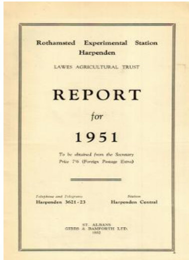
ROTHAMSTED RESEARCH

Rothamsted Report for 1951



Full Table of Content

Field Experiments

Anon

Anon (1952) *Field Experiments ;* Rothamsted Report For 1951, pp 127 - 140 **- DOI: https://doi.org/10.23637/ERADOC-1-73**

FIELD EXPERIMENTS

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 and F. Yates.

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

	Grain	Roots	Hay	Grazing	Total
Classical					
Rothamsted	131	72	47	—	250
Woburn	24	—	—	—	24
Long-period experiments					
Rothamsted	311	264	228	96	899
Woburn	133	314	55	12	514
Annual experiments					
Rothamsted	289	361	108	—	758
Woburn	—	—	—	—	—
Grand total	888	1,011	438	108	2,445

Note. Grain includes cereals, beans, peas, linseed. Roots include potatoes, sugar beet, mangolds, cabbage, broccoli, kale, leeks, red beet. Hay includes meadow and seeds hay, lucerne, cut grass.

The season 1951 was on the whole a difficult one from the point of view of the field experiments. The autumn of 1950 was exceedingly wet and drilling of winter cereals was so delayed that the usual experiment testing the effect of various manurial, spraying and cultivation treatments on the Eyespot disease of wheat could not be drilled at all and was postponed till next year. On Sawyers I the usual wheat experiment testing dung residues after the previous potato crop had to be drilled in so wet a seed-bed that although a fair crop was produced it was not sufficiently uniform for experimental purposes, and no yields were taken.

The wet weather continued in spring, the first four months of the year exceeding the average rainfall by no less than 6·4 in., with the result that drilling spring corn did not commence till the middle of April. After this long period of leaching, winter corn showed very pronounced signs of nitrogen shortage in spring. Plot 15 on Broadbalk, for example, which receives the whole of its nitrogen in the autumn was strikingly yellow and poor-looking compared with neighbouring plots whose nitrogen was spring applied.

June and July gave the only summer weather of the year, rainfall was light in both months and growth was rapid. In this dry spell the soil became dry enough at Woburn to benefit from irrigation, and the new rotation experiment showed big yield increases due to artificial watering in early potatoes, sugar beet, grass and even in barley.

During the dry spell rooks and jackdaws attacked potatoes at Rothamsted, particularly on Highfield, removing many of the seed tubers from the ridges. Certain of the experimental plots were seriously thinned in this way and yields had to be adjusted for plant number. At this period also birds did so much damage to the broccoli

https://doi.org/10.23637/ERADOC-1-73

experiment testing the spread of cauliflower mosaic virus on Highfield that it had to be abandoned. Showery weather set in again in August and lasted through a difficult and protracted harvest. There was some lodging in barley, particularly on the ley arable rotation on Highfield. In this experiment birds attacked the lodged plots to such an extent that no yields were taken. Potato harvest in October was carried out under very good conditions, but the wet weather set in again in November and root lifting and the completion of wheat sowing was delayed.

The Classical Experiments

The classical experiments were continued as usual. In March, Broadbalk wheat which was sown on October 25th looked as well as any on the farm, though the lower end by the drain was very wet and noticeably inferior to the top end. The first-year effect of the bare fallow on Section III was much less noticeable than usual, particularly in the early part of the season, though it stood out better before harvest. Autumn nitrogen either as farmyard manure on plot 2 or sulphate ammonia on plot 15 had very little visible effect on the crop in spring. The dung was more beneficial later in the season, but plot 15 was always exceptionally poor. With the exception of parts of plots 8 and 16 where large dressings of nitrogenous fertilizer are given, there was little lodging. Very thorough pulling of wild oats (*Avena ludoviciana*) in mid-July greatly improved the appearance of the plots for demonstration purposes.

The permanent barley experiment on Hoosfield was in its 100th year, but owing to bare fallows in 1912, 1933 and 1943, only in its 97th crop. It was drilled unusually late on account of the wet spring and was consequently very short in the straw at harvest. Annual weeds were well controlled by spraying with D.N.O.C. (di-nitro-ortho-cresol) but wild oats (*Avena fatua*) which also started into growth unusually late in the season were much in evidence before harvest. Some hand-pulling was carried out but the plots could not be completely cleared.

The barley on the Exhaustion Land sown on March 16th and receiving 2½ cwt. of sulphate of ammonia per acre showed the usual effects of the former phosphatic and dung treatments. In the seedling stage the benefit from phosphatic residues was conspicuous, in mid-season it was not so striking as in recent years, but later in the season the effect was once more apparent. Each of the ten plots was harvested in two sections in 1951 to provide a check on soil variation within plots.

Barnfield mangolds were rather late drilled, but the plants made a good start ; nevertheless the crop was below average in growth especially on the plots receiving dung without inorganic nitrogen and those with complete artificials without dung. The field was very weedy. The sugar beet was a full plant on all plots but the yield of roots was smaller than usual. The Park Grass plots were very late to start growth in spring, but the crop was well up to average at cutting time. A very good second cut was obtained in early October. Wheat on Agdell was a nice-looking crop, but rather small in the ear.

https://doi.org/10.23637/ERADOC-1-73

Long Period Rotation Experiments

These experiments were maintained as usual and in general they call for no special comment in 1951. Some important changes in design were made and these are briefly recorded below.

Market garden experiment, Woburn

This experiment was begun in 1942 to test the effects of repeated dressings of bulky organic manures for building up an ordinary farm soil into a state of fertility suitable for market garden cropping.

The results of the first eight years gave useful information as to the effect of organic manures on peas, leeks, beetroot, and cabbage, but there was no certain evidence of the build-up of soil fertility under repeated applications of these manures. In view of the small number of long-term experiments on vegetable crops and the interest in the action of organic manures it was decided that the experiment should be continued, but in a modified form. The original scheme was to grow two crops every year.

1st year : Green peas followed by leeks.

2nd year : Globe beet followed by winter cabbage.

It was found that in most seasons beet and cabbage could not be left long enough to make full growth if the next crop was to be sown at the proper time ; consequently yields were often poor. Under these circumstances the system of cropping was altered in 1951 ; the pea crop was omitted, and spring cabbage was substituted for winter cabbage, giving three crops in two years. The total amount of organic manures was unchanged, each crop now receiving 10 or 20 tons of organic manures per acre, i.e., 30 or 60 tons for the 2-year rotation.

Irrigation experiments, Woburn

From 1947 onwards five field experiments on the irrigation of sugar beet were carried out at Milford, Surrey and Kesgrave, near Ipswich, under the Committee of Sugar Beet Education and Research.* In 1950 these outside centres were terminated and the work was put on a wider basis under the Agricultural Research Council and transferred to Woburn where a permanent installation for overhead irrigation has been set up. The water is derived from the private supply serving the Duke of Bedford's estate, but since the pressure and flow was inadequate for the full needs of the experiment, a storage tank and pumping engine was provided. At the outset three acres on Butt Close field have been laid out for watering, and it is hoped to extend the experiments to a further three acres later. The cropping at present comprises three series of plots one in each crop of a 3-course rotation :—

1st year : Early potatoes followed by winter cabbage.

2nd year : Sugar beet.

3rd year : Barley.

A fourth series of plots has been put down with a long ley for repeated cuttings as for dried grass over a period of years.

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* The results have been published annually in the Rothamsted Report.

Every crop tests four irrigation treatments at single and double rates of nitrogenous manuring in three fold replication. Adequate basal dressings of phosphate, potash and lime are applied. In the first year, 1951, the yield of early potatoes was more than doubled by irrigation, there was an increase of about 60 per cent in the yield of cut grass, and 20 per cent in barley grain. The irrigation work is conducted by Dr. Penman and reported by the Physics Department.

Ley arable experiments

In the autumn of 1951 the experiments on Highfield and Fosters completed their third preliminary year. Three-year stands of lucerne, cut grass, and grazed ley were ready for ploughing up for test crop wheat on four blocks, while four had completed a sequence of three test crops and were due to come into treatment crops in spring 1952.

Highfield. Wheat was a good clean standing crop which produced 32 cwt. grain per acre. The effect of the double dressing of nitrogen was visible in the colour but had very little effect on the grain and straw weights. Potatoes looked rather poor but gave a mean yield of 10 tons per acre ; they were badly robbed by birds, and had many blighted tubers. Isolated tubers affected with violet root rot were found at lifting time. Barley was excellent but lodged early in the season, and was subsequently so damaged by birds that no yields were taken.

Owing to the late wet spring the growth of grass was much delayed. The plots were fit to graze about the middle of May but at this time the pressure of work on other experiments was so great that, to gain time, all the second and third year plots that were due to be grazed were cut on May 31st : a month later grazing started on all the appropriate treatments. The modified grazing technique whereby the sheep had one fresh enclosure every 24 hours, instead of being in a large enclosure for several days, was closely followed and resulted in better utilization of the herbage and larger liveweight gains. The sheep were on the plots for from five to seven grazing cycles during the season and the team varied from five to three animals according to the amount of grass available. The third year permanent and reseeded grass plots laid up for hay were cut at the beginning of July ; the plots of old grass were thin, patchy and full of buttercups, the newly reseeded ones were more even and less weedy. The lucerne plots in their second and third year produced three useful cuts of green stuff but showed symptoms of potash starvation although the crop received 1½ cwt. high grade muriate of potash per acre spread over the three years. In the late summer the second and third year lucerne was noticed to be wilting and dying off in patches ; the agent responsible was found to be violet root rot (*Rhizoctonia crocorum*). The extent of the attack was very variable between replicates ranging from nothing up to 13 per cent plants affected. The first year lucerne showed stunted and wilted patches which were probably due to the same cause but this remains to be confirmed. All cut grass plots, including the first year, gave 4 cuts of herbage ; the first cut was taken on June 5th on the established plots but not until July 9th on the first year plots.

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Fosters. The test crop wheat on this field was tall, stood well and yielded 28 cwt. at the lower level of nitrogen. The higher level of nitrogenous manuring gave an extra 4 cwt. grain per acre and 8·6 cwt. straw. Barley also was a thick crop and gave 3 cwt. of extra grain for nitrogen and a further 2 cwt. for dung residues ; it tended to lodge where the residues of dung from the previous potato crop coincided with the higher level of nitrogen. The potato crop was much more uniform than on Highfield but yielded rather less. It gave a response of 1·4 tons of potatoes for dung, but little for the higher level of nitrogen. The one year ley, spring sown in 1951 in the open ground, was full of arable weeds and very poor ; it was not weighed. Grass in this exposed field was a week later to start into growth than Highfield. As on Highfield, the reseeded grass and three year leys due to be grazed were first cut on June 6th, and grazing started a month later. There were from 4-6 circuits, with teams of from 2-5 sheep according to the herbage. Lucerne and cut grass gave the same number of cuts as on Highfield, except that the first year cut grass on Fosters was very weedy and poor and gave only one cut taken on October 5th in contrast to four cuts on Highfield. The yields of dry matter from the various grass and legume crops in 1951 are given in the following table.

Yield of herbage crops, Highfield and Fosters, 1951

Mean of both levels of nitrogen

Dry matter : cwt. per acre

		Old grass Hay.	Old grass Grazed	Reseeded grass Hay.	Reseeded grass Grazed	3 year ley Grazed	Reseeded and ley Grazed	Grass Cut	Lucerne Cut
Highfield									
Blocks :	1st year	—	52·2	—	—	—	41·7	42·5	33·3
	2nd year	—	54·2	—	—	—	57·9	66·6	72·6
	3rd year	47·2	23·4*	49·9	18·2*	67·0	—	73·0	73·3
Fosters :									
Blocks :	1st year	—	—	—	—	—	24·4	16·6	13·0
	2nd year	—	—	—	—	—	63·6	71·4	84·2
	3rd year	—	—	47·4	25·1	64·6	—	67·5	88·8

Note. The figures given for the dry matter production on the grazed plots is derived from the sample cuts taken at every grazing before the sheep were admitted. In the special circumstances of 1951 these figures include the contribution of the preliminary cut taken on all the second and third year grazing plots on May 31st on Highfield and June 6th on Fosters. These cuts account for approximately half of the dry matter figure shown, the remainder being the dry matter in the grazing.

* Aftermath grazing.

All grazing was very productive in 1951, more so than in 1950 which was also favourable for grass. The third year grazing on the leys yielded over 3 tons of dry matter per acre, and this was exceeded by the hay plus aftermath grazing on permanent and reseeded grass on both fields. Cut grass also gave over 3 tons of dry matter in the first and second years, and on Highfield over 2 tons of dry matter in the first. Except in the seeding year, lucerne was more productive than any form of grass of the same age ; the highest yield of dry matter was 88·8 cwt. per acre in the third year on Fosters. This result was observed in a more striking degree in 1950.

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In these experiments a double dose of nitrogenous fertilizer is compared with a single dose. This season the effect of the extra nitrogen was in general quite small, the only appreciable response being in aftermath grazing and third year cut grass, in both these crops the increase being about 12 per cent.

Short Period and Annual Experiments

Several of the short period and annual experiments were carried out on behalf of various departments who will themselves report the results. They were :—

(1) Fertilizer placement experiments; winter beans (two experiments) and spring beans—West Barnfield I ; potatoes —Great Harpenden I ; kale—Highfield IV ; lucerne—Long Hoos ; old grass—Highfield IX ; lucerne and cocksfoot ley—Fosters Corner ; Dr. G. W. Cooke, Chemistry Department.

(2) Eyespot of wheat : rotations designed to test the effectiveness of various crop sequences in freeing the land from eyespot (*Cercosporella herpotrichoides*) were continued in Little Knott field. On the north side, the last year of a 3-course rotation showed the effect of 16 different cropping sequences on wheat as a test crop. On the south side, 32 different cropping sequences were being built up for test in wheat in 1953 : Dr. M. D. Glynne, Plant Pathology Department.

(3) Effect of nitrogen, phosphate and potash on the incidence of powdery mildew in wheat—Sawyers III : Dr. F. T. Last, Plant Pathology Department.

(4) Effect of insecticidal treatment on virus spread in potatoes—Great Harpenden I. Repeated sprayings during the season with five insecticides : Dr. C. Potter, Insecticides and Fungicides Department, and Dr. L. Broadbent, Plant Pathology Department.

(5) Spread of two viruses in potatoes—Great Harpenden I : Dr. L. Broadbent, Plant Pathology Department.

(6) Spread of Cabbage Black Ringspot virus in cabbage—Highfield IV : Dr. L. Broadbent, Plant Pathology Department.

(7) The effect of time of sowing and singling on virus spread in sugar beet—Long Hoos : Mr. J. W. Blencowe, Plant Pathology Department.

(8) Wireworm experiments on wheat—Little Hoos :
   (*a*) test of chlordane and gammexane combine-drilled with the seed, and residuals of fumigants applied at heavy rates for the wheat of 1948 ;
   (*b*) test of aldrin and gammexane combine-drilled with the seed, and residuals of dressing of fumigants applied for the wheat of 1948 :

   Dr. C. Potter, Insecticides and Fungicides Department.

Application of dung for potatoes

An experiment testing methods and rates of application of dung to potatoes was repeated for the third season in 1951. Yields were only 3·78 tons in the absence of dung ; the first 5 tons of dung gave a large increase of 1·73 tons, two further increments of dung each

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of 5 tons per acre gave successive increments of 0·69 and 0·61 respectively, showing the falling off at the higher levels noted in the previous years. Sulphate of ammonia gave bigger yields in the presence than in the absence of dung, a result consistent with the large positive interaction observed this season between nitrogen and potash. Dung reduced the response to superphosphate and greatly reduced the response to potash, so much so that in the presence of 15 tons of dung, potash was practically ineffective. In 1951 dung applied in the ridges gave a bigger increase than an equal weight of dung ploughed in in winter or in spring ; this was particularly striking at the low rate of application of 5 tons per acre where the advantage for ridge application was 1·27 tons per acre.

Method of planting potatoes

The study of dropper planting of potatoes begun in 1949 was continued. For mechanical planting the fertilizer was broadcast on the flat, the ridges were then drawn and the seed was placed in the ridges by dropper. The tubers were planted as deep as possible on one set of plots and at the minimum depth to prevent loss through frost and birds on others. The results were :—

Total tubers : tons per acre

Compound Fertilizer cwt. per acre	Hand-planting ordinary method	Machine-planting Deep $\pm 0{\cdot}443$	Machine-planting Shallow	Mean $\pm 0{\cdot}256$
0	3·44	4·73	6·03	4·73
7½	4·67	7·73	7·54	6·65
15	6·59	7·21	8·72	7·51
Mean $\pm 0{\cdot}256$ ...	4·90	6·56	7·43	6·30

The crop was a light one, but it was much improved by fertilizers. The method of planting had a considerable effect on the yield ; even in the absence of fertilizer the machine-planted plots yielded nearly 2 tons more potatoes than the hand-planted ones. During the growing season it was noticed that the plant numbers on the various treatments differed considerably, in spite of the fact that almost equal numbers of tubers per plot had been planted by hand and by machine. Plant counts showed that the mean of all hand-planted plots had 9,900 established plants per acre while the machine-planted plots carried 11,850, an increase of 19 per cent. The mean weight of tubers per plant was also about 19 per cent higher on the machine-planted than on the hand-planted plots ; hence the average improvement in yield due to machine-planting was 42 per cent or nearly 2·1 tons per acre. In this season shallow planting gave significantly more potatoes than deep planting. Fertilizer responses were good generally, but were at least as high on the hand-planted plots as on the others. These experiments will be continued and enlarged to separate the effects of methods of planting from effects due to the location of fertilizer. The loss of plants which has been noted in these experiments when potatoes have been planted in ridges, in certain seasons, needs further examination.

https://doi.org/10.23637/ERADOC-1-73

Late nitrogenous top dressings for cereals

In 1950 field experiments were begun to study the effects of late top dressings of "Nitrochalk", applied when the plants were coming into ear, on the yield and the crude protein content of grain and straw. The first year's results showed that in the conditions encountered in 1950 there was no increase in yield of grain or straw due to late nitrogen, but for each of the crops the heavier dressings of "Nitrochalk" gave an extra hundredweight of crude protein per acre in the total produce. The experiments were continued on a larger scale in 1951. The crops were: wheat (Nord Desprez), barley (Plumage Archer), and spring oats (Sun II). The wheat, which was sown early in the autumn of 1950, had a good start, and on May 25th, 1951, the whole piece received a top dressing of $2\frac{1}{4}$ cwt. of sulphate of ammonia per acre. Owing to the wet spring the barley was not drilled till May 2nd, 1951, and received $1\frac{3}{4}$ cwt. of sulphate of ammonia on June 1st. The oats were drilled on April 19th and received a basal dressing of $1\frac{2}{3}$ cwt. sulphate of ammonia on June 4th. Even the basal dressings were applied rather late in the season this year. The wheat and oats received the experimental top dressings of "Nitrochalk" on July 5th, about a week later than in the previous year. The barley was top-dressed on July 11th, about a fortnight later than in 1950.

The wheat was an excellent crop yielding nearly 37 cwt. of grain per acre without late nitrogen. It was all standing and showed no visible effects from the late nitrogen dressings. The barley was also a fine crop of 33 cwt., but was all lodged, the plots receiving the 3 cwt. dressing of "Nitrochalk" were more flat than the rest and later to ripen. The oat crop was thin, very short in the straw and late to ripen. It yielded 18 cwt. grain and an equal weight of straw, only about half the grain and one-third the straw of the year before. There was no lodging, but the straw was slightly taller and greener where the heavy rate of late top dressing had been applied.

July 1951 was, on the whole, very dry and the few light showers that occurred after top dressing were probably insufficient to carry the fertilizer into the soil. The first useful rain was a fall of 0·65 in. at the end of the month and there was plenty of moisture throughout August. Thus the late dressings were probably less favoured by the weather than in 1950 when there were repeated heavy rains soon after application. The experiments of 1951 were considerably more accurate than those of the previous year, and the effect of 3 cwt. of "Nitrochalk" on yield, though small, was statistically significant for both grain and straw in oats, and for straw in barley. Barley grain weighed in its natural condition was also significantly increased by late nitrogen, but this was largely due to the higher moisture content of the top dressed plots, and the effect was not significant in the dry matter.

The following table gives the yield of grain and straw, the percentage of nitrogen in the dry matter, the increase in crude protein, and the uptake of nitrogen.

Late nitrogenous top dressings, 1951

"Nitrochalk" cwt. per acre	Wheat Grain	Wheat Straw	Barley Grain*	Barley Straw*	Oats Grain	Oats Straw*
			Yield, cwt. per acre			
0	36·7	42·8	31·7	24·5	17·7	12·8
1·5	35·9	44·0	32·4	24·8	18·4	13·9
3	36·4	42·0	33·3	27·4	18·7	14·8
S.E. ± ...	0·56	0·71	0·82	0·76	0·29	0·38
			Mean dry matter, per cent			
	82·4	80·8	80·8	61·5	79·2	58·0
			Nitrogen per cent of dry matter			
0	1·87	0·59	1·87	0·78	2·24	0·69
1·5	1·90	0·65	2·05	0·86	2·39	0·85
3	1·93	0·64	2·16	0·94	2·49	1·02
			Increase in crude protein, cwt. per acre			
1·5	–0·02	0·17	0·45	0·14	0·20	0·19
3	0·09	0·08	0·80	0·42	0·31	0·39
			Percentage uptake of added nitrogen			
1·5	–1	12	30	10	14	13
3	3	3	27	14	11	14

On barley the results of the application of late nitrogen were very similar to those observed in 1950. The higher level of "Nitrochalk" increased the percentage of nitrogen in both grain and straw to give an extra 1·2 cwt. of crude protein per acre of which two-thirds was in the grain. The recovery of nitrogen was about 40 per cent at both levels of manuring. Wheat, already a very heavy crop, was little changed by late top dressing in 1951, although the effects on grain and straw were in the usual direction. The total gain in crude protein from the double dressing was 0·17 cwt. per acre, with an uptake of nitrogen of only 6 per cent. The oats were very poor both in grain and straw and the basal nitrogenous dressing was not applied till June 4th; in spite of this the experimental dressing of "Nitrochalk" produced a noticeable but not spectacular improvement in the yield and composition of the crop. Crude protein was increased by 0·3 cwt. in both grain and straw, the total gain being 0·70 cwt. with a utilization of nitrogen of nearly 27 per cent at both levels.

The experiments show that in the not very favourable circumstances of midsummer 1951 late nitrogenous top dressings were effective on barley, and to a lesser extent on oats, but had little effect on a very heavy crop of wheat.

An eighteen-year experiment on ploughing-in straw and compost

During the last 20 years several long-term field experiments have been started at Rothamsted and Woburn to assess the effects of alternative methods of adding organic matter to soils. Leys, green-manures, farmyard manure, composts and straw have been tested in experiments continued long enough to indicate progressive changes in soil fertility as shown by the yields of arable crops following the contrasted treatments.

One of the Rothamsted experiments, which completed its eighteenth test season in 1951, is reviewed below. Its purpose was to

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* Yield corrected to 85 per cent dry matter.

https://doi.org/10.23637/ERADOC-1-73

test the value of straw ploughed into the land in autumn with fertilizers applied either in the following spring or equally divided between autumn and spring. The two sets of plots with straw were compared with plots without straw and also with other plots receiving straw compost prepared from the same amount of straw and NP fertilizers, the potassium fertilizer being ploughed in with the straw compost.

The above straw and fertilizer treatments were applied to appropriate plots in alternate years in order to have the opportunity of comparing their immediate and residual effects. The experiment consisted of three blocks of land cropped each year with barley, sugar beet and potatoes, respectively, the crops rotating in this order. Each block had 24 plots giving three-fold replication for the four treatments applied in alternate years. (In the early stages of the experiments there were additional factorial tests on two winter green manure crops, but these grew poorly and were soon abandoned).

In addition to the test treatments given in alternate years each plot of sugar beet and potatoes received additional fertilizers as a basal dressing.

The rates of fertilizer dressings and the experimental treatments are summarized below :—

Experimental treatments

In alternate years fertilizers (F) alone with 53·3 cwt. straw per acre or with compost derived from this amount of straw, were applied at the following times :—

		Autumn	Spring
F	...	none	NPK
Ss	...	straw	NPK
Sw	...	straw+½ (NPK)	½ (NPK)
C	...	straw+NP (as compost) +K ploughed in	none

Additional basal dressings for all plots

		Cwt. per acre		
		N	P_2O_5	K_2O
Barley	...	none	none	none
Sugar beet	...	0·2	0·2	0·25
Potatoes	...	0·4	0·4	0·5

Crop rotation and fertilizer applications
(including basal dressings)

		Cwt. per acre		
	Treatment	N	P_2O_5	K_2O
Barley	fertilizers	0·4	0·4	0·50
Sugar beet	residues	0·2	0·2	0·25
Potatoes	fertilizers	0·8	0·8	1·00
Barley	residues	none	none	none
Sugar beet	fertilizers	0·6	0·6	0·75
Potatoes	residues	0·4	0·4	0·50

Allowing for the nutrients in straw and the losses in composting, the combined dressings in the experimental treatments supplied, over and above the basal dressings, approximately :—

			Cwt. per acre		
			N	P_2O_5	K_2O
F	...	...	0·4	0·4	0·5
Ss	...	...	0·7	0·5	1·1
Sw	...	...	0·7	0·5	1·1
C	...	...	0·5	0·3	0·8

A rotation with two root crops in three years was chosen to intensify the loss of organic matter by cultivation. The straw was applied at heavy rates (53 cwt. wheat straw per acre in alternate years) in order to magnify any beneficial effects by improving soil structure, microbiological activity, soil organic matter content or the supply of certain nutrients. The ratio of nitrogen in the associated fertilizers to straw was chosen to conform with the Hutchinson and Richards " nitrogen factor " (0·75 parts N per 100 parts straw), as a conventional estimate of the amount of additional nitrogen likely to be immobilized by the straw in the soil or the compost heap. The compost was made by soaking the straw in water, adding calcium cyanamide and ground phosphate rock with some calcium carbonate when stacking the moistened straw in the open. The compost was put up about May and ploughed in about November at the same time as the chopped straw on other plots. The fertilizers were applied as ammonium sulphate, superphosphate and potassium chloride, except that the basal dressing for sugar beet was given as sodium nitrate and the potassium for potatoes as sulphate. For potatoes the fertilizers applied in spring were placed in the furrows immediately before planting the sets and splitting back the ridges.

The yields for the period 1934 to 1951 inclusive give three full six-year cycles with nine repetitions of the manurial treatments and six seasons for each of the three crops.

Table 1 gives the mean yields for eighteen seasons for each of the three crops, distinguishing those with high fertilizer dressings (with straw or compost on some plots) applied for the test crop and those with low fertilizer dressings without straw or compost, following high dressings to the preceding crops.

The first part of Table 1 shows the immediate and the first year residual effects of the four manurial treatments. The yields of barley, both grain and straw, were reduced appreciably by straw and markedly by compost ploughed in during the autumn. Straw and compost applied for the potato crop had only small and irregular residual effects on the following barley crop. Sugar beet showed similar results, the yields of roots, sugar and tops being reduced appreciably by straw and markedly by compost applied in the previous autumn but scarcely affected by residues from the straw and compost applied for the preceding barley crop.

It is known from another experiment over the same period in the same field (Six-course Rotation) that barley and sugar beet show large responses to nitrogen and small ones to phosphorus or potassium. The effects of straw and compost on barley and sugar beet can be largely explained by the simple assumption that the crops suffered through loss of available nitrogen where straw was applied either directly or in compost. Indeed, the losses in composting agree fairly well with the Hutchinson and Richards factor, assuming that none of the nitrogen immobilized was recovered subsequently. Fifty-three cwt. straw per acre with 0·4 cwt. nitrogen per acre made into compost gave almost the same yields (to within 1 per cent) as plots receiving no additional fertilizer. The loss of available nitrogen was presumably less on the plots where straw was ploughed in directly, because the straw may have used some nitrate which would otherwise have been lost in drainage. Where half or all of the

https://doi.org/10.23637/ERADOC-1-73

fertilizer nitrogen was applied in the spring, some would be used by the crops before the straw could remove it.

Potatoes behaved quite differently from barley and sugar beet. The potatoes showed a gain of about 10 cwt. per acre from straw ploughed in in the previous autumn, provided that the fertilizers were all given to the potato crop in spring, and also good gains from residues of the straw applied for the sugar beet crop (20 cwt. potatoes per acre from straw residues and 12 cwt. from compost residues). At first sight this might suggest that the potato crop responded to some improvement in soil structure. There are, however, strong indications that some other factor was responsible. It is known from the six-course rotation experiment in the same field that potatoes respond particularly well on this soil to additional potassium. The effects of straw and compost on the potato crop may well represent the combined effect of a loss of available nitrogen from straw or compost applied in the previous autumn, as was also shown in the two other crops, and a gain of potassium from the straw.

The second part of Table 1 shows the mean annual changes in yield for each treatment. If straw or compost progressively improved soil fertility, the treated plots would be expected to gain steadily on the untreated plots. There is, however, no general improvement over 18 years on plots receiving straw in alternate years. The only significant differences in the mean annual changes for the sets of four comparable figures tabulated are :

(*a*) for direct applications to potatoes, a progressive improvement for straw with fertilizers divided between winter and spring and also for compost ;

(*b*) for direct application to sugar beet a progressive fall with all straw treatments below those on plots without straw.

The barley crop showed only small and irregular effects of treatments on the slow changes in yield.

The contrasted responses of potatoes and sugar beet to straw and compost are illustrated in Table 2 by estimated yields for the first and last season of the experiment, calculated from the mean yields and the mean annual changes.

At the beginning of the experiment straw applied for the potato crop increased yields if the fertilizers were given in spring, but decreased them if the fertilizers were divided between autumn and spring. At the end of the experiment these two treatments gave similar improvements of about 10 cwts. potatoes per acre. There is little reason to expect soil structure or soil organic matter to be much influenced by the time and method of applying fertilizers, but it is well known that putting fertilizers close to potato sets is much better than ploughing them in during the previous autumn. If the soils were gaining in available potassium through repeated treatment with straw, differences due to the time and method of applying the potassium fertilizer would become progressively less important. As straw with divided fertilizer dressings gave lower yields of potatoes than straw with fertilizers in spring in the early years of the experiment, more potassium would be left unused in the soil. Both at the beginning and the end of the experiment straw residues gave a much bigger increase than the direct applications because in the residual year there would be much less loss of available nitrogen. It would scarcely be expected that structural or organic matter effects from straw residues would be greater than those from straw applied directly for the potato crop. The compost continued to the end of the experiment to depress yields markedly in the year of application but the gain from the residues increased as time went on.

Analyses of the materials throughout the experiment showed that the average straw dressing supplied about 0·6 cwt. K_2O per acre, and the average compost dressing about 0·3 cwt. K_2O per acre. The increases in yield of potatoes for treatments applied for the preceding sugar beet crop were about half as large for compost as for straw, both at the beginning and the end of the experiment. This suggests that the potassium supplied accounted for a large part of any benefit from straw or compost on potatoes.

At the commencement of the experiment the yields of sugar from sugar beet showed little effect from straw or its residues and a small depression from compost applied in the preceding autumn. By the end of the experiment yields were reduced considerably by straw and by compost applied in the preceding autumn. The residues from straw or compost applied for the barley crop had only small effects at any time. The tops of sugar beet showed only very small and irregular progressive changes, the average effects throughout the experiment being similar to those for roots and sugar at the end of the experiment.

As was stated in discussing the mean yields, the effects on sugar beet can be explained by assuming that the main effect of straw or compost is to reduce the supply of nitrogen available to the sugar beet crop. By the end of the experiment the plots with compost from straw and 0·6 cwt. N per acre in fertilizer gave lower yields of sugar than those with 0·2 cwt. N per acre in fertilizer. This tends to confirm a suggestion from other work that straw may immobilize more than 0·75 per cent of additional nitrogen.

Straw may influence soil fertility in so many ways that no simple explanations can be offered for all the results for three crops testing immediate and residual effects over 18 seasons. It is, however, clear that there is no sign of any general improvement in soil fertility through adding large amounts of straw. It may be dangerously misleading to regard straw as the basis for maintaining soil fertility. Straw reduced yields of two of the three crops tested and for sugar beet roots the reductions became more severe as the experiment progressed. Losses were particularly serious where nitrogen and phosphorus fertilizers were used to make straw compost instead of being applied directly to the land. Where straw is applied directly it may be assumed that about one part of extra nitrogen will be required for every 100 parts of straw to prevent serious loss of nitrogen available to crops. The extra nitrogen should be given at the time most suitable for the following crop. There is little sign that the nitrogen immobilized by straw becomes available later in any significant amount.

Provided extra nitrogen fertilizer is used to balance the losses caused by straw, the potassium in the straw may add appreciably to the supply in the soil. The potassium content of straw is very variable ; in this experiment the range was from 0·6 to 1·8 K_2O per cent of the dry matter.

https://doi.org/10.23637/ERADOC-1-73

The interpretations offered above for the effects of straw and compost are being examined more closely by soil analyses and by continuing the experiment in a revised form which will allow tests on straw with extra nitrogen against additional potassium fertilizers. This may allow a clearer opportunity for detecting any physical or other effects from the additional organic matter which may have hitherto been missed.

TABLE 1

Mean yields and mean annual changes in yield, 1934 *to* 1951

Sugar beet roots and tops, potatoes in tons per acre
Barley grain and straw, sugar in cwts. per acre

	Barley		Sugar beet			Potatoes
	Grain	Straw	Roots	Sugar	Tops	
Mean yield :						
Application to test crop						
F	32·3	37·5	11·7	43·3	10·5	9·12
Ss	30·8	34·6	10·9	41·0	9·2	9·64
Sw	30·8	33·4	10·9	40·9	9·0	9·25
C	27·5	29·7	9·9	36·9	7·9	8·00
Application to preceding crop						
F	27·4	29·4	10·0	37·3	7·9	6·99
Ss	27·3	29·5	10·0	37·4	7·8	8·02
Sw	28·0	30·1	10·3	38·6	8·2	8·11
C	26·3	28·8	9·7	36·1	7·8	7·58
S.E. ...	±0·55	—	—	±0·68	±0·23	±0·137
Mean annual change in yield :						
Application to test crop						
F	—0·01	—0·28	0·12	0·42	—0·06	0·06
Ss	—0·11	—0·19	0·05	0·13	—0·11	0·06
Sw	—0·10	—0·15	0·00	—0·11	—0·13	0·13
C	—0·11	—0·28	0·03	0·06	—0·08	0·12
Application to preceding crop						
F	—0·19	—0·28	0·06	0·18	—0·11	0·08
Ss	—0·09	—0·21	0·02	—0·01	—0·06	0·10
Sw	—0·09	—0·24	0·04	0·07	—0·06	0·14
C	—0·05	—0·16	0·00	—0·03	—0·11	0·11
S.E. ...	±0·065	—	—	±0·101	±0·028	±0·019

TABLE 2

Estimated smoothed yields

		First year		*Eighteenth year*	
		Application to :		Application to :	
	Treatment	test crop	preceding crop	test crop	preceding crop
Potatoes, tons per acre (±0·21) :					
F	fertilizers	8·6	6·3	9·7	7·7
Ss	straw, fertilizers in spring ...	9·2	7·1	10·1	8·9
Sw	straw, fertilizers divided ...	8·2	7·0	10·3	9·3
C	compost	7·0	6·7	9·0	8·5
Sugar, cwt. per acre (±1·10) :					
F	fertilizers	39·7	35·8	46·9	38·8
Ss	straw, fertilizers in spring ...	39·9	37·5	42·1	37·3
Sw	straw, fertilizers divided ...	41·8	38·0	40·0	39·2
C	compost	36·4	36·4	37·4	35·8