# Report for 1949

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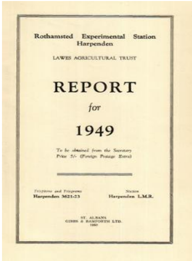
Rothamsted Experimental Station
Harpenden

LAWES AGRICULTURAL TRUST

REPORT
for
1949

# Field Experiments

## The Plot Committee

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# FIELD EXPERIMENTS

By the PLOT COMMITTEE

## FIELD EXPERIMENTS AT ROTHAMSTED AND WOBURN

The following members of the staff, who constitute the Field Plots Committee, are responsible for planning and carrying out the programme of field experiments: E. M. Crowther (Chairman), H. V. Garner (Secretary), H. H. Mann, J. R. Moffatt, D. J. Watson, F. Yates.

The number of plots handled by the Field Staff at Rothamsted and Woburn were as follows :—

| | Grain | Roots | Hay | Grazing | Total |
|---|---|---|---|---|---|
| *Classical Experiments* | | | | | |
| Rothamsted .. | 121 | 72 | 47 | — | 240 |
| Woburn .. .. | 24 | — | — | — | 24 |
| *Modern Long-Term Experiments* | | | | | |
| Rothamsted .. | 279 | 232 | 84 | 32 | 627 |
| Woburn .. .. | 149 | 218 | 31 | 12 | 410 |
| *Annual Experiments* | | | | | |
| Rothamsted .. | 489 | 208 | 12 | — | 709 |
| Woburn .. .. | — | — | — | — | — |
| *Total* | | | | | |
| Rothamsted .. | 889 | 512 | 143 | 32 | 1,576 |
| Woburn .. .. | 173 | 218 | 31 | 12 | 434 |
| Grand Total ... | 1,062 | 730 | 174 | 44 | 2,010 |

Note : Grain includes cereals, beans, peas, linseed. Roots include potatoes, sugar beet, mangolds, cabbage, leeks. Hay includes lucerne and cut grass.

One experiment of 40 plots on winter beans on Stackyard Field could not be drilled owing to the wet state of the ground in late autumn and was abandoned, so the number of plots actually harvested on the two farms was 1970.

The season 1949 was remarkably dry, mild and bright. Every month from January to September inclusive was below the average in rainfall, and there had been no excess of rain at the end of 1948. There was very little severe frost in the winter, and practically no snow. The characteristics of the season and the effects of the weather on crops are fully described in the section of this report dealing with the Rothamsted and Woburn farms.

In the year under review the classical and long-period experiments were continued. Most of them have already been summarised in recent Reports.

## LEY ARABLE EXPERIMENT, ROTHAMSTED

The general purpose and the scheme of treatments of the new ley arable experiments at Rothamsted were given in the Report for 1948, p.98.

The first year of this elaborate and exacting experiment has been used in developing the technique. Wheat was grown on two blocks on Highfield and two on Fosters. On Highfield where the wheat was drilled on recently ploughed old turf, the plant came well but went off badly during the winter and looked very poor indeed at the turn of the year. Later earth nut (*Conopodium denudatum*) appeared as a

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serious weed in the crop and was considerably reduced by dusting with M.C.P.A. weedkiller. The crop then improved a little and yielded 15·6 cwt. grain per acre. There were no visible effects due to the different levels of nitrochalk on the sub-plots. On Fosters the wheat was earlier sown and looked distinctly better, the effect of added nitrogen was also slightly greater than on Highfield. The mean yield was 23·3 cwt.

All leys and legumes were sown in the open ground in the spring of 1949. Conditions were by no means ideal as the seedbeds were very dry ; nevertheless the take was reasonably good, with lucerne as the best-looking patches on both fields, though some of the leys and reseeded grass (identical at this stage) looked fresh and covered the ground well. As the dry weather persisted in early summer all young sowings had a great struggle with strong-growing weeds, thistles on Highfield, " knotgrass " (*Polygonum aviculare*) on Fosters. The " knotgrass " dominated the leys so badly in early autumn that the plots were sprayed with sulphuric acid which clearly shifted the balance in favour of the grass.

Grazing by sheep was reduced by the very dry weather to only two rounds per plot in 1949, and the established grass land in Highfield did no better than the new stands. There were two cuts of cut grass on Highfield, but only one on Fosters. Lucerne gave one light cut on each field. By late summer everything except the lucerne was badly burnt up. The season was used to develop a grazing technique. Temporary post and netting fences were tried but did not hold the stock, particularly when an enclosure was grazed right down and the animals were hungry. These fences will be replaced in future by wheeled iron hurdles, a type that has been used successfully at Woburn for a similar purpose.

### Spring-sown Cereals

For the past three seasons four kinds of cereal crops have been compared for spring sowing. The experiments were located in a different field each year. The crops were : Star oats, Atle wheat, Bersee wheat, and Plumage Archer barley. All crops were tested at several nitrogen levels, sulphate of ammonia being applied at 0, 0·3, 0·6, 0·9 cwt. N. per acre. Superphosphate and muriate of potash were also tested. The mean results over the three years were as follows :—

*Mean Yields and Responses: cwt. per acre* 1947-49

| Fertilizers | Grain | | | | Straw | | | |
|---|---|---|---|---|---|---|---|---|
| | Oats | Atle | Bersee | Barley | Oats | Atle | Bersee | Barley |
| 0·0 cwt. N .. .. | 16·4 | 18·6 | 19·2 | 23·5 | 33·2 | 28·4 | 27·5 | 25·5 |
| 0·3 ,, ,, .. .. | 20·9 | 21·5 | 23·8 | 27·3 | 38·9 | 34·2 | 34·4 | 31·1 |
| 0·6 ,, ,, .. .. | 22·3 | 23·0 | 24·3 | 28·4 | 39·2 | 37·9 | 38·9 | 35·0 |
| 0·9 ,, ,, .. .. | 23·3 | 22·8 | 25·3 | 27·7 | 40·7 | 38·7 | 40·8 | 36·0 |
| Mean .. .. | 20·7 | 21·4 | 23·2 | 26·7 | 36·0 | 34·8 | 35·4 | 31·9 |
| Response to Superphosphate .. | 1·6 | −0·6 | −0·3 | 0·8 | 0·4 | 0·1 | 0·3 | 0·8 |
| Response to Muriate of Potash .. | −0·3 | −0·4 | 1·2 | 1·8 | −0·6 | 0·4 | −0·1 | 1·2 |

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In grain production barley stands well above the other spring-sown cereals at all levels of nitrogenous manuring. On the average oats and Atle wheat each yielded 6 cwt. less than barley, and spring sown Bersee wheat about 3½ cwt. less. In these three experiments Bersee wheat sown in the spring gave somewhat higher yield than Atle though it was later to ripen. All the cereals responded well to nitrogenous dressing, but all showed a marked falling off in response at the higher levels. Thus the first 1½ cwt. of sulphate of ammonia produced a mean increase over all crops of 4 cwt. of grain. When the dressing of sulphate of ammonia was raised to 3 cwt. per acre the further increase was only 1 cwt. grain while 4½ cwt. of sulphate of ammonia gave practically the same yield as 3 cwt. There was no very marked difference between the behaviour of the different crops in their responses to nitrogen, oats were perhaps slightly more responsive than barley at all levels; the wheats being intermediate. The level of yield and responses to nitrogen varied with the season, in particular in the abnormally dry season 1949 the nitrogen responses were lower than in the other two more favourable years.

The responses to phosphate and potash were much smaller than to nitrogen. Oats gave significant responses to phosphate in two years out of the three; the yield of Bersee wheat and barley was slightly increased by potash.

The nitrogen responses in the straw were larger than the corresponding grain responses, and though they fell off somewhat at the higher levels they showed less curvature. In the moist season 1948 oats and barley produced about 6 cwt. more straw and wheat from 12-17 cwt. per acre more than in the dry years. In wheat and barley the responses to nitrogen were bigger and more sustained in the wet season than in the dry ones. Phosphate and potash had very little effect on straw yield. The biggest increase, 1·2 cwt. per acre, was produced by muriate of potash in the straw of barley.

## The Annual Experiments of 1949

The following brief notes deal with the main points arising from those annual experiments of 1949 which do not belong to larger series of experiments or are not reported elsewhere by the departments specially concerned.

### *Potatoes*

There were three annual experiments on potatoes:—(1) Four levels of farmyard manure applied in three different ways, in presence and absence of each of the three main nutrients, N, P, K. This experiment was carried out on Sawyers III. The dressings of dung were 0, 5, 10, and 15 tons per acre and these were applied either ploughed-in in winter, or ploughed-in in spring, or spread in the ridges in spring. The whole experimental area was ploughed both for the winter and for the spring application. The potatoes without dung gave 5½ tons of potatoes; on the average of all methods of application dung increased the crop by ½ ton for each 5 tons applied, the effect being practically linear up to the maximum dressing. The three methods of application give closely similar results on the average of all rates. Since no adjustment was made for loss during storage the spring applications were derived from rather heavier amounts of dung than were actually applied in the winter dressings. A fuller examination of this experiment will be made when the response curves are available for each method of application. Potash was the most effective supplementary nutrient in the absence of dung but the responses were steadily reduced almost to zero as the dressings of dung were increased. Nitrogen gave good effects even in the presence of dung. (2) Time of planting experiment, Sawyers III. This has now been tested on a different field each year for several seasons. The earliest planting on March 29th gave a yield of 5·4 tons which fell to 4·5 tons for the latest planting on May 30th, the other plantings being intermediate in yield. Dung gave a response of 2 tons per acre which was practically independent of the date of planting the potatoes. Nitrogen with a mean increase of 0·7 tons and potash with a mean increase of 0·5 tons were distinctly more effective on the earliest planting than on the rest. As usual there was a negative interaction between dung and potash. The above experiment was used by the Plant Pathology Department for observations on the spread of virus diseases and will be more fully reported by them. (3) Methods of planting potatoes, Great Knott III. Arising out of the remarkably rapid increase in the mechanical planting of potatoes, a start was made in 1949 in testing different methods of placing the tubers and applying the fertilizers. The standard method of applying fertilizers down the ridges followed by hand planting gave significantly lower average yields than planting by the dropper either on the flat or in the ridges. The seed was infected with 'dry rot' and although it was carefully sorted it is possible that some diseased tubers were planted. The loss of plant due to this cause would probably be more severe on the dried-out open ridges which were hand-planted than on either of the other methods where the sets were put straight into moist soil. Fertilizer application at 8 or 16 cwt. per acre gave very small increments in yield in this experiment so the comparison of different methods of incorporating the artificials led to no clear results. The experiment will be repeated for several seasons.

*Linseed.* Great Knott I. An experiment was put down to test combine drilling of PK fertilizer against the same fertilizer broadcast. The material was used in granular and also in powder form, each at single and double rates per acre. Sulphate of ammonia was also tested. The plant was good and even but the plots were badly infected with Fat Hen early in the summer. This was well controlled by spraying with liquid "Agroxone" but the yield of the crop was probably reduced by weediness and drought so that finally poor yields of only about 4 cwt. of seed per acre were obtained. Under these circumstances the only definite result was a reduction of yield when the heavy dressing of fertilizer was put in with the combine drill. Thus 6 cwt. of fertilizer broadcast gave 4·5 cwt. grain and 7·9 cwt. of straw; if drilled-in the yields were only 3·3 cwt. grain and 4·9 cwt. straw. There was no certain difference between powder and granular fertilizer.

*Spring bean varieties*

Four Dutch varieties of spring beans were compared with five English and Scottish strains at three seed rates (1, 1½, and 2 units).

The rates were calculated to provide equal numbers of seeds per acre. This involved seedings by weight varying from 0·8 to 2·5 cwt. per acre at the lowest rate. Yields of all varieties were light. They ranged from 5·3 cwt. for a Dutch Pigeon bean to 12·5 cwt. for an Essex strain of horse bean. The English strains from the National Institute of Agricultural Botany, and a strain of Scotch Mazagan bean gave higher yields than the Dutch horse beans, particularly at the lower seed rates. Practically all varieties gave profitable increases for increased seed rates in the sense that the increase in grain yield was usually about twice the weight of the extra seed sown. One Dutch variety of Broad beans with very large seeds failed to justify the heavier seed rates.

*Other experiments*

In addition to the above experiments, the following were conducted either as part of a series or specially for departments who will report the results elsewhere. (1) Placement experiments on threshed peas and spring beans. Broadcast application of PK fertilizer at several rates compared with fertilizer placed by a special experimental drill (2) Experiments on wheat, Little Knott. Agricultural conditions affecting the incidence of eyespot disease. Tests of seed rate, level of and time of application of nitrogen top dressing, sulphuric acid spraying. (Plant Pathology Department.) (3) Experiments on wheat, Little Hoos. Control of wireworm by soil fumigants. Residual effects of fumigation treatments applied to wheat in autumn 1947 (Insecticides Department).

EXHAUSTION LAND, HOOSFIELD.

The exhaustion land consists of two acres in Hoosfield lying between the acre devoted to alternate wheat and fallow and the Long Hoos boundary. Since the early continuous experiments on potatoes were terminated in 1901 this land carried a series of corn crops, either unmanured or with nitrogen only. For many years the yields of grain and straw were measured on all the old potato plots, but this was allowed to lapse after the first world war. Nevertheless the cereals still showed small but quite noticeable residual effects in the spring associated with certain of the former treatments. These residues had attracted little attention in recent years, but in the very dry spring of 1949 the crop of barley showed such remarkable differences from plot to plot that a fresh examination of the site and crops was clearly necessary.

Soon after the barley germinated it was apparent that the young plants on those parts of the field where the former experimental potatoes had received either no manure or nitrogen only were in a miserable condition. They were stunted with dull greyish leaves carrying purplish markings, showing in fact all the symptoms of acute phosphate deficiency. The sites of the old dung plots and plots that had received a long series of superphosphate dressings for the potatoes carried normal plants. The effect was so striking that the Chemistry Department set on foot an intensive sampling of crops and soil. Air photographs taken on May 13th showed the differences in ground cover very clearly. A month later the worst leaf symptoms of phosphate deficiency had disappeared, but big differences in development and maturity remained. The old plots were cut out and harvested separately, and chemical work on the grain and straw samples will shortly be put in hand. Arising out of the renewed interest in this piece of land it was thought desirable to put on record as much of its previous history as could be ascertained from old records.

The first mention of this area of the Rothamsted farm appears in 1856 in a paper by Lawes and Gilbert dealing with a system of growing wheat advocated by the Rev. S. Smith of Lois Weedon in Northamptonshire. The plan was to grow wheat year after year in the same field, the land being subdivided into alternate narrow strips of crop and fallow. The crop of one year stood on the fallow ground of the year before. The wheat was unmanured and deep cultivation was practised. This experiment began in 1851 and continued till 1855. From 1856-1874 this land carried a succession of wheat crops in a fertilizer experiment on four plots rather on the lines of Broadbalk. The annual treatments for wheat were: (1) complete minerals, (2) nitrogen and minerals, (3) nitrogen only, (4) no manure. The yield of these plots for the first 8 year period appear in the Journal of the Royal Agricultural Society of England, 1864, vol. 25, where they were compared with the corresponding yields of Broadbalk. The figures for the whole 19 years are in the Rothamsted archives.

In 1876 the fertilizer experiment on continuous potatoes began on the same plots and the treatments were so arranged that all four previous treatments for wheat were carried through into the potatoes on the same land. Additional treatments for potatoes were obtained by halving the original wheat plots.

The potato experiment continued until the crop of 1901 after which the land carried a series of cereal crops, usually barley, without manure of any kind. Yields were taken yearly till 1922, when cereal cropping continued without fertilizer but the crops were not weighed. Even at that period the residual effects of the dung and phosphate treatments in barley were still plainly visible, particularly in certain seasons. In 1940, it was decided to give generous basal dressings of sulphate of ammonia only, and since then the cereals have received about 3 cwt. nitrogenous fertilizer per acre yearly. It was in the presence of 2¼ cwt. of sulphate of ammonia that the barley of 1949 showed the remarkable residual effects previously described.

### Irrigation of Sugar Beet

Two experiments were carried out in 1949, one on Mr. F. A. Secrett's farm at Milford, where experiments had been in progress for the previous two seasons, and the other on the land of Messrs. W. O. and P. O. Jolly at Kesgrave, near Ipswich. Both soils were light and free draining and both farmers practised overhead irrigation on commercial vegetable crops.

The summer was even drier than the very dry year 1947, and in great contrast to the wet summer of 1948 when irrigations had no effect. The following table shows the monthly rainfall at both centres during the summer months.

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*Summer Rainfall, inches*

| | Milford | | | Kesgrave |
|---|---|---|---|---|
| | 1947 | 1948 | 1949 | 1949 |
| May .. .. .. .. | 1·67 | 2·06 | 2·21 | 1·99 |
| June .. .. .. .. | 2·14 | 2·60 | 0·45 | 0·42 |
| July .. .. .. .. | 1·06 | 0·96 | 0·73 | 0·72 |
| August .. .. .. | 0·52 | 4·02 | 0·96 | 1·54 |
| Total .. .. .. | 5·39 | 9·64 | 4·35 | 4·67 |

At Milford the experiment was a 6 × 6 Latin Square with the following treatments on the main plots:

1 and 2 No water (O)
3 Full irrigation as directed by farmer (F)
4 As 3, with Chilean potash nitrate in irrigation water (FS)
5 Restricted irrigation, based on weather data (R)
6 Restricted to a lower level, based on weather data (M)

All plots received a basal fertilizer dressing supplying 0·42 cwt. N, 0·68 cwt. $P_2O_5$, and 0·89 cwt. $K_2O$ with 5½ cwt. salt per acre.

Within each main plot 4 levels of nitrochalk were tested:—

| | | |
|---|---|---|
| (a) | No extra nitrochalk | Total N 0·4 cwt. N |
| (b) | 2 cwt. nitrochalk | ,, ,, 0·7 ,, ,, |
| (c) | 4 ,, ,, | ,, ,, 1·0 ,, ,, |
| (d) | 6 ,, ,, | ,, ,, 1·3 ,, ,, |

At Kesgrave the general arrangements were similar but the experiment was smaller and simpler; being 4 randomized blocks of 3 main plots, each split for three levels of nitrochalk.

Main plots:—1. No water (O)
2. Watering as directed by farmer (J)
3. Watering based on climatic data (M)

All plots received 0·43 cwt. N, 1·07 cwt. $P_2O_5$, 0·86 cwt. $K_2O$, and 3½ cwt. salt.

| | | | |
|---|---|---|---|
| Sub-plots:— | (a) | No extra nitrochalk | Total N 0·4 cwt. N |
| | (b) | 3 cwt. nitrochalk | ,, ,, 0·85 ,, ,, |
| | (c) | 6 ,, ,, | ,, ,, 1·30 ,, ,, |

The crop at Milford was grown on narrow rows of 17 inches and closely singled, to give a very high plant population of 37,000. Unfortunately an extremely early and severe attack of virus yellows occurred. All plants were infected by the end of June and there is no doubt that the yield was seriously reduced. At Kesgrave a good commercial plant of 26,000 was secured. The virus yellows attack commenced about a month later than at Milford, and although the crop was damaged the effects were in no way exceptional.

The main results from both centres are set out in the following table:

*Milford*, 1949

Effect of Irrigation, dissolved nitrate, and fertilizer nitrogen

| | Mean Yield | Irrigation, inches 0 | 6½ | 8½ | 13 | S.E. | Increase for Nitrate | S.E. |
|---|---|---|---|---|---|---|---|---|
| Roots, tons .. | 16·3 | 14·3[1] | 17·5 | 17·8 | 16·9 | 0·42 | 0·1 | 0·59 |
| Sugar % .. | 12·2 | 12·0[2] | 12·3 | 12·5 | 12·3 | 0·13 | —0·2 | 0·19 |
| Sugar, cwt. .. | 39·9 | 34·6[3] | 42·9 | 44·5 | 41·6 | 1·34 | —0·6 | 1·89 |
| Tops, tons .. | 19·0 | 14·4[4] | 20·5 | 20·3 | 21·0 | 0·44 | 2·1 | 0·62 |
| Plants, thous... | 37·5 | 37·8[5] | 38·1 | 37·5 | 36·4 | 0·33 | 0·7 | 0·47 |
| Noxious N .. | 68·5 | 81·5[6] | 63·3 | 59·6 | 59·2 | 3·30 | 7·0 | 4·60 |

[1] 0·30  [2] 0·09  [3] 0·94  [4] 0·31  [5] 0·23  [6] 2·3

| | *Fertilizer Nitrogen, cwt. per acre* 0·4 | 0·7 | 1·0 | 1·3 | S.E. |
|---|---|---|---|---|---|
| Roots, tons .. .. .. | 16·8 | 16·3 | 16·6 | 15·6 | 0·22 |
| Sugar % .. .. .. | 12·4 | 12·3 | 12·1 | 12·0 | 0·064 |
| Sugar, cwt .. .. .. | 41·6 | 40·2 | 40·2 | 37·5 | 0·60 |
| Tops, tons .. .. .. | 18·0 | 18·7 | 19·2 | 20·0 | 0·27 |
| Plants, thous. .. .. | 37·9 | 37·7 | 37·4 | 36·8 | 0·23 |
| Noxious N .. .. .. | 63·1 | 64·4 | 72·8 | 73·9 | 1·72 |

*Kesgrave*, 1949

Effect of irrigation and Fertilizer Nitrogen

| | Mean Yield | Irrigation, inches 0 | 4 | 5½ | S.E. | Nitr'n., cwt. per acre 0·4 | 0·85 | 1·3 | S.E. |
|---|---|---|---|---|---|---|---|---|---|
| Roots, tons | 14·4 | 11·3 | 15·3 | 16·4 | 0·35 | 14·6 | 14·3 | 14·1 | 0·23 |
| Sugar % | 14·5 | 13·6 | 15·0 | 15·0 | 0·18 | 15·1 | 14·6 | 13·9 | 0·082 |
| Sugar, cwt. | 42·0 | 30·8 | 46·0 | 49·3 | 1·25 | 44·5 | 42·1 | 39·5 | 0·72 |
| Tops, tons | 10·2 | 9·5 | 9·7 | 11·3 | 0·29 | 9·3 | 10·4 | 10·8 | 0·25 |
| Plants, thous. | 26·6 | 26·9 | 26·5 | 26·4 | 0·34 | 27·7 | 27·3 | 24·8 | 0·33 |
| Noxious N | 69·6 | 78·3 | 65·9 | 64·5 | 3·6 | 59·6 | 70·9 | 78·2 | 1·8 |
| Dirt Tare % | 16·0 | 21·2 | 14·7 | 12·3 | | 15·6 | 16·8 | 15·7 | |

The features of the Milford experiment were the very early and severe virus yellows attack and the exceptionally low sugar content of 12·0 per cent. The result was only a moderate yield of 34·6 cwt. of sugar on the dry plots in spite of a very high plant population. The lightest watering, 6½ inches in five applications, increased the output of sugar by 8·3 cwt. per acre, but there was no definite increase for the higher levels of watering. The heaviest watering, 13 inches in nine applications, gave a smaller yield of sugar per acre than 6½ or 8 inches, but not significantly so. Nitrogen in moderate dressings was ineffective and at the highest rate it significantly depressed the yield of sugar. There was no marked interaction between the effect of water and nitrogen. So far as the other attributes of the crop were concerned the sugar percentage was slightly but significantly raised by watering and depressed by nitrogen. Tops were increased by 6·1 tons by the lightest watering, with no further response for heavier applications, they were also slightly increased by nitrogen. Plant population was slightly reduced by the heaviest watering and by the highest nitrogen application. The figure for noxious nitrogen was greatly reduced by watering, and markedly increased by nitrogen. The effect of adding Chilean potash nitrate, providing 0·4 cwt. N and 0·3 cwt. $K_2O$ per acre, in the irrigation water was negligible so far as sugar was concerned, but it increased the tops by 2 tons and like fertiliser nitrogen it tended to raise the proportion of noxious nitrogen.

At Kesgrave with a crop of 30·8 cwt. of sugar on the dry plots, 4 inches of irrigation gave no less than 15·2 cwt. sugar per acre and there was a further increase for 5½ inches. Nitrogen reduced the quantity of sugar per acre significantly. These two factors showed a marked interaction, for the benefit from watering was much less when nitrogen was present, or alternatively the poor effect of nitrogen was most conspicuous on the watered plots.

| | |
|---|---|
| Effect of 5½ inches water, no nitrogen .. .. | 23·4 cwt. sugar |
| Effect of 5½ inches water, with nitrogen .. | 12·9 ,, ,, |
| Effect of 1·3 cwt. nitrogen, no water .. .. | 1·2 ,, ,, |
| Effect of 1·3 cwt. nitrogen, with 5½ inches water | —9·3 ,, ,, |

At Kesgrave the effects on the other attributes of the crop were closely parallel to those observed at Milford. Watering increased the sugar percentage significantly, and nitrogen depressed it by 1·2 per cent. Both water and nitrogen increased the tops. Heavy nitrogen depressed the plant number. There was a decrease in noxious nitrogen due to watering, and an increase due to nitrogen. The roots on the dry plots were noticeably more hairy than the rest and picked up more soil at lifting time. The difference was clearly reflected in the figures for tare.

The main conclusions from the experiments of 1949 is that in a very dry year with an exceptionally hot dry summer, 6 inches of irrigation water was sufficient for a full crop, though it is possible that a disease-free crop might have used more. The interaction of nitrogen and watering will be further examined in future experiments.

### Two Course Rotation

When agricultural salt was included from 1940 onwards as a treatment in the standard manurial experiments on sugar beet carried out in all Factory areas it soon became clear that 5 cwt. of salt per acre produced substantial increases in the yield of sugar over a wide range of conditions. The question then arose whether repeated applications of salt on the same land would continue to be effective for sugar beet. There was the further possibility, widely believed by farmers, that continued use of agricultural salt might damage the soil either structurally or in other ways. To test these points a long-period experiment was begun at Rothamsted in 1942. In order to break the sequence of sugar beet crops, a two-course rotation of sugar beet followed by barley was adopted, barley being chosen because it was the one cereal popularly supposed to benefit from salt dressings.

Two blocks of land were assigned to sugar beet and barley in Long Hoos field, the crops being changed over each year to give the two-course rotation. The following scheme of treatments was adopted. Four rates of salt application, 0, 2½, 5, and 7½ cwt. per acre, were used for the sugar beet. The salt was applied either before the winter ploughing or harrowed into the seedbed in spring

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a few weeks before drilling the seed. On one set of plots these treatments were given to the sugar beet only, the following barley crop receiving no salt; on the remaining plots the barley also received salt treatments but at only half the rate given to sugar beet on the same plot. The sugar beet also tested muriate of potash at approximately 0, 2, 4 cwt. per acre, the muriate dressings being the equivalent of 1¼ and 2½ cwt. of agricultural salt. All dressings were repeated according to the above scheme on their respective plots, hence at the heaviest rate certain plots received 7½ cwt. of salt per acre to sugar beet followed next year by 3¾ cwt. per acre to barley. For the first two sugar beet crops in 1942 and 1943 and the first barley crop in 1943 the early application of salt was broadcast in the spring on land that had already been ploughed in the previous autumn. Subsequently for the six years 1944-49 inclusive, the early application of salt was always ploughed-in in winter for both crops.

The average results of the direct application of salt and muriate of potash to sugar beet taken over the 8-year period 1942-49 are given in Table I. The figures are the means of the two methods of applying salt on plots, half with salt to sugar beet only and half with salt repeated at half rate to barley.

*Table I. Sugar Beet* 1942-1949

Effect of Agricultural Salt and Muriate of Potash

Sugar: cwt. per acre

| Salt to sugar beet cwt. | Muriate of potash 0 | 2 cwt. | 4 cwt. | Mean |
|---|---|---|---|---|
| 0 .. .. .. | 40·9 | 43·7 | 45·9 | 43·5 |
| 2½ .. .. .. | 50·0 | 47·8 | 49·0 | 48·9 |
| 5 .. .. .. | 50·0 | 50·2 | 49·5 | 49·9 |
| 7½ .. .. .. | 48·0 | 49·4 | 50·0 | 49·1 |
| Mean .. .. .. | 47·2 | 47·8 | 48·6 | 47·9 |

The level of cropping was very good. Agricultural salt in the absence of potash gave on the average the extraordinary increase of 9·1 cwt. sugar per acre for the 2½ cwt. dressing. There was no indication of any benefit from heavier dressings of salt. In fact there was some suggestion that in the absence of potash 7½ cwt. salt per acre was too much. Potash without salt also gave notable increases in the yield of sugar, but on a much smaller scale than the equivalent amount of salt. When salt was supplied there was no further increase due to potash, but salt still increased the crop substantially even when large amounts of potash were supplied. These results are in accord with those of the Factory Series of sugar beet fertiliser experiments in which on an average of 140 trials 5 cwt. of salt in the absence of potash gave 5·1 cwt. sugar, 2 cwt. of muriate of potash in the absence of salt gave 2·8 cwt. of sugar, and the two nutrients in combination gave 5·5 cwt. sugar.

The yearly increases due to salt in the absence of potash and to potash in the absence of salt are given in Table II for the eight crops of sugar beet grown in 1942-49.

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*Table II*

Effect of salt (without potash) and of muriate of potash (without salt) in individual years 1942-49
1Na, 2Na, 3Na = 2½, 5, 7½ cwt. salt per acre to sugar beet, repeated at half rate to barley on half the plots
1K, 2K = 2, 4 cwt. muriate of potash per acre to sugar beet only
Sugar: cwt. per acre

| | 1942 | 1943 | 1944 | 1945 | 1946 | 1947 | 1948 | 1949 | Mean |
|---|---|---|---|---|---|---|---|---|---|
| No Salt, No Potash | 54·5 | 57·0 | 27·2 | 58·3 | 52·3 | 23·7 | 33·4 | 21·0 | 40·9 |
| Increase for:— | | | | | | | | | |
| 1Na | 6·6 | 9·3 | 9·4 | 8·0 | 7·9 | 13·5 | 10·3 | 7·4 | 9·1 |
| 2Na | 9·0 | 9·5 | 8·9 | 6·2 | 5·6 | 15·8 | 8·4 | 8·9 | 9·0 |
| 3Na | 6·7 | 5·7 | 5·0 | 4·4 | 3·7 | 14·2 | 8·5 | 8·7 | 7·1 |
| 1K | −0·9 | 5·7 | −0·1 | 4·5 | −0·8 | 7·6 | 0·8 | 5·7 | 2·8 |
| 2K | 2·8 | 6·3 | 4·4 | 3·2 | 6·9 | 7·4 | 2·3 | 6·6 | 5·0 |
| SE+ | 2·63 | 3·07 | 2·47 | 2·15 | 2·71 | 3·54 | 3·12 | 1·36 | — |

The yearly responses to the first two rates of application of salt were large and very consistent. In every year except 1948 the highest dose of 7½ cwt. salt gave less sugar than the 5 cwt. application, and in 6 years 7½ cwt. salt gave less sugar than 2½ cwt. of salt, but none of these differences between rates of application of salt was significant in a single year. The comparatively poor effect of the heaviest dressing was most noticeable in the earlier years of the experiment; by 1947 the heavily treated plots were practically as good as the others. The data give no support to the idea that agricultural salt may lose its effectiveness for sugar beet if repeated at frequent intervals on the same land.

The effect of muriate of potash varied widely from year to year. In half the seasons the lower rate was ineffective, but in the others it gave an increase of about 6 cwt. of sugar per acre. The double rate gave better results even in the years when the single dose failed. As with salt there was no indication that the effect of potash fell off after many repetitions on the same plots. Indeed both nutrients at all rates gave bigger increases in the last four crops than the first four.

For the years 1944-49 there were no appreciable differences between salt ploughed-in in winter and salt broadcast on the seedbed in spring, and no effect from applying additional salt to the preceding crop of barley. Averaging all levels of salt, the figures were:

| | *Sugar: cwt. per acre* |
|---|---|
| No Salt | 38·7 |
| Increase for:— | |
| Salt ploughed-in in winter | 6·1 |
| Salt broadcast on seedbed in spring | 6·3 |
| Salt applied to sugar beet only | 6·1 |
| Salt to sugar beet and at half rate to barley | 6·3 |

Measurements of the effects of salt and potash were made on the other attributes of the crop and a condensed summary is given in Table III.

*Table III*

Effect of salt (mean of all rates of application) without potash, and potash (mean of all rates) without salt

| | Roots tons | Tops tons | Sugar per cent. | Plant No. thous. |
|---|---|---|---|---|
| Mean yield, no salt, no potash | 11·7 | 10·7 | 17·3 | 23·8 |
| Increase for:— | | | | |
| Salt, no potash | 2·1 | 1·1 | 0·5 | 1·0 |
| Potash, no salt | 0·9 | 0·6 | 0·4 | 0·5 |

Salt had a markedly beneficial effect on all attributes, including plant number. Potash was about equal to salt in raising the sugar content, but only about half as effective on the remaining attributes. Examination of the yearly results shows that there was no reduction of plant number even in the presence of the highest dressings of salt and potash used together.

*Effects on Barley.* On the barley crop potash is always residual. Half the barley plots testing salt have salt applied directly at half rates and the remaining half tested only the residues from salt treatments given to the preceding sugar beet crop. The effects of these treatments averaging methods of applying salt are set out in Table IV.

*Table IV. Barley: cwt. per acre,* 1943-49
Effect of residual potash, and salt (direct and residual)

| | Muriate of potash cwt. | | | |
|---|---|---|---|---|
| Salt cwt. | 0 | 2 | 4 | Mean |
| 0 .. .. .. | 27·7 | 28·3 | 27·6 | 27·9 |
| $1\frac{1}{4}$ .. .. .. | 28·5 | 29·0 | 28·7 | 28·7 |
| $2\frac{1}{2}$ .. .. .. | 27·6 | 27·9 | 27·3 | 27·6 |
| $3\frac{3}{4}$ .. .. .. | 27·1 | 29·0 | 28·4 | 28·2 |
| Mean .. .. .. | 27·7 | 28·6 | 28·0 | 28·1 |

Very satisfactory crops of barley were grown each year. On the average of the seven years neither residual potash nor salt had much effect on the yield of barley. The lightest dressing of each gave an average increase of only about 0·8 cwt. grain and there was no further increase for higher rates. In certain years, however, the effects were appreciable. In 1947 and 1949 the effects of residual potash were significant. In 1943 and 1945 there were significant improvements from salt, the direct effects of salt at half rate being greater than the residual effects of the full dressings. The mean effect on barley straw of residual potash and of salt directly applied was negligible.

Salt application produced visible effects on the physical state of the surface soil on this heavy loam when the land was in plough furrow. This was specially noticeable on the sugar beet areas on plots receiving the heavier applications in repeated dressings although it could also be observed on the barley land. The furrows on plots with much salt had a smooth slightly glazed appearance and were lighter in colour than those without salt. The effect was most noticeable after heavy rain. After harrowing the tilth on the heavily salted plots was noticeably more lumpy than the rest, but rolling produced a satisfactory seedbed everywhere and, as the figures show, the sugar beet plant population was not adversely affected. When lifting took place in wet weather the soil was more sticky on the heavily salted plots.