2O$ | +0.73 | +0.32 | −0.41 | ±0.423 |
| 1934 | Wimblington | 1.12cwt. $K_2O$ | +4.93 | +2.68 | −2.25 | ±0.354 |
| 1935 | Wimblington | 1.25cwt. $K_2O$ | +2.43 | −0.03 | −2.46 | ±0.404 |
| 1936 | Wimblington | 1.25cwt. $K_2O$ | +0.93 | −0.03 | −0.96 | ±0.891 |

Responses to Superphosphate

| | | Amount of superphosphate | | | | |
|---|---|---|---|---|---|---|
| 1937 | Rothamsted . . | 0.8 cwt. $P_2O_5$ | +1.52 | +0.85 | −0.67 | ±0.423 |
| 1935 | Wimblington | 1.0 cwt. $P_2O_5$ | +0.49 | +0.45 | −0.04 | ±0.404 |
| 1936 | Wimblington | 1.0 cwt. $P_2O_5$ | +0.03 | −0.80 | −0.83 | ±0.891 |

For mean yields see Table X.



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*Effects of dung on the responses to artificials*

The question whether artificials may be profitably applied on land which is also being dunged has been studied in several experiments, see Table XII on previous page. These show the responses to sulphate of ammonia and minerals in the absence and in the presence of dung.

With potatoes the responses to sulphate of ammonia were increased in presence of dung in seven out of eight experiments, the increase being significant at Rothamsted in 1935. These increases are presumably due to the minerals contained in the dung, since sulphate of ammonia produced no increase when applied without dung or minerals.

The responses to sulphate of potash were decreased by the addition of dung in four experiments out of five, the decrease being significant at Wimblington in 1934 and 1935. In the remaining experiment, potash had no appreciable effect.

The response to superphosphate was decreased in presence of dung at Rothamsted in 1937, though not significantly. At Wimblington in 1935, the response was unaltered, while in the remaining experiment the effects of superphosphate were not significant.

TABLE XIII

*Responses to Artificials*

*Sugar Beet Roots (tons per acre)*

Responses to Sulphate of Ammonia (0.6 cwt. N)

| | | Dung | | Difference Pres. minus Abs. |
|---|---|---|---|---|
| | | Absent | Present | |
| 1933 | Rothamsted .. | +0.15 | +0.05 | −0.10[1] |
| 1934 | Rothamsted .. | +1.38 | +1.83 | +0.45[2] |
| 1937 | Wragby .. | +1.89 | +0.68 | −1.21 |
| 1937 | Market Rasen | +3.00 | +2.28 | −0.72 |

Responses to Muriate of Potash (1.0 cwt. $K_2O$)

| | | | | |
|---|---|---|---|---|
| 1936 | Rothamsted .. | −0.39 | −0.25 | +0.14 |
| 1937 | Rothamsted .. | +0.74 | +0.12 | −0.62 |
| 1937 | Woburn .. | +1.48 | +0.74 | −0.74 |

Responses to 5 cwt. Superphosphate + 3 cwt. 30% Potash Salt

| | | | | |
|---|---|---|---|---|
| 1936 | Gainsborough | +0.78 | −0.23 | −1.01 |
| 1936 | Wragby .. | +0.98 | +0.57 | −0.41 |
| 1937 | Wragby .. | +1.31 | +1.30 | −0.01 |
| 1937 | Market Rasen | +2.32 | +0.68 | −1.64 |

S.E. of differences (1) ±0.674. (2) ±0.636.

With sugar beet roots the responses to sulphate of ammonia were not significantly affected by the addition of dung in any of the three experiments in which sulphate of ammonia produced a clear response in roots. The responses to muriate of potash were somewhat decreased by dung in two experiments; in the third, potash produced small but not significant depressions in yield both in

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presence and absence of dung. In the further experiments containing minerals (superphosphate and potash salt), the responses to minerals were slightly decreased by the addition of dung.

TABLE XIV

*Kale (tons per acre)*

| | Woburn 1932 Sulphate of ammonia : cwt. N | | | | Woburn 1936 Sulphate of ammonia | |
|---|---|---|---|---|---|---|
| | None | 0.2 | 0.4 | 0.8 | 0.4 cwt. N | 0.8 cwt. N |
| No dung | 13.29 | 17.76 | 19.67 | 24.36 | 10.14 | 13.67 |
| Dung | 19.19 | 21.24 | 23.67 | 28.74 | 13.14 | 15.49 |
| Standard errors | | | ±0.713 | | ±0.357 | |

With kale, the responses to sulphate of ammonia were smaller in presence of dung in both experiments, though not significantly so.

TABLE XV

*Residual effects of Dung on the Succeeding crop (cwt. per acre)*

| Dung applied to | | Amount of dung | Succeeding crop | Mean yield | Increase for dung |
|---|---|---|---|---|---|
| | | tons | | | |
| Potatoes | 1916 | 10 | Wheat grain | 11.9 | +2.4 |
| Potatoes | 1920 | 15 | Wheat grain | 17.8 | +3.6 |
| Potatoes | 1936 | 15 | Spring oats grain | 20.2 | +2.7 |
| Kale | 1932 | 15 | Barley total produce | 95.1 | +12.2 |
| Kale | 1936 | 15 | Barley grain | 12.0 | +2.2 |
| Barley | 1921 | 14 | Clover 1921 green weight | 9.2 | +6.7 |
| | | | Clover 1922 hay | 45.5 | +8.2 |
| | | | Clover 1923 hay | 13.0 | +2.3 |

The residual effects are striking. Dung applied to potatoes or kale increased the succeeding cereal crops by over 2 cwt. grain per acre in every case. In an experiment in which dung was applied to barley, clover sown under the barley continued to benefit from the dung for at least three seasons, the green weights being doubled by the dung in the first season.

## POULTRY MANURE

The consignments of dried poultry manure for the 1933-36 experiments were obtained from Suffolk, but for the 1937 experiments the supply was from Hampshire : the percentages of nitrogen, phosphoric acid and potash were very similar :—

| | | Percentage in dried manure | | | | |
|---|---|---|---|---|---|---|
| | | Nitrogen | $P_2O_5$ | $K_2O$ | Ash | Dry matter |
| 1936 | Suffolk .. .. | 3.90 | 3.53 | 1.70 | 35.3 | 88.7 |
| 1937 | Hampshire .. .. | 3.75 | 3.43 | 1.76 | 22.2 | 85.1 |

In the first three years in which the manures were applied the poultry manure was distinctly inferior to the sulphate of ammonia. The direct effect of poultry manure, based on 29 experiments, only amounted to 64 per cent. of the direct effect of sulphate of ammonia.

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