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# Memoranda of the Field Experiments at Rothamsted: May 1881



[Full Table of Content](#)

## Experiments on Clover; Hoos Field

### Rothamsted Research

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## EXPERIMENTS ON THE GROWTH OF LEGUMINOUS CROPS.

## I.—BEANS, PEAS, AND TARES—GEESCROFT FIELD.

EXPERIMENTS on the growth of Leguminous corn-crops (beans, peas, and tares), with different descriptions of manure, were commenced in 1847, about nine acres being devoted to the purpose.

Experiments with BEANS were continued without a break, for thirteen consecutive seasons, to 1859 inclusive; but, during the later years, the crop fell off very much, and the land became very foul.

In 1860 the land was fallowed.

In 1861 a crop of wheat, without manure, was taken.

In 1862 beans were again sown, but with some variation in the manuring.

In 1863 the land was fallowed.

In 1864, 5, 6, 7, 8, and 9, beans were grown, with much the same manures on the same plots, each year, as in 1862.

In the winter of 1869-70, 5000 lbs. of fresh burnt lime were applied per acre, over all the plots.

In 1870 beans were grown with the same manures on the respective plots as in 1864-69.

In October 1870 winter beans were sown (without manure), but the plants were to so great an extent destroyed by the severe weather which followed, that, in April 1871, the crop was ploughed up, and the land left fallow.

During the winter and early spring of 1871-2, the land was so wet that it could not be prepared in time for sowing. It was therefore left fallow for 1872; at the end of May it was subsoiled to a depth of about 12 inches, and re-ploughed in July.

The winter and early spring of 1872-3 were also so extremely wet, that it was again impossible to prepare the land in time for sowing; it was, however, ploughed up towards the end of March, again left fallow, and re-ploughed in July and October (1873).

On February 2, 1874, the land was again set with Beans, but without manure.

In 1875 Beans were re-sown, with the same manures on the respective plots as in 1864-1870; but owing to the wetness of the land in the first instance, and the subsequent hindrance by other spring sowing, they were not put in until April 1 and 2.

The wetness of the winter 1875-6, again prevented the preparation of the land in due time; and, though the manures were sown, and the land ploughed, it was left fallow during the summer of 1876.

Early in October, 1876, winter Beans were put in (drilled), without further manuring.

In 1878 the usual manures were sown, and beans were drilled on February 26.

Owing to the wetness of the winter, and the foul condition of the land, it was left fallow in 1879.

Owing to the continued wetness in the autumn, the severe winter, and foulness of the land, it could not be got into order for sowing, and remained fallow in 1880.

During 1880 the land was ploughed, scarified, and partially cleaned, but owing to the wetness of the autumn and the wetness and severity of the winter, it was again impossible to work the land in time for sowing; and it still remains fallow (1881).

The general result of the experiments with BEANS has been that mineral constituents used as manure (more particularly potass), increased the produce very much during the early years; and, to a certain extent, afterwards, whenever the season was favourable for the crop. Ammonia-salts, on the other hand, produced very little effect; notwithstanding that a Leguminous crop contains two, three, or more times as much nitrogen as a Gramineous one grown under similar conditions as to soil, &c. Nitrate of soda has, however, produced more marked effects. But Leguminous crops grown too frequently on the same land seem to be peculiarly subject to disease, which no conditions of manuring that we have hitherto tried seem to obviate.

Experiments with PEAS were soon abandoned, owing to the difficulty of keeping the land free from weeds, and an alternation

of BEANS and WHEAT was substituted; the Beans being manured much as in the experiments with the same crop grown continuously as above described. But the wetness of the winter of 1871-72 prevented the sowing of the Beans for the season of 1872; and again the wetness of the autumn and winter of 1872-3 prevented the sowing of the wheat until April 4, 1873, when Nursery wheat was put in, which, however, did not come to maturity, but was cut in the middle of September, yielding about 27 cwts. of gross produce per acre, containing too little corn to be worth thrashing. The land was ploughed in October 1873, and sown with beans February 3, 1874. On October 23, 1874, wheat was sown without manure. Beans should have been sown in 1876; indeed, the manures were sown, but, for the reason stated above, the land was left fallow; and wheat was put in October 24 (1876). In 1878 Beans were drilled, on February 26, with the usual manures. Owing to the wetness of the winter, and the condition of the land, it was left fallow in 1879; and it continues so up to the present time (May 1881).

In alternating WHEAT with BEANS, the remarkable result had been obtained, that nearly as much wheat, and nearly as much nitrogen, were yielded in eight crops of wheat in alternation with the highly nitrogenous beans, as in sixteen crops of wheat grown consecutively without manure in another field, and also nearly as much as were obtained in a third field in eight crops alternated with bare fallow.

Experiments with TARES, like those with Peas, were soon abandoned, and for the same reasons. Beans were at first substituted, with some variation in the description of the manures employed; but this experiment has likewise been abandoned for some years.

II.—RED CLOVER (*Trifolium pratense*).

## 1. Experiments on ordinary arable land.—HOOS FIELD.

EXPERIMENTS on the growth of Clover, on ordinary arable land, with many different descriptions of manure, were commenced in 1849, and, with the occasional interposition of a corn-crop, or fallow, were continued up to 1877, inclusive.

As with other Leguminous crops, the result was, that mineral constituents applied as manure (particularly potass) considerably increased the early crops. Ammonia-salts had little or no beneficial effect, and were sometimes injurious. It may be added, that the beneficial effects of long previous applications of potass have been apparent whenever there was any growth at all. To go a little more into detail:—

In the first year, 1849, the crops were throughout very heavy; especially with mineral, and without nitrogenous manure.

In autumn 1849 wheat was sown, and in spring 1850 Red Clover. In 1851 small cuttings were taken; and in 1852, though the crops were not heavy, there was by no means a failure.

Since that time, however, all attempts to grow clover year after year on this ordinary arable land have failed to give anything like a full crop, or even a plant which would stand the usual time on the ground.

Small cuttings were obtained in the autumns of 1855 and 1859, from seed sown in the spring of those years; and small but rather heavier cuttings in June and August 1865, from seed sown in 1864.

In April 1868 a portion only of the land was sown with Clover, and the plant for the most part died off in the winter.

In April 1869 the same portion was resown, and gave a small cutting in September of that year; but the plant again died off in the winter.

In April 1870 Clover was sown over the whole of the experimental land, this time in conjunction with Barley; but on those portions which had also been sown in 1868 and 1869 the plant again died off during the winter and early spring; whilst from those which had not been sown in 1868 and 1869 two small cuttings were taken in 1871.



EXPERIMENTS ON THE GROWTH OF LEGUMINOUS CROPS—*continued*.

In the spring of 1872, the plant being then almost entirely gone, the land was ploughed up. It was again ploughed in July 1872, and in March 1873; the intention being to sow some other Leguminous crop; but owing to the wetness and lateness of the season this was not done; the land was again left fallow, and re-ploughed in the beginning of June and the end of July (1873).

On May 4, 1874, the land was again ploughed, and sown with Red Clover seed, May 5, without manure. The plant came up well, and was very forward in September, when the flowering stems were cut down, but left on the land. During the winter and early spring the plant on those portions from which cuttings had been taken in 1871 almost entirely failed, and the land was ploughed up in May, and again in August (1875); whilst on those from which none had been taken since 1869 a fair plant remained, and two small cuttings were obtained, namely on June 23, and on August 9 and 12 (1875). On September 22, this portion of the land was ploughed up.

In May (1876) the whole was re-ploughed, again in July and September, and left fallow.

In May 1877, Barley and Clover were sown over the whole of the experimental Land, without further manuring, but the clover plant completely died off during the winter.

On two occasions (1851 and 1854) heavy dressings of Farnyard dung were applied to some of the plots; and in 1854 some received a dressing of 20 tons of dung, and 5000 lbs. of lime, per acre.

On some portions of the land Clover was sown 12 times during the 30 years, 1848–1877, and more frequently alone than with a corn-crop; but in 9 out of the last 10 trials the plant died off in the winter and spring succeeding the sowing the seed.

In 1878 the land was devoted to experiments with various Leguminous plants, differently manured, and these experiments are still in progress (1881); for further particulars see p. 16.

In reference to these field experiments on clover, it may be added that, in 1864, a portion of the land was trenched 2 feet deep, and one-third of the manure was mixed with the layer from 24 to 16 inches, one-third from 16 to 8 inches, and the remainder from 8 inches upwards. Owing to the characters of the season, the mechanical condition of the land was at first very unfavourable after this treatment; but, although many years have now elapsed, and the excess of constituents supplied was in some cases considerable, the plant has died off as completely on these plots as elsewhere.

Again, in the winter of 1867–8 a number of small beds, each 3 yards  $\times$  2, were arranged on the previously unmanured plot of the experimental land. These were dug, some to the depth of 9 inches, some to the depth of 18, some to the depth of 27, and some to the depth of 36 inches, and sown to the respective depths with different mixtures; supplying in some cases very large amounts of potass, soda, lime, magnesia, phosphoric acid, sulphuric acid, nitrate of soda, &c.

From three similar sized beds, the soil was removed to the depths of 9, 18, and 27 inches respectively, and replaced by soil taken at the same depths from a garden border, on a portion of which Clover had been grown successfully since 1854, as described on the next page.

In April 1868 clover was sown on the whole of these small beds (as well as on some other portions of the experimental land); but the plant for the most part died off during the following winter.

In April 1869 the small beds (and the other portions as in 1868) were re-sown, small quantities of clover were cut in September of that year, but the plant again died off in the winter.

In April 1870 Clover was again sown on the small beds in conjunction with barley (as on all the rest of the experimental land), but the plant again died in the winter.

In the spring of 1871 the small beds were again re-sown, and the three with garden-soil were entirely enclosed, both around and above, by galvanised wire netting. Small cuttings were taken from these small beds in July 1872; and (excepting from the beds of garden-soil, which had yielded considerably more than the others in 1872), larger cuttings were taken in July 1873. The produce was the largest where potass and nitrate of soda were employed, and where they were applied in the largest quantity, and to the greatest depths.

In April 1874 there was still some healthy plant on all the beds, but it was considered to be too irregular to preserve. It was, therefore, dug in. The artificially-manured beds were re-manured as before, but only to the depth of 9 inches, and seed was sown on May 4th, July 6th, and October 22nd; each time the plant coming up well, but subsequently dying off. On the three beds of garden-soil, the plant from the first sowing (May 4), for the most part stood; requiring only to be made good here and there on July 6; and in September small cuttings were taken.

More small beds were arranged in the spring of 1874; on which the manures were dug in, at the various depths, on May 11th to 14th, and the seed sown on May 16th. At this time, the wire netting was removed from above the three beds of garden-soil, but the whole series of small beds was now surrounded with netting, to keep out ground game. One series of the new plots received sulphate of potass only, another nitrate of soda only, and a third the two together. The plants came up fairly well, but there were some blanks in the rows, which were re-sown on October 22 (1874). A cutting was taken on June 22 and 23 (1875) from these new beds; the blanks in the rows were re-sown on July 24; a second cutting was taken on August 17; and the blanks were again re-sown on September 22 (1875). The plant was the most even on the beds with sulphate of potass, less so on those with nitrate of soda, and less still on those with both together. The amount of produce was also greater with each of the manures used separately, than with the mixture of the two.

In May, 1875, the plant was entirely gone on the old artificially-manured beds, which were then dug up, and prepared for re-sowing. On the three beds of garden-soil, though the rows were imperfect, some healthy plants still remained, and gave a small cutting on June 22. On July 24 these beds were dug up; and they, as well as the artificially manured ones just referred to, were re-sown with seed. All came up well, but in May (1876), the plants on the beds of garden-soil were entirely gone, and those on the artificially manured ones nearly so, but they yielded small cuttings on July 17 (1876).

The plants on the new artificially manured beds, like those on the older ones, showed failure in the spring of 1876; but also, like them, gave small cuttings in July. All the small beds were dug up in August (1876); the artificially manured ones re-manured as in 1874, the manures dug in to a depth of 9 inches, and seed was sown on September 1, which came up, but the plants died off on all the plots in the winter of 1876–7.

In May 1877, all the small beds were dug up, and sown with Barley and Clover. To try the effects of shelter, the Barley stubble was left unusually high, but the young clover plants completely died off during the winter (1877–8).

In the spring of 1878 the beds were dug up, and cleaned; and they were re-sown with Clover, without further manuring, on June 12 and 13. All came up well, but the plant was almost entirely destroyed by "Fly."

In May 1879, there remained about a quarter of a plant on the plot with the largest amount of mineral manure, including potass, and sown to the greatest depth, and perhaps a third of a plant where the same mineral manures, with nitrate of soda in addition, had been applied; but there was scarcely a single plant on any of the other plots. On June 9 and 10, 1879, all the beds were cleaned, and re-sown with seed, which came up well; but a very wet and cold season following, most of the plants died off during the summer and autumn.

Early in June 1880, all the small beds were cleaned, and forked up; and on June 10, they were re-sown with seed without further manure. All came up well, but the plants were for the most part destroyed by the severe winter which followed.

In May, 1881, there was perhaps half a plant on two or three only out of the forty small beds; namely, where the mixed mineral manure, including potass, was used without nitrogenous manure; and the greatest vigour was where the manure was applied in the largest quantity, and to the greatest depths. On no other beds (not even on the three made up of garden-soil) was there nearly as much plant; and now (May 1881) all the small beds have been cleaned, the clover plants forked in, manures also forked in, as in 1876, to a depth of 8 or 9 inches, and clover seed sown.

It will be observed that, although in the earlier years, the three small beds in the field which had been artificially made up of surface-soil and subsoil brought from a highly manured



EXPERIMENTS WITH VARIOUS LEGUMINOUS PLANTS.—HOOS FIELD.

The land upon which attempts had been made to grow Red Clover in frequent succession since 1849, was devoted to experiments with various Leguminous Plants in 1878; so that the present season, 1881, is the fourth year of these experiments. The object was to ascertain whether, among a selection of plants all belonging to the Leguminous family, but of different habits of growth, and especially of different character and range of roots, some could be grown successfully for a longer time, and would yield more produce, containing more nitrogen as well as other constituents, than others; all being supplied with the same descriptions and quantities of manuring substances, applied to the surface soil. Further, whether the success in some cases, and the failure in others, would afford additional evidence as to the source of the nitrogen of the Leguminosae generally, and as to the causes of the failure of Red Clover in particular, when it is grown too frequently on the same land. Below, is given a list of the plants now growing (1881), all of which were sown on April 9; and, excepting in the few cases stated, the same description has been sown in each of the four years. The same mineral manure (if any) is applied to the same plot of each *Series*. *Series 1*, has mineral manure only; *Series 2*, the same mineral manure, and nitrates of soda; *Series 3*, the same mineral manure, and on one portion ammonia-salts, on another a dressing of cow's urine, and on another rape-cake, in addition. The mineral manures were applied in the quantities per acre stated in the Table, in 1878, and in 1880. The nitrates of soda, and the ammonia-salts, have been applied, in each of the four years, 1878, 1879, 1880, and 1881. The cows'-urine was applied in the second year only, 1879. The rape-cake was applied in the first and third years, 1878 and 1880; in the former on three lands, but in the latter on only two. It is estimated that already several times as much nitrogen has been removed in some of the other plants as in the Red Clover; but it is too soon to form any general conclusions from the results.

(Area under Experiment, about 3 acres, each plot, about  $\frac{1}{4}$ th acre.)

| PLANTS GROWN ON EACH PLOT.                           |                                       | MANURES; QUANTITIES PER ACRE.   |  |
|--|---------------------------------------|---------------------------------|--|
| No.  | Botanical Names.                      | Common Names.                   | Notes.   |
| 1  | <i>Trifolium pratense</i>             | Common Red, or Broad Clover.    |  |
| 2  | <i>Trifolium pratense pervenne</i> .. | Pervenne Clover, or Cow-grass.  |  |
| 3  | <i>Trifolium pratense hybridum</i> .. | Stations hybrid (Cow Clover).   |  |
| 4  | <i>Trifolium repens</i> ..            | Common white, or Dutch Clover.  |  |
| 5  | <i>Trifolium repens pervenne</i> ..   | Giant pervenne, White Clover.   |  |
| 6  | <i>Trifolium hybridum</i> ..          | Alsike Clover.                  |  |
| 7  | <i>Trifolium incarnatum</i> ..        | Early Red or Crimson Clover.    |  |
| 8  | <i>Trifolium hardiflorum album</i> .. | Late White Clover               |  |
| 9  | <i>Medicago lupulina</i> ..           | Non-such, or Black Medick.      |  |
| 10   | <i>Medicago lupulina</i> ..           | Black Medick.                   |  |
| 11   | <i>Melilotus indicus</i> ..           | Black Clover, or Purple Medick. |  |
| 12   | <i>Lotus corniculatus</i> ..          | Common Bird's-foot Trefoil      |  |
| 13   | <i>Vicia sativa</i> ..                | Summer Tare, or Vetch.          |  |
| 14   | <i>Onobrychis sativa</i> ..           | Common Saintoin ..              |  |
|  |                                       |                                 | <i>T. procumbens</i> (yellow Trefoil, or-Hop Clover) in 1878 and 1879. <i>T. incarnatum</i> (late Red Clover) in 1880. No seed sown in 1878. |
|  |                                       |                                 | <i>Lathyrus pratensis</i> (Meadow Vetchling) in 1878.  |
| MANURES; QUANTITIES PER ACRE.                        |                                       |                                 |  |
| Series 1 (6 Lands). <sup>1</sup>                     |                                       | Series 2.                       |  |
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