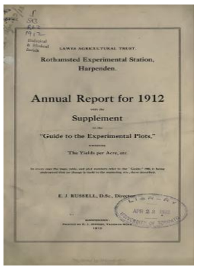
# Annual Report for 1912 With the Supplement to the Guide to the Experimental Plots Containing the Yields per Acre, Etc.


Rothamsted Experimental Station, Harpenden.

Annual Report for 1912

Supplement

"Guide to the Experimental Plots."

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## Rothamsted Report for the Year 1912

### Rothamsted Research

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# ANNUAL REPORT

## FOR THE YEAR 1912

THE season of 1912 was characterised by its cold, wet, sunless summer, which stood out in sharp contrast with the hot, dry summer of 1911. Throughout it was unfavourable to crop growth, and the yields on the permanent plots, where but little opportunity arises for cleaning operations, were low in comparison with those on adjacent fields under ordinary cultivation. The winter ploughing was got through satisfactorily in spite of the unsuitable weather; the dry autumn of 1911 had left the land too hard to break up, and when the rain came in December there was no less than 6 inches—over 3½ inches above the average. January, February and March also were wet. April was a remarkable month: it was the driest and almost the sunniest April of which records exist at Rothamsted. May also was dry and warm. But the summer months were wet: in August rain fell on 27 days, amounting during the month to 6·5 inches—nearly 4 inches above the average. Only once before have we had so wet an August, and that was in 1879. The sunless character of the summer may be gauged by the fact that the total number of hours of sunshine for the 3 months July, August and September was only 351, while the average for the previous 19 years was 585. Not till October did drier, warmer weather set in.

The variety of wheat grown this year was Little Joss. It did not stand the winter very well on our poor land. Very fair crops were obtained on the Rotation Plots in Little Hoos field. Here mangolds had been grown in 1911 and the land was left in clean condition. The plots which have received no manure since 1904 gave over 20 bushels per acre, while those that received dung this year gave over 34; the weight in many cases exceeded 61 lb. per bushel. On Harpenden Field, which is in ordinary cultivation, a good yield was also obtained after a summer fallow. But the crop on Broadbalk field, where wheat has been grown continuously since 1843, was practically a failure. Four of the plots gave less than 3 bushels per acre, most of them gave less than 8; while even on the dunged plot the yield was below 17 bushels per acre, and the weight per bushel did not usually much exceed 58 lb. The seed was sown early in October, and the young plant came up well and looked distinctly promising. Before long, however, the Black Bent grass (*Alopecurus agrestis*), one of the most pernicious and troublesome weeds on this field, began to appear, and made such good growth during the wet mild winter that the wheat was soon hidden. By the time the ground was dry enough to allow of hoeing it was covered with a uniform green carpet, in which the rows of wheat could only with difficulty be distinguished. Hoeing was continued through April and May, and in June recourse was had to hand weeding. None of these measures however proved successful; the weeds flourished and the crop did not; and our efforts were discontinued when it became evident that they were doing more harm than good.

The success of the wheat on Little Hoos and Harpenden Fields shows that the failure on Broadbalk is not directly attributable to



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the season, bad though this had been. The weeds were no doubt closely connected with the failure, and some observations were begun, and are being continued, to discover their effect on the crop. It is not a sufficient explanation to say that the weeds took water and food from the soil; in point of fact the Broadbalk soil during the growing season was moister and richer in nitrate than the soil of the other fields. *Alopecurus* is one of the worst of the weeds; it seems first to have caused trouble on the dunged plot, where it was noticed among other weeds in 1869, and was very rampant in the wet seasons 1878 and 1879. In 1886 and succeeding years it was so bad that extensive hand weeding became necessary and many of the wheat plants had their roots loosened during the process; by this time it had become bad on Plot 11 also (receiving ammonium salts and superphosphate). The extreme course of fallowing the land was adopted in 1904 and 1905, one half of the field only being sown in each year, but still the grass survived: since then wider drills have been adopted (12-in.) to facilitate hoeing and hand weeding, but again without success; and now narrower drills are being tried.

A hypothesis has been put forward that the wheat plant excretes a substance toxic to itself which is gradually accumulating in the Broadbalk soil; laboratory experiments have so far failed to support this view. In any case *Alopecurus* seems to excrete nothing toxic to itself.

The continuous barley plots on Hoos Field were completely fallowed this year in the hope of clearing the land of weeds.

The mangolds (Sutton's Yellow Globe) were drilled in Barnfield on May 6th. As usual of late years, the plants on the dunged strips started well and continued well; they were, however, somewhat attacked by a leaf spot. The fate of those on the strips receiving no organic manure varied with the state of the ground; where a fine seed bed had been obtained (as on Strip 5, receiving superphosphate only) germination was rapid, but the young plant was killed by the drought in May, and reseeding became necessary. On the other hand, where the ground was rough (as on Strip 4, receiving complete mineral manure) germination was delayed till the drought was ended, and then the plants made satisfactory growth. One of the most interesting features of the plots receiving no organic manures is the way in which the operation of manures upon the texture of the soil becomes magnified.

The 17th four course Rotation was begun on Agdell Field with a crop of swedes, the variety being Sutton's Magnum Bonum. Seed was drilled on May 24th and germination was greatly favoured by the rain early in June, so that a good plant was obtained, which grew well right through the season. The completely manured plots gave a yield of 26¼ tons per acre. The plot receiving superphosphate and potassium salts only, but no nitrogen compounds and on which no clover is grown, gave 7½ tons of roots and ½ ton of leaves, but the plant showed all the signs of nitrogen starvation. Last year this plot gave an extraordinarily high yield of wheat; almost 32 bushels of grain and 29 cwts. of straw. The source from which the necessary nitrogen is obtained is not wholly evident. The continuously unmanured plot gave the usual diminutive roots, 8 cwt. per acre only being obtained where no clover is grown, and 2·3 cwt. where clover had been taken two years before. It was early



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discovered at Rothamsted that turnips without manure fail to develop, the roots becoming no larger than radishes. The cause of this remarkable collapse is not clear. This same plot that fails altogether to produce turnips gave us last year a fair crop of wheat, 23·9 bushels of grain and 20·4 cwt. of straw per acre; and two years earlier it had given 11·4 bushels of barley and 10·1 cwt. of straw. The phosphoric acid in the soil is now reduced very considerably and this is no doubt an important factor in depressing the yield. Mangolds on continuously unmanured land do not fail in this complete manner, indeed the only other crop on our farm that behaves like swedes is clover. The phenomenon is not connected with the fact that crops of turnips have previously been growing on the same land, because in 1908 a crop of turnips was taken in Barnfield on the mangold plots (mangolds having failed) where no turnips had been grown since 1870, and the unmanured plot gave identical results with the unmanured plot on Agdell. Equally remarkable is the curious effect of clover taken two years previously in depressing the yield on the unmanured and on the completely manured plots, the drop being from 8 cwt. to 2·3 in the former case and from 587 to 463 cwt. in the latter.

There is evidence that the exhaustion of lime from the completely manured plot, which is accelerated by the use of ammoniacal manures, is beginning to affect the plant, and this year we noted a considerable amount of finger and toe.

The yield of grass was poor. The dry weather in April kept the plant back and no satisfactory growth began till too late. Cutting took place on June 19th and 20th, and the hay was harvested in good condition. A heavy second cut was obtained on September 10th and 11th. There were more weeds than usual, especially on Plot 8 which receives phosphates, sodium and magnesium salts, but no potassium salts or nitrogenous manures: here the weeds formed two thirds of the herbage while the leguminosæ formed only 5 per cent. Addition of potassium salts to the manure (Plot 7) doubled the crop but halved the proportion of weeds so that the gain was almost wholly in the clovers and grasses. Addition of nearly 2½ cwt. (275 lb.) nitrate of soda to this complete manure did not increase the crop; the explanation is to be found in the fact that the clovers are adversely affected so that the natural nitrogen-gathering power of the herbage is diminished, while weeds come in and take their place. Thus the quality of the herbage actually suffers. One of the most important practical lessons brought out by the Rothamsted Grass Experiments is that the manuring of grass land is a matter that requires very intelligent and careful consideration. The added manure favours some of the species at the expense of the rest. A new type of herbage may even set up, which may be very different from the old. Of course, on temporary grass land and leys of short duration the case is different; here nitrogenous and other artificial manures exert their full effect and no complication arises through change of flora or suppression of the clovers.

The trials with the new nitrogenous fertilisers were continued and are giving a steady accumulation of valuable information with regard to their effects on the different crops. This year nitrate of lime, nitrite of soda, and nitrate of ammonia were used on mangolds in Little Knotwood Field, and all gave crops equal to that obtained from nitrate of soda. But this result does not necessarily prove that



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all the manures are equally effective. The yield was only 18½ tons per acre, and was clearly being kept down by some factor outside the nitrogen supply. It has already been stated that the season was not a good one for mangolds at Rothamsted.

In the Laboratory and Pot Culture House a considerable amount of work is being carried out on the production of plant food in the soil. As the supply of nitrogenous food frequently constitutes the limiting factor in crop production our work is largely restricted to the nitrogen cycle in the soil; the other factors are, however, always taken into account and come in for a number of subsidiary investigations. It has been shown that the production of ammonia and nitrate (two very important nitrogenous foods) is largely the work of bacteria. In normal soils, however, the bacteria are not working at their full efficiency. A factor has been discovered limiting the numbers of bacteria and therefore of the amount of decomposition they effect. All the available evidence goes to show that this factor is biological: it is capable of growth, is put out of action by heat or antiseptics, and can only be set up again by infection from outside: it does not, however, appear to consist of bacteria and is provisionally identified with the protozoa, of which numbers have been found in all the soils examined. Partially sterilised soils from which the factor has been eliminated are found to contain larger numbers of bacteria than untreated soils, and to accumulate ammonia and nitrates at a greater rate: they are, as might be expected, more productive. Methods are being worked out for applying this kind of soil treatment on the large scale, but instead of setting up a large number of field plots to discover some cheap and convenient process the simpler alternative is adopted of inducing horticulturists who go in for intensive culture to adopt some of the methods known to work.

The tomato and cucumber growers have responded well to this invitation, and during the past three seasons a number of experiments have been carried out in our Laboratory and Pot Culture House to solve some of the problems arising out of the application of partial sterilisation to their particular work. The arrangement has been advantageous in many ways. Certain very interesting lines of investigation have been opened up that promise to throw much light on our general fertility problems and that we should probably not have found otherwise. The growers also have expressed their interest in the very practical way of organising an Experiment Station to be started in the Lea Valley district and devoted exclusively to the investigation of problems connected with the glass house industry. Finally, the method of partial sterilisation has now passed out of the laboratory into the hands of the practical man, and each season becomes cheaper and applicable to a wider range of growers; we are also learning what are the difficulties attendant on the use of the method in practice.

Our new conception is that the soil organisms may be divided roughly into two groups in their relation to the processes of food production: a useful group and a detrimental group. The latter are, speaking generally, more readily killed than the former. Conditions that are harmful to active life in the soil tend therefore to reduce their numbers and lead to an increased activity of the useful bacteria. On the other hand, conditions favourable to active life tend to keep up the detrimental organisms and therefore to reduce the useful bacterial activity. We have thus been able to render intelligible a number of obscure and paradoxical effects that have hitherto caused considerable perplexity. It has already been observed by practical men in various countries that certain soil conditions harmful to the growth of organisms were ultimately beneficial to productiveness: such are long continued and severe frost, long drought (especially if associated with hot weather), sufficient heat, treatment with appropriate dressings of lime, gas lime, carbon disulphide, etc. Further, it has been observed that conditions which are undoubtedly favourable to life, such as the combination of warmth, moisture and organic manures found in glass houses, lead to reduced productiveness after a time. We are investigating a number of such problems from this new point of view.

The survey of the soil fauna is in the hands of Mr. Goodey, who has already picked out and identified a number of the ciliates commonly present, and is now turning his attention to the more difficult problems presented by the amœbæ and flagellates.

The decomposition processes in the soil lead to a reduction of the stock of the soil nitrogen. Part of the ammonia and nitrates is taken up by the plant: this represents a profitable use. Part, however, is lost, and for some long time past investigations have been in hand to measure and, if possible, reduce these losses. Drain gauge or lysimeter experiments, continued over a period of 25 years by Dr. Miller and still going on, have shown that about 50 lb. per acre of nitrogen compounds, chiefly nitrates, were washed out each year in the drainage water during the earlier part of the period, and about 35 lb. later on. The lysimeters are kept without crop or manure; they are uncultivated except in so far as is necessary to remove weeds. When last the percentage of nitrogen in the soil was determined, the loss of nitrogen was found to be equal, within the error of experiment, to the amount of nitrogen recovered in the drainage water. Under these conditions, therefore, the essential change in nitrogen compounds is confined to ammonia production and nitrification. But on the cropped plots where large quantities of manure are added other losses appear to go on, which are now under investigation.

Fortunately there are gains from natural sources. Analyses made on a systematic plan by Dr. Miller have shown the low amount of nitrogen compounds in rain collected at out-lying lighthouses, and the uniform and somewhat higher amount contained in rain collected in country districts. In the rain of towns a still larger quantity is present. About 4 lb. of nitrogen per acre is thus brought down each year to the soil. The chief gain, however, appears to be brought about by bacteria. When land at Rothamsted is left in grass or allowed to cover itself with wild vegetation, its percentage of nitrogen rapidly increases. How much is due to symbiotic fixation in the nodules of leguminous plants and how much to the free living Azotobacter is not easy to decide; but Dr. Hutchinson has shown that Azotobacter can fix considerable quantities of nitrogen under the conditions actually obtaining. The percentage of nitrogen present in a mixture of sand and crop residues increased when cultures of Azotobacter and cellulose-decomposing organisms were added, but not otherwise. Growing plants were able to utilise the nitrogen thus fixed. Again, when sugar was added to some of the



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nitrogen-starved barley plots an increased crop was obtained, similar to that which a dressing of nitrogenous manure would have given. This result, however, only followed when the sugar was added in the warm autumn weather; in cold spring the sugar had a deleterious effect.

Dr. Winifred E. Brenchley has continued her plant work on the same lines as before. The amount of growth a plant makes in a given soil is known to depend on the amount of food supplied, and this relationship forms the basis of the connection between the plant nutrition work and the soil work. But a hypothesis is current, and is backed by sufficient circumstantial evidence to make it worthy of consideration, that inorganic plant poisons act as stimulants to growth if supplied in sufficiently small quantities. If this hypothesis were well founded it would introduce a wholly new set of factors into plant nutrition relationships and would, in addition, form a basis for important practical developments. Water cultures have, therefore, been made to test this hypothesis as completely as possible. The compounds tested have been copper sulphate, manganese sulphate, zinc sulphate, sodium arsenite, arsenious acid and boric acid, and a wide range of concentrations has been adopted. Numerous plants have been tried, but on the whole barley and peas have proved most satisfactory. Copper sulphate was invariably toxic, even in such high dilutions as 1 part of the salt to 10 millions of water. The effect varied, however, with the plant, and was considerably masked in presence of nutrient salts. The fact that boric acid decidedly increased the growth of peas raises the interesting question whether boron is in some way advantageous to the pea and therefore to be regarded as a nutrient. In the case of barley no similar increase in growth has yet been obtained. Some specific effect is clearly indicated and the hypothesis is shown not to hold in its general form.

The weed investigations have been carried into Norfolk this season. Although the work is not yet concluded, certain general conclusions are already beginning to take shape. A definite association seems to exist between the weeds and the soil, the determining factor being, however, the texture of the soil rather than its geological origin, excepting only in the case of the chalk soils. The association is sometimes so close that it extends over a wide area; thus *Euphorbia exigua* and *Ranunculus arvensis* were always seen on heavy loams or clays. Sometimes, however, the association is affected by climatic or other factors; thus *Matricaria inodora* was common on clay in Bedfordshire but absent near Bath. The two cases are distinguished as "general" and "local" association. Very few plants, however, could be said to be symptomatic of soil conditions in the sense of being restricted to any one type of soil, but a good many plants are characteristic, *i.e.*, are more frequently found associated with one soil than with any other. *Rumex acetosella*, *Spergula arvensis* and *Sceleranthus annuus* may be regarded as symptomatic of soils giving no carbonate reaction with dilute hydrochloric acid. A relationship also exists between the weeds and the crop: various species of *Geranium* and *Plantago lanceolata* are very common in temporary grasses ("seeds" crops), while *Poa annua*, *Polygonum aviculare* and *P. convolvulus* are very rare. No doubt the conditions of cultivation account for this. It is surprising how many of the weeds belong to the *Compositæ*, at least half the genera of this order providing species of weeds. On the other hand, *Rosaceæ* and *Leguminosæ* supply very few weeds.

The important problems connected with quality of crops are now under investigation. For some time past we have been studying the herbage of grazing land and found that the conventional methods of analysis failed to distinguish between poor herbage and highly nutritious herbage that fattened sheep without artificial food. In other investigations at Rothamsted the conventional methods have equally failed and it has become necessary to go into the problem systematically and improve our knowledge of what confers "quality" on crops.

This work has now been put in hand. Mr. Davis is engaged on an exhaustive study of the constituents of the commoner crops and has begun by investigating the nature and amount of the various sugars present. The analytical difficulties are very considerable, and unsuspected sources of error have been revealed in some of the methods in use. In particular the addition of basic lead acetate in relatively large proportions for eliminating amino-acids, tannins, etc., gives rise to difficulties in estimating cane sugar, because the sodium acetate. formed when the lead is removed by sodium carbonate, protects the sugar from inversion by weak acids. Objection can similarly be raised against other methods, but the progress that has been made up to the present fully justifies the hope that a satisfactory solution will be found of the various difficulties encountered.

The following papers have been published during the year.

WINIFRED E. BRENCHLEY. "*The Weeds of Arable Land in relation to the Soils on which they grow.*" II. Annals of Botany. 1912. **26**, 95—109.

This investigation was conducted during the season of 1911 at several centres in Wiltshire and Somersetshire, and the results are compared with those obtained in Bedfordshire in 1910.

A general resemblance can be traced both as regards distribution and variety of the species, but there were notable exceptions.

In Bedfordshire, *Bartsia Odontites* is typically confined to clay and is not seen on the chalk; in the west country it occurred chiefly on the chalk. *Matricaria inodora*, very plentiful in Bedfordshire, was not found in the west. *Capsella Bursa-pastoris*, *Euphorbia exigua* and *Tussilago Farfara* were chiefly found on clay in the west; in Bedfordshire, on the other hand, the first two were rarely found on clay, while the third occurred on all types of soil. Of the so-called *Calcifuges* of the Bedfordshire soil, *Poa annua* alone retained that character in the west, the others, *Alopecurus agrestis*, *Anagallis arvensis*, *Chenopodium album*, *Euphorbia exigua*, *E. helioscopia*, *E. peplus*, *Veronica arvensis*, *V. hederæfolia*, all flourished on the chalk there. On the other hand, several plants occurring on various types of soil in Bedfordshire are definitely associated with chalk soils alone in the west. Some of these differences in behaviour may be influenced by the character of the seasons, 1910, when the observations were made in Bedfordshire, having been cold and wet, while 1911, when the western observations were made, was unusually hot and dry.



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WINIFRED E. BRENCHLEY. "*The Development of the Grain of Barley.*" Annals of Botany. 1912. **26**, 903—928.

This investigation was carried out on the same lines as the earlier work on wheat. The increase in weight of the whole plant which has gone on during the growing period ceases about 15 or 18 days before harvest, and a fall in weight sets in through dessication and other changes. This is the critical point at which maturation begins. From now onward there is no further change in the actual amount of nitrogen or phosphoric acid present in the grain, although the percentage amount rises by reason of the loss of moisture and carbohydrate. The ash decreases somewhat, the losses being comparable with those observed by Le Clerc and Brezeale and attributed by them to leaching. These changes are hardly seen in wheat, which has a much shorter ripening period.

Observations were made on the accumulation of the starch. This was found to be deposited progressively from the chalazal end of the grain up towards the embryo, its first appearance being in the cells in the flanks of the grain.

Certain nuclear changes were also observed: the nuclei first lose their nucleoli and then gradually get deformed and squeezed out into networks of varying degrees of coarseness. The deformation may be attributed to the pressure of the increasing starch grains; it seems to progress from both ends of the grain simultaneously towards the middle, and the last cells affected are those of the sub-aleuronic layer of the endosperm.

LILIAN M. UNDERWOOD. "*A note on Onion Couch.*" Journal of Agricultural Science. 1912. **4**.

One of the commonest grasses in the hedges and thickets of this country is the Tall Oat Grass (*Arrhenatherum avenaceum*, Beauvais); it is often found in meadows also. A form of this grass known as "Onion Couch," distinguished by the possession of a chain of swellings or knots at the base of the stems where the nodes swell, is a common weed on arable land, especially on lighter soils. As each knot is capable of giving rise to a new plant, the weed is dangerous and difficult to eradicate.

Botanists differ as to whether the bulbous form is entitled to specific rank. Bentham and Hooker do not recognise the onion form at all, while Reichenbach distinguishes it as *Arrhenatherum nodosum* and Lindley as *Arrhenatherum bulbosum*. The question is whether the swelling is a congenital variation of specific value or the outcome of physiological response to the conditions of the habitat.

To test this point, seeds of the two forms were sown in pots containing respectively moist and dry soil, sandy soil and clay soil, in shady situations and conditions of checked evaporation. In all cases the plants were similar to the parents: the bulbous form remained bulbous and the other form did not develop swellings. It appears therefore that the habit of forming bulbs is hereditary and does not depend on the conditions of the habitat.

WILLIAM A. DAVIS. "*The Estimation of Potassium, especially in Fertilisers, Soil Extracts and Plant Ashes.*" Journal of Agricultural Science. 1912. **5**, 52—66.

An examination of the methods in use for determining potassium shows that the ordinary platinum method is very uncertain, and affected by errors that make it undesirable apart from considerations of the growing cost of platinum.

A careful study was therefore made of the perchloric acid method which has been widely adopted in Germany. The details as now used in our work are as follows:—The solution of chlorides is evaporated to dryness in a porcelain dish and ignited for about 15 minutes at a dull red heat so as to throw out iron, etc., as oxides, as in Neubauer's simplified method (Landw. Versuchs. Stat. 1905, **63**, 141). If sulphates are present in large amount, 5 to 10 c.c. of saturated barium hydroxide solution are first added to precipitate $SO_4$. The soluble alkali salts are then extracted with boiling water as completely as possible, the iron oxide residue being broken up with a glass rod during the extraction. The aqueous extract is filtered into a glass evaporating dish ($3\frac{1}{4}$ ins. diam.), and the process is usually complete when the dish is full. The aqueous extract should be quite colourless and free from iron (if not, this shows that the ignition was not carried on long enough). It is now treated with 2·5 c.c. of perchloric acid solution, sp. gr. 1·125 (20%) and evaporated *nearly* to dryness on a sand bath not too strongly heated; the evaporation must be carried to the point of vigorous evolution of heavy white fumes of perchloric acid. The soluble perchlorates are now taken up by stirring with 20 c.c. of 95-96% alcohol and, after settling, the clear solution is poured off through a 9 cm. filter paper which has been dried to constant weight at 100° in a stoppered weighing bottle ($1\frac{1}{2}$ in. diam. × 2 in.). 10 c.c. of 95% alcohol saturated with potassium perchlorate are now added and the insoluble potassium perchlorate transferred as completely as possible to the weighed filter paper. The last traces of precipitate are washed into the filter paper with another 20 or 30 c.c. of the alcohol containing perchlorate, and finally the perchloric acid itself is washed out of the filter as completely as possible. For this purpose the washings are tested, until quite free from acidity, with sensitive litmus paper. Care must be taken that the top edge of the filter paper is washed well. The freedom of the filter paper from perchloric acid is shown by its not blackening during the subsequent drying in the oven at 100°. The use of a glass dish for the evaporation of the solution in the early part of the process greatly simplifies the complete removal of the last traces of perchlorate precipitate to the filter paper, as these last traces are then plainly visible. In washing, a total quantity of 120-150 c.c. of 95% alcohol can be safely used without causing any perceptible loss of potassium perchlorate, although less usually suffices unless much NaCl is present. After washing, the filter paper and precipitate are dried in a steam oven for about 20 minutes, whilst still in the funnel, the filter paper plus precipitate is then transferred to its weighing bottle and the drying completed until the weight is constant. 1 mgrm. $KClO_4 = 0{\cdot}3401$ mgrm. $K_2O$.

A Gooch crucible or Soxhlet tube can also be employed for collecting the potassium perchlorate, but if this is used, care must be taken that the asbestos layer is sufficiently thick to prevent the finely divided potassium perchlorate from passing through. With a layer $\frac{1}{8}$ in. thick perfectly accurate results can be obtained. In



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rapid working, when a large number of analyses have to be made, the Gooch crucible is preferable to a filter paper.

A. D. HALL and E. J. RUSSELL. "*On the Causes of the High Nutritive Value and Fertility of the Fatting Pastures of Romney Marsh and other Marshes in the S.E. of England.*" Journal of Agricultural Science. 1912. **4**, 339—370.

A number of pastures of known agricultural value were kept under observation during the seasons 1909-1911, and attempts were made to trace out the causes of the high value of some fields and the poor value of others.

It was found that the feeding value of the pasture grass is determined not only by the floral type (*i.e.*, the botanical composition of the herbage), but also by the habit of growth.

The floral type is determined by climatic factors, temperature, and the supply of air and of water to the roots, the reaction of the soil and the treatment of the grass, but it is not necessarily affected by variations in the amount of nitrogenous plant food present.

The habit of growth, on the other hand, is governed by a different set of factors more difficult to ascertain. In the cases dealt with in this paper the most important appeared to be the supply of nitrates and ammonia in the soil, *i.e.*, the ease of decomposition of the organic matter; the supply of phosphate was also an important factor.

Thus, floral type and habit of growth are independent. Cases are described in this paper where the general soil conditions and floral type persist over two adjoining fields, but the habit of growth and the feeding value of the grass are very different.

In attempting to ameliorate a pasture, it is necessary to ascertain whether its poverty is due to bad floral type or to habit of growth. Mere casual inspection is insufficient to determine differences in type because a tendency to flower may make one species appear much more prominent than it really is. Thus the percentage of buttercups was found to be the same in two fields but appeared to be much higher in the field where it produced flowers than in the other where it did not.

In the cases examined, a leafy habit of growth obtained in the fatting fields, and a stemmy habit in the poorer fields, the floral type being, as already stated, constant. Although the difference in feeding value was known to be great, the differences revealed by the ordinary methods of chemical analysis were very small. The ordinary methods are clearly inadequate for dealing with pasture grasses.

The soils of the fatting fields possess no constant special features revealed by the ordinary chemical or mechanical analyses. Their striking characteristic was the high rate at which nitrates were produced. They also contained a relatively large amount of total phosphoric acid. Experiments on the spot showed that they had a somewhat better texture than the soils of the non-fatting fields, allowing excess of water more readily to drain away, and retaining moisture better during dry weather, but this property could not be correlated with the mechanical composition of the soil. Soil analysis does not give as clear indications with pasture soils as it does with arable soils.

The rate of formation of ammonia and nitrates, which appeared to be the determining factor, is under investigation in our laboratory.

### INVESTIGATIONS ON SICKNESS IN SOIL.

This series of investigations deals with the remarkable falling off in productiveness of soils kept well moistened, warmed, aerated and supplied with organic matter, *i.e.*, under conditions favourable to the development of micro-organisms. It is difficult to account for this result on the old view that the useful plant-food making bacteria are the only active micro-organisms in the soil. On the other hand, our new view that detrimental organisms are also present readily explains the observed facts. Since the detrimental organisms are more easily killed than the useful ones, it follows that partial sterilisation should be an effective method of dealing with such soils, and experiments have fully borne out this conclusion.

I. E. J. RUSSELL and J. GOLDING. "*Sewage Sickness.*" Journ. Agric. Science, 1912. **5**, 27—47.

An extension of the experiments reviewed in the last Report. It is shown that two factors come into play: a falling off in the rate of percolation due to physical causes and a falling off in bacterial activity due to an abnormal development of the detrimental factor.

II. E. J. RUSSELL and F. R. PETHERBRIDGE. "*Sickness in Glasshouse Soils.*" Journ. Agric. Science, 1912. **5**, 86—111.

The "sickness" that speedily supervenes in glass houses run at a high pitch (such as cucumber houses) and less slowly in houses run at a lower pitch (such as tomato houses) is traced to two causes: an accumulation of various pests, and an abnormal development, especially in cucumber houses, of the factor detrimental to bacteria. The properties of this factor show that it is identical in character with that present in normal soil and in sewage sick soil, and strongly indicate its biological nature. No evidence of a soluble toxin could be obtained. Partial sterilisation was found to be a satisfactory method of treatment.

III. E. J. RUSSELL and F. R. PETHERBRIDGE. "*Partial Sterilisation of Soil for Glasshouse Work.*" First Report, Journal of the Board of Agriculture, 1912. **18.** Second Report (*ibid*), 1913. **19.**

These Reports are intended for practical growers and deal with the application of partial sterilisation methods to sick soils.

## OTHER PUBLICATIONS.

Besides the papers just described, the following have been written by members of the Staff:—

WINIFRED E. BRENCHLEY. "*Weeds, their Peculiarities and Distribution.*" Science Progress, 1912. **23.**
"*Weeds in Relation to Soils.*" Journ. Board of Agric. April, 1912.

A. D. HALL. "*The Rothamsted Experimental Station, 1843-1911.* Trans. Highland and Agric. Soc., 1912. **24.**
"*Recent Advances in Agricultural Science.*" "*The Fertility of the Soil.*" Royal Institution of Great Britain, May 24th, 1912.

H. B. HUTCHINSON and N. H. J. MILLER. "*The Direct Assimilation of Inorganic and Organic Forms of Nitrogen by higher Plants.*" Journ. Agric. Science, 1912. **4.**
(An extension of the experiments reviewed in the last Report).

E. J. RUSSELL. "*Soil Conditions and Plant Growth.*" Longmans & Co.

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# CROPS GROWN IN ROTATION. AGDELL FIELD.

## PRODUCE PER ACRE.

| Year. | CROP. | O. Unmanured. 5. Fallow. | O. Unmanured. 6. Beans or Clover. | M. Mineral Manure. 3. Fallow. | M. Mineral Manure. 4. Beans or Clover. | C. Complete Mineral and Nitrogenous Manure. 1. Fallow. | C. Complete Mineral and Nitrogenous Manure. 2. Beans or Clover. |
|---|---|---|---|---|---|---|---|
| **FIFTEENTH COURSE, 1904-7.** | | | | | | | |
| 1904 | Roots (Swedes) Cwt. | 16·8 | 6·4 | 151·2 | 171·4 | 318·6 | 203·2 |
| 1905 | Barley Grain ... Bus. | 15·5 | 7·3 | 16·0 | 15·2 | 23·1 | 31·4 |
| | Barley Straw ... Cwt. | 10·6 | 8·0 | 10·5 | 11·3 | 13·5 | 20·1 |
| 1906 | Clover Hay ... Cwt. | — | 4·1 | — | 41·0 | — | 9·5* |
| 1907 | Wheat Grain ... Bus. | 16·3 | 21·4 | 19·1 | 36·8 | 25·1 | 29·3 |
| | Wheat Straw ... Cwt. | 21·4 | 27·1 | 28·6 | 49·6 | 35·3 | 35·1 |
| **SIXTEENTH COURSE, 1908-11.** | | | | | | | |
| 1908 | Roots (Swedes) Cwt. | 21·6 | 6·4 | 179·0 | 235·8 | 395·4 | 314·0 |
| 1909 | Barley Grain ... Bus. | 11·4 | 10·0 | 17·4 | 22·1 | 26·8 | 33·4 |
| | Barley Straw ... Cwt. | 10·1 | 11·3 | 12·7 | 16·9 | 18·7 | 23·8 |
| 1910 | Clover Hay 1st crop Cwt. | — | 1·6 | — | 24·1 | — | 32·2 |
| | Clover Hay 2nd crop Cwt. | — | 15·8 | — | 40·0 | — | 44·5 |
| 1911 | Wheat Grain ... Bus. | 23·9 | 24·5 | 31·9 | 37·8 | 33·3 | 38·0 |
| | Wheat Straw ... Cwt. | 20·4 | 21·4 | 28·6 | 33·5 | 29·3 | 32·5 |
| **PRESENT COURSE (17th), 1912-** | | | | | | | |
| 1912 | Roots (Swedes) Cwt. | 8·2 | 2·3 | 151·7 | 251·9 | 586·6 | 463·0 |

* The plant almost entirely failed on this plot, and new seed was sown broadcast on May 1st, 1906.



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## METEOROLOGICAL RECORDS, 1912

(*See "Guide," 1906, page 16, Table IX.*)

| | Rain. | | | Drainage through soil. | | | Bright Sunshine. | Temperature. | |
|---|---|---|---|---|---|---|---|---|---|
| | Total Fall. | | No. of Rainy Days. | | | | | | |
| | 5-inch Funnel Gauge. | 1/1000 Acre Gauge. | 1/1000 Acre Gauge. | 20 ins. deep. | 40 ins. deep. | 60 ins. deep. | | Max. | Min. |
| | Inches. | Inches. | No. | Inches. | Inches. | Inches. | Hours. | °F. | °F. |
| Jan. ... | 3·738 | 3·886 | 18 | 3·684 | 3·636 | 3·582 | 41·2 | 43·0 | 33·4 |
| Feb. ... | 2·008 | 2·210 | 17 | 1·825 | 1·875 | 1·854 | 39·2 | 46·9 | 35·4 |
| March ... | 4·141 | 4·288 | 21 | 3·423 | 3·440 | 3·357 | 89·4 | 51·0 | 39·0 |
| April ... | 0·131 | 0·166 | 2 | 0·003 | 0·035 | 0·038 | 239·5 | 58·4 | 36·8 |
| May ... | 1·415 | 1·474 | 12 | 0·007 | 0·017 | 0·034 | 177·0 | 64·7 | 45·2 |
| June ... | 3·139 | 3·284 | 16 | 0·514 | 0·547 | 0·508 | 194·1 | 65·8 | 49·0 |
| July ... | 3·225 | 3·354 | 14 | 1·134 | 1·174 | 1·079 | 151·0 | 70·4 | 53·4 |
| August ... | 6·277 | 6·528 | 27 | 4·165 | 4·112 | 4·001 | 98·9 | 62·4 | 49·0 |
| Sept. .. | 2·528 | 2·718 | 10 | 1·639 | 1·523 | 1·500 | 101·5 | 59·4 | 44·8 |
| Oct. ... | 2·632 | 2·744 | 14 | 1·895 | 1·866 | 1·867 | 135·4 | 56·1 | 36·9 |
| Nov. ... | 2·407 | 2·517 | 14 | 1·936 | 1·988 | 1·961 | 39·9 | 48·1 | 36·5 |
| Dec. ... | 3·263 | 3·423 | 23 | 3·109 | 3·046 | 3·044 | 30·4 | 49·9 | 37·9 |
| Total or Mean | 34·904 | 36·592 | 188 | 23·334 | 23·259 | 22·825 | 1337·5 | 56·3 | 41·4 |

## MANGOLDS, BARN FIELD, 1912.

(*See "Guide," 1906, page 11, Table VI.*)

| Strip. | Strip Manures. | | Cross Dressings. | | | |
|---|---|---|---|---|---|---|
| | | | O. | N. | A. | A.C. | C. |
| | | | None. | Nitrate of Soda. | Ammonium Salts. | Rape Cake & Ammonium Salts. | Rape Cake. |
| | | | Tons. | Tons. | Tons. | Tons. | Tons. |
| 1 | Dung only ... | R. | **16·91** | **29·38** | **24·51** | **25·76** | **23·75** |
| | | L. | 4·20 | 6·79 | 7·47 | 9·00 | 7·43 |
| 2 | Dung, Super, Potash | R. | **18·51** | **29·92** | **27·85** | **31·80** | **28·39** |
| | | L. | 4·37 | 7·87 | 8·42 | 10·35 | 7·67 |
| 4 | Complete Minerals | R. | **2·62** | **15·25** / **15·05** | **10·78** | **27·99** | **21·53** |
| | | L. | 1·05 | 4·33 / 5·23 | 2·96 | 9·20 | 4·83 |
| 5 | Superphosphate only | R. | **2·10** | **9·46** | **3·14** | **8·63** | **9·10** |
| | | L. | 1·04 | 3·48 | 2·54 | 5·17 | 3·78 |
| 6 | Super and Potash | R. | **2·13** | **12·22** | **10·30** | **24·36** | **19·20** |
| | | L. | 0·86 | 3·28 | 2·98 | 8·50 | 3·68 |
| 7 | Super, Sulph. Mag. & Chloride Sodium | R. | **2·04** | **13·03** | **11·12** | **24·00** | **21·27** |
| | | L. | 0·97 | 3·73 | 3·14 | 8·46 | 4·90 |
| 8 | None ... ... | R. | **1·14** | **4·10** | **1·48** | **8·82** | **9·07** |
| | | L. | 0·88 | 2·70 | 1·52 | 5·20 | 3·93 |

R = roots. L = leaves. Tons per acre in all cases.

# HAY. THE PARK GRASS PLOTS, 1912.

(*See "Guide," 1906, page 19, Table XI.*)

| Plot. | Manuring. | Yield of Hay per acre. | | |
|---|---|---|---|---|
| | | 1st Crop. | 2nd Crop. | Total. |
| | | Cwt. | Cwt. | Cwt. |
| 3 | Unmanured ... ... ... ... | 7·7 | 2·5 | 10·2 |
| 12 | | 11·7 | 8·5 | 20·2 |
| 2 | Unmanured (1) ... ... ... | 11·5 | 4·0 | 15·5 |
| 1 | Ammonium Salts alone (1) ... ... | 13·5 | 10·1 | 23·6 |
| 4-1 | Superphosphate of Lime ... ... | 12·7 | 4·5 | 17·2 |
| 8 | Mineral Manure without Potash ... | 13·5 | 9·0 | 22·5 |
| 7 | Complete Mineral Manure ... ... | 27·9 | 18·5 | 46·4 |
| 6 | As 7, 1869 and since (2) ... ... | 23·3 | 14·5 | 37·8 |
| 15 | As 7, 1876 and since (3) ... ... | 24·5 | 12·5 | 37·0 |
| 5 | Superphosphate and Potash, 1898 and since ... ... ... ... | 9·0 | 6·7 | 15·7 |
| 17 | Nitrate of Soda alone ... ... | 23·2 | 8·0 | 31·2 |
| 4-2 | Superphosphate and Amm. Salts ... | 17·2 | 7·9 | 25·1 |
| 10 | Mineral Manure (without Potash) and Amm. Salts ... ... ... | 21·0 | 11·4 | 32·4 |
| 9 | Complete Mineral Manure and Amm. Salts ... ... ... ... ... | 28·2 | 7·8 | 36·0 |
| 13 | Dung and Fish Guano, once in 4 years | 28·5 | 13·8 | 42·3 |
| 11-1 | Complete Mineral Manure and extra Amm. Salts ... ... ... ... | 44·5 | 22·7 | 67·2 |
| 11-2 | As 11-1, and Silicate Soda ... ... | 47·7 | 24·9 | 72·6 |
| 16 | Complete Mineral Manure and Nit. Soda = 43 lb. N. ... ... ... | 29·2 | 11·5 | 40·7 |
| 14 | Complete Mineral Manure and Nit. Soda = 86 lb. N. ... ... ... | 38·4 | 14·5 | 52·9 |

Quick Lime (ground) at the rate of 2000 lb. per acre, applied to the South half of plots 1 to 4-2, 7 to 11-2, 13 and 16, in January, 1907.

(1) Received Farmyard dung, 8 years, 1856—63. (3) Nitrate of Soda alone previously.

(2) Ammonium Salts alone previous to 1869.

# BOTANICAL COMPOSITION, PER CENT.

**First Crop, 1912.**

(*See "Guide," 1906, page 20, Table XII.*)

| Plot. | Manuring. | Gramineæ. | Leguminosæ. | Other Orders. |
|---|---|---|---|---|
| | | Per cent. | Per cent. | Per cent. |
| 3 | Unmanured ... ... ... | 40·5 | 5·0 | 54·5 |
| 4-1 | Superphosphate of Lime ... | 32·5 | 13·6 | 53·9 |
| 8 | Mineral Manure without Potash | 30·2 | 5·0 | 64·8 |
| 7 | Complete Mineral Manure ... | 46·3 | 18·7 | 35·0 |
| 6 | As 7, 1869 and since (2) ... ... | 46·0 | 20·5 | 33·5 |
| 15 | As 7, 1876 and since (3) ... ... | 38·7 | 24·8 | 36·5 |

## WHEAT. BROADBALK FIELD, 1912.

(*See "Guide," 1906, page 26, Table XIV.*)

| Plot | Manuring. | Dressed Grain. Yield per Acre. | Dressed Grain. Weight per Bushel. | Straw per Acre. |
|---|---|---|---|---|
| | | Bushels. | lb. | Cwt. |
| 2 | Farmyard Manure ... ... ... | 16·9 | 58·5 | 17·6 |
| 3 | Unmanured ... ... ... ... | 4·5 | 59·0 | 5·6 |
| 5 | Complete Mineral Manure ... ... | 5·5 | 58·8 | 5·8 |
| 6 | As 5, and single Amm. Salts ... | 2·4 | 58·3 | 3·9 |
| 7 | As 5, and double Amm. Salts ... | 7·1 | 58·3 | 8·4 |
| 8 | As 5, and treble Amm. Salts ... | 10·5 | 58·1 | 13·5 |
| 9 | As 5, and single Nitrate Soda ... | 9·8 | 58·4 | 11·1 |
| 10 | Double Amm. Salts alone ... ... | 2·4 | 57·6 | 3·4 |
| 11 | As 10, and Superphosphate ... ... | 2·1 | 58·3 | 4·4 |
| 12 | As 10, and Super and Sulph. Soda | 5·1 | 57·6 | 8·0 |
| 13 | As 10, and Super and Sulph. Potash | 6·1 | 57·7 | 9·5 |
| 14 | As 10, and Super and Sulph. Mag. | 2·8 | 57·4 | 5·8 |
| 15 | Double Amm. Salts in Autumn, and Minerals ... ... ... ... | 5·3 | 58·1 | 7·1 |
| 16 | Double Nitrate and Minerals ... | 10·7 | 57·8 | 15·1 |
| 17 | Minerals alone, or double Amm. Salts | *6·8 | *58·0 | *7·5 |
| 18 | alone, in alternate years ... ... | †5·9 | †58·1 | †7·7 |
| 19 | Rape Cake alone ... ... ... | 7·4 | 58·4 | 8·7 |
| 20 (1) | As 7, but excluding Superphosphate | no crop | no crop | no crop |

* Produce by Ammonium Salts. † Produce by Minerals.

(1) Commenced in 1906.

NOTE.—Owing to the foulness of the land on the upper half of the field the produce here recorded was that obtained on the lower half of the field only. (See notes on the crop at p. 5).

## PERMANENT BARLEY PLOTS. HOOS FIELD, 1912.

(*See "Guide," 1906, page 33, Table XVI.*)

Fallow in 1912.



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## OATS. HOOS FIELD, 1912.

(Previous Cropping: Potatoes, 1876-1901; Barley, 1902 and 1903; Oats, 1904; Barley, 1905 and since.)

(*See "Guide," 1906, page 40, Table XIX.*)

| Plot | Manures applied to the Potatoes, 1876-1901. Unmanured since. | Dressed Grain. | | Straw per Acre. | Total Produce per Acre. |
|---|---|---|---|---|---|
| | | Yield per Acre. | Weight per Bushel. | | |
| | | Bushels. | lb. | Cwt. | lb. |
| 1 | Unmanured ... ... ... | 4·9 | 27·6 | 4·3 | 666 |
| 2 | Unmanured 1882 to 1901, previously Dung only ... | 12·8 | 26·7 | 8·0 | 1252 |
| 3 | Dung 1883 to 1901 ... ... | 15·2 | 27·8 | 13·2 | 2014 |
| 4 | Dung 1883 to 1901 ... ... | 19·3 | 25·9 | 15·3 | 2319 |

## OATS. HOOS FIELD, 1912.

(Previous Cropping: Potatoes, 1876-1901; Barley, 1902 and 1903; Oats, 1904; Plots 5, 7, 9, Cow Peas (failed), 1905; Plots 6, 8, 10, Red Clover, 1905: 1906-1911, all Plots Red Clover.)

(*See "Guide," 1906, page 40.*)

| Plot. | Manures applied to the Potatoes, 1876-1901. Unmanured since. | Dressed Grain. | | Straw per Acre. | Total Produce per Acre. |
|---|---|---|---|---|---|
| | | Yield per Acre. | Weight per Bushel. | | |
| | | Bushels. | lb. | Cwt. | lb. |
| 5 | Ammonium Salts ... ... | 33·0 | 30·4 | 18·5 | 3171 |
| 6 | Nitrate of Soda ... ... | 30·9 | 30·6 | 18·6 | 3138 |
| 7 | Ammonium Salts and Mixed Minerals ... ... | 45·0 | 31·6 | 25·9 | 4442 |
| 8 | Nitrate of Soda and Mixed Minerals ... ... | 46·7 | 32·8 | 27·5 | 4747 |
| 9 | Superphosphate ... ... | 35·3 | 32·8 | 18·7 | 3361 |
| 10 | Mixed Minerals ... ... | 36·8 | 32·6 | 20·3 | 3589 |

## WHEAT AFTER FALLOW (without manure 1851 and since). HOOS FIELD, 1912.

(*See "Guide," 1906, page 41, Table XX.*)

| | |
|---|---|
| Dressed Grain ... ... | Yield—4·2 Bushels per Acre.<br>Weight per Bushel—57·8 lb. |
| Straw ... ... ... | 6·3 cwt. per Acre. |
| Total produce ... ... | 972 lb. per Acre. |



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## COMPARATIVE TEST OF NITROGENOUS FERTILISERS.

## MANGOLDS, LITTLE KNOTT WOOD FIELD, 1912.

| Plot. | Manuring. | Produce per acre. | | |
|---|---|---|---|---|
| | | Roots. | Leaves. | Total. |
| | | Tons. | Tons. | Tons. |
| 1 | 3 cwt. Superphosphate, and 2 cwt. Sulphate of Potash ... ... | 11·5 | 3·8 | 15·3 |
| 2 | As 1, and Nitrate of Lime = 70 lb. N. | 18·4 | 6·3 | 24·7 |
| 3 | As 1, and Nitrate of Soda = 70 lb. N. | 18·4 | 6·4 | 24·8 |
| 4 | As 1, and Nitrite of Soda = 70 lb. N. | 17·1 | 5·5 | 22·6 |
| 5 | As 1, and Nitrate of Ammonia = 70 lb. N. ... ... ... ... | 18·0 | 5·6 | 23·6 |

### COMPARISON OF THE YIELD PER ACRE OF OATS AND BARLEY GROWN TOGETHER, AND EACH ALONE, WITHOUT MANURE. AFTER SWEDES IN 1911.

## SAWPIT FIELD, 1912.

| Plot. | Crop. | Dressed Grain. | | Straw. | Total Produce. |
|---|---|---|---|---|---|
| | | Yield. | Weight per Bushel. | | |
| | | Bushels. | lb. | Cwt. | lb. |
| 1 | Oats and Barley ... | 27·7 | 49·0 | 26·3 | 4318 |
| 2 | Oats alone ... ... | 17·3 | 33·1 | 26·4 | 3593 |
| 3 | Barley alone ... ... | 36·2 | 50·5 | 26·8 | 5081 |

# LITTLE HOOS FIELD, 1904-1912.

## RESIDUAL VALUE OF VARIOUS MANURES.

(*See "Guide," 1906, pages 41 and 42.*)

### TOTAL PRODUCE—Grain and Straw, or Roots and Leaves, per acre.

| Series and Plot. | Manuring. | Swedes 1904. | Barley 1905. | Man-golds 1906. | Spring Wheat 1907. | Swedes 1908. | Barley 1909. | Wheat 1910. | Man-golds 1911. | Wheat 1912.* |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Tons. | lb. | Tons. | lb. | Tons. | lb. | lb. | Tons. | Bushels. |
| A 1 | Unmanured ... ... ... | 10·3 | 2323 | 17·1 | 3650 | 14·0 | 3792 | 2270 | 11·6 | 19·4 |
| 2 | Dung (ordinary), 1904, '8 & '12 | **13·1** | 4649 | 18·2 | 4673 | **19·1** | 5128 | 2572 | 13·9 | **34·3** |
| 3 | ,, ,, 1905 & 1909 | 8·8 | **3501** | 17·5 | 5393 | 14·5 | **5544** | 2681 | 14·1 | 26·9 |
| 4 | ,, ,, 1906 & 1910 | 8·8 | 2269 | **18·2** | 5471 | 15·5 | 4057 | **2406** | 12·5 | 29·2 |
| 5 | ,, ,, 1907 & 1911... | 9·8 | 2402 | 14·9 | **6903** | 17·3 | 4581 | 2358 | **15·8** | 26·8 |
| B 1 | Dung (cake fed), 1904, '8 & '12 | **15·7** | 4177 | 19·4 | 4319 | **22·4** | 5362 | 2386 | 14·1 | **35·6** |
| 2 | Unmanured ... ... ... | 10·0 | 2417 | 16·2 | 4025 | 14·3 | 3862 | 2261 | 12·0 | 21·8 |
| 3 | Dung (cake fed), 1905 & 1909 | 9·5 | **5530** | 18·5 | 5497 | 14·2 | **6641** | 2921 | 14·2 | 29·4 |
| 4 | ,, ,, 1906 & 1910... | 11·4 | 2772 | **25·6** | 6489 | 16·9 | 4400 | **3502** | 14·4 | 26·5 |
| 5 | ,, ,, 1907 & 1911... | 9·4 | 2649 | 14·4 | **9407** | 19·0 | 4298 | 2369 | **17·1** | 31·4 |
| C 1 | Shoddy, 1904, 1908 & 1912 ... | **14·7** | 3656 | 21·0 | 4667 | **19·7** | 3969 | 2295 | 11·4 | **28·4** |
| 2 | ,, 1905 & 1909 ... ... | 11·1 | **4363** | 23·6 | 4550 | 16·3 | **4558** | 2387 | 11·6 | 26·1 |
| 3 | Unmanured ... ... ... | 10·6 | 2588 | 17·7 | 4334 | 15·1 | 3850 | 2561 | 11·7 | 24·2 |
| 4 | Shoddy, 1906 & 1910 ... ... | 10·7 | 2512 | **24·2** | 6231 | 19·1 | 4466 | **3461** | 14·0 | 30·4 |
| 5 | ,, 1907 & 1911 ... ... | 10·3 | 2615 | 16·9 | **7495** | 22·2 | 5448 | 2560 | **14·7** | 29·8 |
| D 1 | Guano, 1904, 1908 & 1912 ... | **14·6** | 2550 | 20·1 | 4056 | **20·9** | 3608 | 1742 | 10·5 | **28·8** |
| 2 | ,, 1905 & 1909 ... ... | 11·0 | **5176** | 19·7 | 4165 | 15·3 | **6834** | 2114 | 11·5 | 24·1 |
| 3 | ,, 1906 & 1910 ... ... | 10·9 | 2857 | **25·6** | 4846 | 15·9 | 4053 | **3392** | 11·1 | 22·5 |
| 4 | Unmanured ... ... ... | 10·6 | 2985 | 18·7 | 4618 | 17·4 | 4510 | 2739 | 11·8 | 26·9 |
| 5 | Guano, 1907 & 1911 ... ... | 10·6 | 2680 | 17·4 | **7375** | 15·7 | 4014 | 2374 | **14·2** | 26·3 |
| E 1 | Rape Cake, 1904, 1908 & 1912 | **14·1** | 2674 | 17·8 | 3887 | **19·7** | 3750 | 2180 | 10·7 | **27·7** |
| 2 | ,, 1905 & 1909 ... | 11·2 | **4185** | 17·9 | 4326 | 15·1 | **5203** | 2242 | 11·7 | 22·3 |
| 3 | ,, 1906 & 1910 ... | 9·5 | 2645 | **22·7** | 4584 | 14·5 | 3866 | **3486** | 11·5 | 22·2 |
| 4 | ,, 1907 & 1911 ... | 10·5 | 2734 | 19·4 | **6619** | 15·2 | 4661 | 2516 | **14·5** | 25·1 |
| 5 | Unmanured ... ... ... | 10·8 | 2769 | 19·5 | 4527 | 14·7 | 4155 | 2784 | 12·7 | 21·1 |
| F 1 | Unmanured ... ... ... | 11·7 | 3132 | 22·9 | 4749 | 14·1 | 4814 | 3166 | 8·7 | 31·6 |
| 2 | Superphosphate, 1904, '8 & '12 | **12·2** | 3025 | 23·2 | 5064 | **16·9** | 4726 | 3223 | 10·9 | **33·4** |
| 3 | ,, 1905 & 1909... | 10·2 | **3949** | 23·6 | 4956 | 14·6 | **4973** | 2922 | 11·7 | 31·9 |
| 4 | ,, 1906 & 1910... | 9·7 | 3913 | **24·1** | 5419 | 16·0 | 5280 | **2682** | 12·8 | 34·9 |
| 5 | ,, 1907 & 1911... | 9·7 | 4221 | 23·6 | **5698** | 16·4 | 5641 | 3190 | **14·2** | 35·4 |
| G 1 | Bone Meal, 1904, 1908 & 1912 | **12·9** | 3176 | 23·1 | 5203 | **16·7** | 4445 | 3345 | 9·9 | **32·8** |
| 2 | ,, 1905 & 1909 ... | 10·1 | **3636** | 22·1 | 5821 | 14·3 | **4922** | 3657 | 9·9 | 32·7 |
| 3 | Unmanured ... ... ... | 10·2 | 3495 | 20·6 | 5491 | 12·7 | 4247 | 3701 | 9·2 | 29·0 |
| 4 | Bone Meal, 1906 & 1910 ... | 9·9 | 3450 | **22·6** | 6043 | 14·2 | 4711 | **3263** | 10·5 | 31·8 |
| 5 | ,, 1907 & 1911 ... | 9·2 | 3525 | 22·1 | **6276** | 19·9 | 5285 | 3512 | **12·6** | 34·4 |
| H 1 | Basic Slag, 1904, 1908 & 1912 | **11·8** | 4400 | 20·5 | 6285 | **13·8** | 4182 | 3564 | 11·5 | **35·7** |
| 2 | ,, 1905 & 1909 ... | 10·4 | **4002** | 21·3 | 5930 | 13·6 | **4530** | 3596 | 12·0 | 33·7 |
| 3 | ,, 1906 & 1910 ... | 9·4 | 3662 | **21·4** | 5860 | 13·6 | 4431 | **3943** | 12·5 | 29·1 |
| 4 | ,, 1907 & 1911 ... | 9·1 | 3624 | 17·0 | **5816** | 14·4 | 3860 | 3804 | **12·0** | 32·5 |
| 5 | Unmanured ... ... ... | 8·6 | 3293 | 17·4 | 5933 | 11·4 | 4511 | 4005 | 10·5 | 30·1 |

The yields on the plots to which the manure was applied in any given year are printed in heavier type.
* Dressed Grain only.



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