Yields of the Field Experiments 1898

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Rothamsted Research

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MEMORANDA

OF THE

ORIGIN, PLAN, AND RESULTS

OF THE

FIELD AND OTHER EXPERIMENTS,

CONDUCTED

On the Farm and in the Laboratory

OF

SIR JOHN BENNET LAWES, BART., D.C.L., LL.D., SC.D., F.R.S.,

AT

ROTHAMSTED, HERTS.

Being a Report to the Lawes Agricultural Trust Committee,

By SIR J. HENRY GILBERT, F.R.S.

ISSUED BY THE COMMITTEE.

FIFTY-FIFTH YEAR OF THE EXPERIMENTS.

1898.

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ORIGIN, SCOPE, AND PLAN,

OF THE

ROTHAMSTED EXPERIMENTS.[1]

Mr. (now Sir) John Bennet Lawes was the founder of the Rothamsted Experimental Station. He commenced experiments with different manuring substances, first with plants in pots, and afterwards in the field, soon after entering into possession of his hereditary property at Rothamsted[2] in 1834. The researches of De Saussure on vegetation were the chief subjects of his study to this end. Of all the experiments so made, those in which the neutral phosphate of lime, in bones, bone-ash, and apatite, was rendered soluble by means of sulphuric acid, and the mixture applied for root-crops, gave the most striking results. The results obtained on a small scale in 1837, 1838, and 1839, were such as to lead to more extensive trials in the field in 1840 and 1841, and subsequently.

In 1843, more systematic field experiments were commenced; and a barn, which had previously been partially applied to laboratory purposes, became almost exclusively devoted to agricultural investigations. The foundation of the Rothamsted Experimental Station may be said to date from that time (1843).

The Rothamsted station has from the commencement been entirely disconnected from any external organization, and has been maintained entirely at the cost of Sir John Lawes. It had in previous years been stated, that he had further set apart a sum of £100,000, the Laboratory, and certain areas of land, for the continuance of the investigations after his death. In February 1889, Trustees were appointed, and the necessary Trust Deed was executed; and, in accordance with the provisions of the Deed, a Committee of Management was soon afterwards appointed, and entered upon its duties.

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(1) The statement of the origin, scope, and plan, of the Rothamsted Investigations, was originally drawn up in answer to a circular letter issued by a Committee appointed to arrange for the commemoration of the twenty-fifth anniversary of the establishment of the First Experimental Station in Germany (Möckern), which was held in Leipzig in September 1877. The precise form of the statement depended on the order and form of the questions to which it was an answer. It was published in German, almost in full, with the series of reports of other Experimental Stations, which was issued at the time of the Jubilee Meeting. (Die landwirthschaftlichen Versuchs-Stationen. Band xxii. 1877.) To the general statement, which is annually given in the form in which it was originally drawn up, but which is each year corrected up to date, are appended lists of the titles of all the papers already published, with full reference to the Journals in which they appeared.

(2) **Rothamsted is in Hertfordshire, twenty-five miles from London, on the Midland Railway; Station, Harpenden. Postal address—Rothamsted, St. Albans. Telegraphic address—Harpenden.**

N.B.—It is requested that those wishing to inspect the experiments will give notice, either by letter or telegram, to Sir John B. Lawes, Bart., or to Sir J. Henry Gilbert, as to the time of their intended visit.

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From June 1843, up to the present time, Dr. (now Sir) J. Henry Gilbert has been associated with Sir John Bennet Lawes in the conduct of the experiments, and has had the direction of the laboratory.

In 1854–5 a new laboratory was built, by public subscription of agriculturists, and was presented to Sir John Lawes in July 1855, from which date the old barn-laboratory was abandoned, and the new one has been occupied.

The number of assistants and other helps has increased from time to time. At first only one laboratory man was employed; but very soon a chemical assistant was necessary, and next a computer and record-keeper.

For many years the staff has consisted of—

One or two, and sometimes three, chemists.

Two or three general assistants. One of these is usually employed in routine chemical work, but sometimes in more general work. The chief occupation of the general assistants is to superintend the field experiments—that is, the making of the manures, the measurement of the plots, the application of the manures, and the harvesting of the crops; also, the taking of samples, the preparation of them for preservation or analysis, and the determinations of dry matter, ash, &c. These assistants also keep the meteorological records, and superintend any experiments made with animals.

A botanical assistant has also occasionally been employed, with from three to six boys under him; and with him has been associated one of the permanent general assistants, who at other times undertakes the botanical work.

Two or three (and sometimes four) computers and record-keepers have been occupied in calculating and tabulating field, feeding, and laboratory results, copying, &c.

A laboratory man, and other helps, are also employed.

Besides the permanent laboratory staff, chemical assistance has frequently been engaged in London, or elsewhere. In this way, Mr. R. Richter, now of Charlottenburg (Berlin), but who was for some years in the Rothamsted Laboratory, has executed much analytical work sent from Rothamsted. He has, in fact, here and at Charlottenburg, made more than 800 complete analyses of the ashes of various products, animal and vegetable, of known history.

The field experiments, and occasionally feeding experiments, also employ a considerable but a very variable number of agricultural labourers.

There is now a collection of more than 45,000 bottles of samples of experimentally-grown vegetable produce, of animal products, of ashes, or of soils, besides some thousands of samples not in bottles; and, the Laboratory having become very inconveniently full, a new detached building—a "Sample House"—was erected in the autumn of 1888, comprising two large rooms for the storing of specimens, and for some processes of preparation, and also a drying room. The Laboratory, where a very large number of specimens, and the records, will still be kept, is thus relieved of the heavier, the more bulky, and the more combustible, of its former contents, and also of the risk of fire from stove-drying.

Nothing has been done at Rothamsted in the way of manure-feeding-stuff- or seed-control.

The investigations may be classed under two heads :—

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I.—FIELD EXPERIMENTS, EXPERIMENTS ON VEGETATION, Etc.

The general scope and plan of the field experiments has been:—

To grow some of the most important crops of rotation, each separately, year after year, for many years in succession on the same land, without manure, with farmyard-manure, and with a great variety of chemical manures; the same description of manure being, as a rule, applied year after year on the same plot. Experiments on an actual course of rotation, without manure, and with different manures, have also been made. In this way field experiments have been conducted for the periods, and over the areas, indicated in the following Table:—

Crops.	Duration.	Area.	Plots.
	Years.	Acres.	
Wheat (various manures)	55	11	34 (or 37)
Wheat, alternated with Fallow ..	47	1	2
Wheat (varieties)	15	4–8	about 20
Barley (various manures)	47	4¼	29
Oats (various manures)	10 (1)	0¾	6
Beans (various manures)	32 (2)	1¼	10
Beans (various manures)	27 (3)	1	5
Beans, alternated with Wheat	28 (4)	1	10
Clover (various manures)	29 (5)	3	18
Various Leguminous Plants	21	3	18
Turnips (various manures)	28 (6)	8	40
Sugar Beet (various manures)	5	8	41
Mangel-Wurzel (various manures) ..	23	8	41
Total Root Crops ..	56		
Potatoes (various manures)	23	2	10
Rotation (various manures)	51	3	12
Permanent Grass (various manures)	43	7	22

(1) Including 1 year Fallow.
(2) Including 1 year Wheat, and 5 years Fallow.
(3) Including 4 years Fallow. (4) Including 2 years Fallow.
(5) Clover, 12 times sown (first in 1848), 8 yielding crops, but 4 of these very small, 1 year Wheat, 5 years Barley, 12 years Fallow.
(6) Including Barley without Manure 3 years (11th, 12th, and 13th seasons).

Comparative experiments with different manures have also been made on other descriptions of soil, in other localities.

Samples of all the experimental crops are taken, and brought to the laboratory. Weighed portions of each are partially dried, and preserved for future reference or analysis. Duplicate weighed portions of each are dried at 100° C., the dry matter is determined, and it is then burnt to ash on platinum sheets, in cast-iron muffles. The quantities of ash are determined and recorded, and the ashes themselves are preserved for reference, or analysis.

In a large proportion of the samples the nitrogen is determined; and in some the amount existing as albuminoids, amides, and nitric acid.

In selected cases, illustrating the influence of season, manures, exhaustion, &c., complete ash-analyses have been made, numbering in all about 800.

Also in selected cases, illustrating the influence of season and manuring, quantities of the experimentally-grown Wheat grain have been sent to the mill, and the proportion and composition of the different mill-products determined.

In the Sugar Beet, Mangel-Wurzel, and Potatoes, the sugar has in many cases been determined by polariscope, and frequently by copper also.

In the case of the experiments on the Mixed Herbage of Permanent Grass-land, besides the samples taken for the determination of the chemical composition (dry matter, ash, nitrogen,

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woody fibre, fatty matter, and composition of ash), carefully averaged samples have frequently been taken for the determination of the botanical composition. In this way, on four occasions, at intervals of five years—viz., in 1862, 1867, 1872, and 1877—a sample of the produce of each plot was taken, and submitted to careful botanical separation, and the percentage, by weight, of each species in the mixed herbage determined. Partial separations, in the case of samples from selected plots (frequently of both first and second crops), have also been made in many other years.

Investigation of Soils.

Samples of the soils of most of the experimental plots have been taken from time to time, generally to the depth of 9, 18, and 27 inches, sometimes to twice, and sometimes, for special purposes, to even four times this depth; samples being taken at two, or sometimes even at eight places, on the same plot. In this way more than 4200 individual samples have been taken; but sometimes those of corresponding depth from the different places on the same plot, have been at once mixed, so that the number for analysis has thus been reduced by about two-fifths. The individual or mixed samples are submitted to partial mechanical separation; generally some further mixtures are then made; and weighed portions (frequently several), of the individual or mixed sifted soils, are carefully preserved for analysis. In a large number of samples the loss on drying at different temperatures, and at ignition, has been determined. In most the nitrogen has been determined, in many by the soda-lime method, but in recent years the Kjeldahl method has also been used. In many the carbon, and in many the nitrogen as nitric acid, and the chlorine, have been determined. Some experiments have also been made on the comparative absorptive capacity (for water and ammonia) of the different soils and subsoils. The systematic investigation of the amount, and the condition, of the nitrogen, and of some of the more important mineral constituents, of the soils of the different plots, and from different depths, has been undertaken, and is from time to time recurred to.

Rainfall and Drainage.

Almost from the commencement of the field experiments the rainfall has been measured, for more than forty-five years in a gauge of one-thousandth of an acre area, as well as in an ordinary small funnel-gauge of 5 inches diameter. An 8-inch "Board of Trade" copper gauge has also been in use since January 1, 1881. The nitrogen, as ammonia and as nitric acid, has periodically, and for some years past monthly, been determined in the rain waters. The chlorine has been determined in a considerable series of samples; and sometimes the sulphuric acid also.

Three "drain-gauges," also each of one-thousandth of an acre area, for the determination of the quantity and composition of the water percolating respectively through 20 inches, 40 inches, and 60 inches depth of soil (with its subsoil in natural state of consolidation) were constructed in 1870. A more numerous series of smaller "drain-gauges," arranged for the investigation of the influence of different crops, and of different manures, on the amount and composition of the drainage waters, were constructed in 1874; but they proved not to be water-tight, and have therefore not been used.

Each of the differently manured plots of the permanent experimental Wheat-field having a separate pipe-drain, samples of the drainage waters have been, and are still, collected and analysed. For the purpose of collection, an open pit was, in 1866, dug at the point of junction of each individual plot-drain with the main cross-drain, and the connection broken. The collection-pits were, however, 22 yards further from the manure- and crop-line of the plots at one side of the field than at the other. During the spring of 1896, a brick trench, 434 feet long, and nearly 3 feet wide and deep, was constructed, at a uniform distance from the manure- and crop-line of all the plots, into which the plot-drain of each was brought; a length of cement-jointed glazed piping being substituted for the "horse-shoe and sole" drains, up to within 6 feet of the manure- and crop-line, thus equalising and lessening the distance that the unjointed drains run under unmanured and uncropped land

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subject to the passage downwards of surface-water. This arrangement for the better collection of the drainage water from the experimental plots has already been found to be a great improvement; and it will doubtless prove of much value in the future.

Nearly 25 years ago, Professor Frankland determined the nitrogen, as ammonia, as nitric acid, and as organic nitrogen, and also some other constituents, in many samples both of the rain and of the various drainage-waters collected at Rothamsted. The late Dr. Voelcker also determined the combined nitrogen, and likewise the incombustible constituents, in sixty-five samples of the drainage-waters. And Dr. W. J. Russell has determined the sulphuric acid in some of the monthly mixed samples of rain-water.

The nitrogen existing as nitric acid, sometimes that in other forms, and also some other constituents, are, and for some time past have been, determined periodically, in the Rothamsted Laboratory, in both the rain and the various drainage waters.

Amount of Water Transpired by Plants.

Commencing in 1849, experiments were made, for ten years in succession, to determine the amount of water given off by plants during their growth. In this way various plants, including representatives of the gramineous, the leguminous, and other Orders, were experimented upon. Similar experiments were also made with various evergreen and deciduous trees.

Botanical Characteristics, &c.

Having regard to the difference in the character and amount of the constituents assimilated by plants of different botanical relationships, under equal external conditions, or by the same description of plants, under varying conditions, observations have been made on the character and range of the roots of different plants, and on their relative development of stem, leaf, &c. In the case of various crops, but more especially with Wheat and Beans, samples have been taken at different stages of growth, and the composition determined, in more or less detail, sometimes of the entire plant, and sometimes of the separated parts. In a few cases, the amounts of dry matter, ash, nitrogen, &c., in the above-ground growth of a given area, at different stages of development, have been determined. The amounts of stubble of different crops have also occasionally been estimated. Experiments have also been made to ascertain approximately the acidity of the root-sap of a large number of plants representing various Natural Orders.

Experiments on the Assimilation of Free Nitrogen.

Experiments were commenced in 1857, and conducted for several years in succession, to determine whether plants assimilate free or uncombined nitrogen, and also various collateral points. Plants of the gramineous, the leguminous, and of other families, were operated upon. The late Dr. Pugh took a prominent part in this inquiry. The conclusion arrived at was that our agricultural plants do not themselves directly assimilate the free nitrogen of the air by their leaves.

In recent years, however, the question has assumed quite a new aspect. It now is—whether the free nitrogen of the atmosphere is brought into combination under the influence of micro-organisms, or other low forms, either within the soil, or in symbiosis with a higher plant, thus serving indirectly as a source of nitrogen to plants of a higher order. Considering that the results of Hellriegel and Wilfarth on this point were, if confirmed, of great significance and importance, it was decided to make experiments at Rothamsted on somewhat similar lines. Accordingly, a preliminary series was undertaken in 1888; more extended series were conducted in 1889, and in 1890; and the investigation was continued up to the commencement of the year 1895. The results obtained show that, when a soil growing leguminous plants is infected with appropriate organisms, there is a development of the so-called leguminous nodules on the roots of the plants, and, coincidently, increased growth, and gain of nitrogen. The results are further referred to at pp. 37 and 44–5.

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II.—EXPERIMENTS ON ANIMALS, Etc.

Experiments with the animals of the farm were commenced early in 1847, and have been continued, at intervals, nearly up to the present time.

The following points have been investigated:—

1. The amount of food, and of its several constituents, consumed in relation to a given live-weight of animal within a given time.

2. The amount of food, and of its several constituents, consumed to produce a given amount of increase in live-weight.

3. The proportion, and relative development, of the different organs or parts of different animals.

4. The proximate and ultimate composition of the animals in different conditions as to age and fatness, and the probable composition of their increase in live-weight during the fattening process.

5. The composition of the solid and liquid excreta (the manure) in relation to that of the food consumed.

6. The loss or expenditure of constituents by respiration and the cutaneous exhalations—that is, in the mere sustenance of the living meat-and-manure-making machine.

7. The yield of milk in relation to the food consumed to produce it; and the influence of different descriptions of food, on the quantity, and on the composition, of the milk.

The general plan of experimenting was as follows:—

To provide data as to the amount of food, or its several constituents, consumed in relation to a given live-weight of animal within a given time, and to produce a given amount of increase in live-weight, several hundred animals—oxen, sheep, and pigs—have been experimented upon. Selected lots of animals were supplied, for many weeks, or for months consecutively, with weighed quantities of foods, selected and allotted according to the special point under inquiry. The composition of the foods was determined by analysis. The weights of the animals were taken at the commencement, at intervals during the progress, and at the conclusion of the experiment.

The amount, and relative development, of the different organs and parts were determined in 2 calves, 2 heifers, 14 bullocks, 1 lamb, 249 sheep, and 59 pigs.

The percentages of water, mineral matter, fat, and nitrogenous substance, were determined in certain separated parts, and in the entire bodies, of ten animals—namely, one calf, two oxen, one lamb, four sheep, and two pigs. Complete analyses of the ashes, respectively, of the entire carcasses, of the mixed internal and other "offal" parts, and of the entire bodies, of each of these ten animals, have also been made.

From the data provided, as just described, as to the chemical composition of the different descriptions of animal, in different conditions as to age and fatness, the composition of the increase whilst fattening, and the relation of the constituents stored up in increase to those consumed in food, have been estimated.

To ascertain the composition of the manure in relation to that of the food consumed, oxen, sheep, and pigs, have been experimented upon.

In the case of oxen, the food and litter (sometimes with an acid absorbent), were weighed, sampled, and analysed; the animals were fed in boxes, for periods of from five to nine weeks, and the total dung produced was well mixed, weighed, sampled, and analysed. The constituents determined in the food and litter on the one hand, and in the dung on the other, were dry matter, ash, and nitrogen.

In the case of sheep no litter was used; the animals were kept in lots of five, on rafters, through which (but with some little loss) the solid and liquid excreta passed on to a sheet-zinc flooring at such an incline that the liquid drained off at once into carboys containing acid, and the solid matter was removed two or three times daily, and also mixed with acid. The

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constituents determined in the food and manure were dry matter, mineral matter, sometimes woody-fibre, and nitrogen.

In the case of pigs, individual male animals were experimented upon, each for periods of three, five, or ten days only. Each animal was kept in a frame, preventing it from turning round, and having a zinc bottom, with an outlet for the liquid to run into a bottle, and it was watched night and day, and the voidings carefully collected as soon as passed, which could easily be done, as the animal never passed either fæces or urine without getting up, and in getting up he rang a bell, and so attracted the notice of the attendant. The constituents determined were, in the food and fæces, dry matter, ash, and nitrogen, and in the urine, dry matter, ash, nitrogen, and urea.

The loss or expenditure of constituents, by respiration and the cutaneous exhalations has not been determined directly, that is, by means of a respiration-apparatus, but only by difference, that is, by calculation, founded on the amounts of dry matter, ash, and nitrogen in the food, and in the (increase) fæces, and urine.

Independently of the points of inquiry above enumerated, the results obtained have supplied data for the consideration of the following questions:—

1. The sources in the food of the fat produced in the animal body.
2. The characteristic demands of the animal body (for nitrogenous or non-nitrogenous constituents of food) in the exercise of muscular power.
3. The comparative characters of animal and vegetable food in human dietaries.

Supplementary Investigations.

In conjunction with the late Professor Way, an extensive investigation was undertaken on the application of town sewage to different crops, but especially to grass. The amount, and the composition, of both the sewage and the produce grown were determined; and, in selected cases, the composition of the land drainage-water was also determined. Comparative experiments were also made on the feeding qualities of the differently grown produce; the amount of increase yielded by oxen, and the amount and composition of the milk yielded by cows, being determined. In this inquiry part of the analytical work was performed at Rothamsted, but most of it by Professor Way in London.

The chemistry of the malting process, the loss of food constituents during its progress, and the comparative feeding value of barley and malt, have been investigated.

Experiments were commenced in 1884, and continued for several years, to determine the changes and losses which food-crops undergo in the process of ensilaging. Experiments have also been made to determine the comparative value as food—of red-clover-silage as against red-clover-hay-chaff and swedes, when given (with other foods), to fattening oxen; of red-clover-silage, and meadow-grass-silage, as against mangels, when given (with other foods) to milking cows; of silaged green oats, against oats (grain and straw) allowed to ripen, given (with other foods) to fattening oxen; and of meadow-grass-silage, as against corresponding meadow-grass-hay, given (with other foods) to fattening oxen.

A mixed crop of beans, peas, tares, and oats, was silaged in 1886, 1887, and in 1888, and the changes and losses determined by weight and analysis, but the silage was not fed experimentally. A similar mixed crop was sown in June 1889; but it failed, and was ploughed up.

Although many of the results of the investigations above enumerated have already been published, a large proportion as yet remains unpublished.

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The following lists give the titles of the papers already published, arranged in two Series, and within each Series arranged in chronological order; and they show in what Journal each paper appeared.

SERIES I.—REPORTS OF FIELD EXPERIMENTS, EXPERIMENTS ON VEGETATION, &c.

PUBLISHED 1847—1898, INCLUSIVE.

1. Agricultural Chemistry (Jour. Roy. Ag. Soc. Eng., vol. viii., p. 226) 1847
2. Agricultural Chemistry, Turnip Culture (Jour. Roy. Ag. Soc. Eng., vol. viii., p. 494) 1847
3. Experimental Investigation into the Amount of Water Given Off by Plants during their Growth, especially in relation to the Fixation and Source of their various Constituents (Jour. Hort. Soc. Lond., vol. v., p. 38) 1850
4. Report of some Experiments undertaken at the suggestion of Professor Lindley, to ascertain the Comparative Evaporating Properties of Evergreen and Deciduous Trees (Jour. Hort. Soc. Lond., vol. vi., p. 227) 1851
5. Agricultural Chemistry, especially in relation to the Mineral Theory of Baron Liebig (Jour. Roy. Ag. Soc. Eng., vol. xii., p. 1) 1851
6. On the Amounts of, and Methods of Estimating, Ammonia and Nitric Acid in Rain-water (Report of the British Association for the Advancement of Science for 1854—Liverpool Meeting) 1854
7. Report to the Right Hon. the Earl of Leicester, on the Experiments, conducted by Mr. Keary, on the Growth of Wheat upon the same land for four successive years, at Holkham Park Farm (Jour. Roy. Ag. Soc. Eng., vol. xvi., p. 207) 1855
8. On some points connected with Agricultural Chemistry; being a reply to Baron Liebig's "Principles of Agricultural Chemistry" (Jour. Roy. Ag. Soc. Eng., vol. xvi., p. 411) 185
9. On the Growth of Wheat by the Lois Weedon System, on the Rothamsted Soil; and on the Combined Nitrogen in Soils (Jour. Roy. Ag. Soc. Eng., vol. xvii., p. 582) 1856
10. On some points in the Composition of Wheat Grain, its Products in the Mill, and Bread (Journal of the Chemical Society of London, vol. x., p. 1) 1857
11. On the Growth of Barley by Different Manures continuously on the Same Land; and on the Position of the Crop in Rotation (Jour. Roy. Ag. Soc. Eng., vol. xviii., p. 454) 1857
12. Report of Experiments with different Manures on Permanent Meadow Land, with Tabular Appendix (Jour. Roy. Ag. Soc. Eng., vols. xix., p. 552, and xx., pp. 228 and 398) 1858–9
13. Report of Experiments on the Growth of Red Clover by different Manures (Jour. Roy. Ag. Soc. Eng., vol. xxi., p. 178) 1860
14. On the Sources of the Nitrogen of Vegetation; with special reference to the question whether Plants Assimilate Free or Uncombined Nitrogen.—Abstract (Proceedings of the Royal Society of London, vol. x., p. 544) 1860
15. On the Application of Different Manures to Different Crops, and on their Proper Distribution on the Farm 1861
16. On some Points in connection with the Exhaustion of Soils.—Abstract (Report of the British Association for the Advancement of Science for 1861—Manchester Meeting) 1861
17. On the Sources of the Nitrogen of Vegetation, with special reference to the question whether Plants Assimilate Free or Uncombined Nitrogen (Philosophical Transactions, part 2, 1861, p. 431) 1861
18. Report of Experiments made at Rodmersham, Kent, on the Growth of Wheat by different Descriptions of Manure for several years in succession on the same land (Jour. Roy. Ag. Soc. Eng., vol. xxiii., p. 31) 1862

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19. The Effects of Different Manures on the Mixed Herbage of Grass Land (Jour. Roy. Ag. Soc. Eng., vol. xxiv., p. 131) 1863
20. On the Sources of the Nitrogen of Vegetation, with special reference to the question whether Plants assimilate Free or Uncombined Nitrogen (Jour. Chem. Soc., new series, vol. i.; entire series, vol. xvi.) 1863
21. Liebig and the "Mineral Theory"(note, extracted from a paper by Messrs. Lawes and Gilbert, Jour. Roy. Ag. Soc. Eng., vol. xxiv., part 2) 1863
22. Further Report of Experiments with Different Manures on Permanent Meadow Land (Jour. Roy. Ag. Soc. Eng., vol. xxiv., part 2) 1863
23. Report of Experiments on the Growth of Wheat for Twenty Years in Succession on the same land (Jour. Roy. Ag. Soc. Eng., vol. xxv., parts 1 and 2) 1864
24. On the Selection of Artificial Manures for the Sugar-cane 1864
25. On the Accumulation of the Nitrogen of Manure in the Soil (Report of the British Association for the Advancement of Science for 1866—Nottingham Meeting) .. 1866
26. Preliminary Notice of Results on the Composition of Wheat grown for twenty years in succession on the same land (Report of the British Association for the Advancement of Science for 1867—Dundee Meeting) 1867
27. On the Home Produce, Imports, and Consumption of Wheat (Jour. Roy. Ag. Soc. Eng., vol. iv., s.s., part 2) 1868
28. Exhaustion of the Soil in relation to Landlords' Covenants, and the Valuation of Unexhausted Improvements (read before the London Farmers' Club, April 4, 1870) 1870
29. Scientific Agriculture with a view to Profit (read before the Maidstone Farmers' Club, Dec. 15, 1870) 1870
30. Reports of Experiments on the Influence of various Manures on different Species of Plants (Proceedings of the Royal Horticultural Society, p. 19) 1870
31. Effects of the Drought of 1870 on some of the Experimental Crops at Rothamsted (Jour. Roy. Ag. Soc. Eng., vol. vii., s.s., part 1) 1871
32. Notes on Clover Sickness (Jour. Roy. Hort. Soc., vol. iii., p. 86) 1871
33. Report of Experiments on the Growth of Barley for Twenty Years in Succession on the same land (Jour. Roy. Ag. Soc. Eng., vol. ix., s.s., parts 1 and 2) 1873
34. Unexhausted Tillages and Manures, with reference to the Landlord and Tenant (Ireland) Act, 1870 1874
35. On the more frequent Growth of Barley on Heavy Land (read before the London Farmers' Club, February 1, 1875) 1875
36. On the Valuation of Unexhausted Manures (Jour. Roy. Ag. Soc. Eng., vol. xi., s.s., part 1) 1875
37. Note on the Occurrence of "Fairy Rings" (Jour. Linn. Soc., Botany, vol. xv., p. 17) 1875
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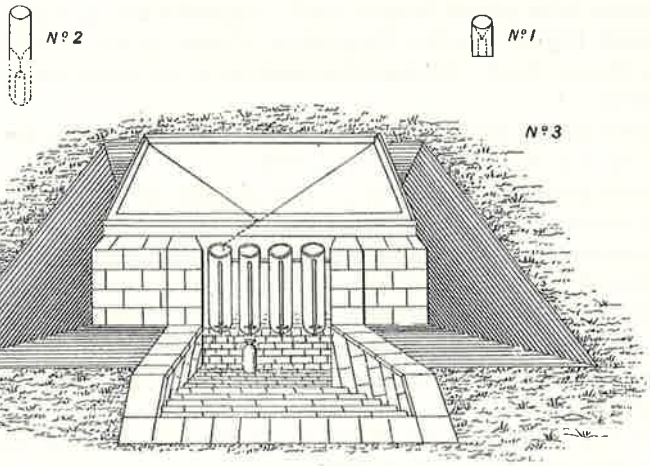
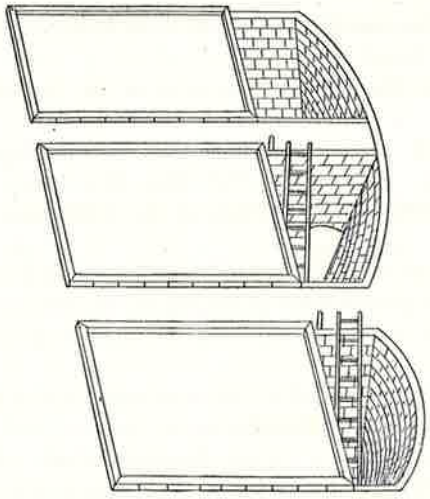
THE ROTHAMSTED RAIN GAUGES.



VIEW SHOWING THE COLLECTORS.

No. 1.—Small Funnel-gauge, 5 inches diameter.
No. 2.—Small Funnel-gauge, 8 inches diameter.
No. 3.—Large Gauge—
Size—7 feet 3·12 in. × 6 feet.
Area—One thousandth of an acre.
4 collectors, each holding Rain = 0·500 in.
Gauge-tubes graduated to .. 0·002 in.
Overflow tank to hold Rain = 2·000 ins.
Small cylinder, tube graduated to 0·001 in.
(For quantities less than 0·05 in.)
No. 4.—Stand with level marble top, for measuring.

THE ROTHAMSTED DRAIN GAUGES.



VIEW.

3 Drain Gauges—
Each 7 feet 3·12 in. × 6 feet = $\frac{1}{1000}$th acre area :
Respectively 20, 40, and 60 inches depth of soil.
2 collectors, each holding Drainage = 0·500 in.
Gauge-tubes graduated to .. .. 0·002 in.
Overflow tank to hold Drainage .. = 2·000 ins.

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GENERAL SUMMARY OF THE RESULTS RELATING TO RAINFALL AND DRAINAGE AT ROTHAMSTED.

As already explained (p. 6), the Rainfall has been measured at Rothamsted, in gauges of different sizes almost from the commencement of the Field Experiments; and the Drainage through 20 inches, 40 inches, and 60 inches, of unmanured and uncropped soil, in its natural state of consolidation, has been collected from September 1870, up to the present time, a period of nearly 28 Harvest-years. The nitrogen as nitric acid in the drainage waters was determined occasionally during the first 7 years of their collection (1870–1 to 1876–7); but from 1877–8 up to the present time, a period of more than 20 Harvest-years, it has been determined in proportional samples for each month. A summary of the numerical results relating to rainfall, drainage, and loss of nitrogen by the drainage, will be found in the Table at pp. 18–19.

The figures show that over the 20 Harvest-years, 1877–8 to 1896–7, there was an average annual loss of nitrogen in the drainage, of 35·07 lbs. through 20 inches, 30·83 lbs. through 40 inches, and 33·87 lbs. through 60 inches depth, of unmanured and uncropped soil; or, taking the average of the three gauges, of about 33 lb. per acre per annum of nitrogen, corresponding to an average annual loss of nearly 2 cwts. of nitrate of soda.

With reference to the large amounts of loss of nitrogen by the drainage thus indicated, it is to be borne in mind, that probably not more than an average of about 5 lbs. would be contributed annually per acre from the atmosphere in rain and the minor aqueous deposits, exclusive of any condensation by the soil. Moreover, the soil of the drain-gauges had been unmanured since 1868; but, being exposed to the access of air from below as well as from above, the oxidation of the nitrogenous matters of the soil and subsoil may be more active than in similar soil in its natural condition. On the other hand, the soil was without any vegetation to arrest the nitric acid formed; whilst, in some cases of fallow-land which had been manured and cropped in the ordinary course, and which would therefore be in a much higher "condition" than the soil of the drain-gauges, as much, or even more nitrogen as nitric acid, has been found to be present in the autumn, to the depth of 18 or 27 inches.

As the three drain-gauges of unmanured and uncropped soil have been in operation since September 1870—that is, for 27 Harvest-years to the end of August 1897—it is obviously of interest to consider whether or not there is evidence of decline in the amount of nitric acid annually formed in the soil over that period. As the drainage waters were not systematically sampled and analysed until 1877, accurate estimates of the amount of nitric acid in the drainage of the first 7 years of the experiments cannot be made; but the indication is, that it averaged more over those earlier than over the subsequent years. Examination of the results for the four 5-yearly periods of the 20 years, 1877–8 to 1896–7, shows that the average annual loss of nitrogen per acre in the drainage was, over the first 5 years considerably more than the average of the 20 years, but over the second 5 it was less than the average, and over the third 5 less than over the second; whilst over the last five years (1892–3 to 1896–7) the loss somewhat exceeded that of the preceding five years. The details show, that the excess over the first 5 years was due to very excessive amounts in the second and fourth years of the twenty; and that these were coincident with very excessive amounts of rain and of drainage. The loss over the second 5 years was considerably less than over the first, and somewhat lower than the average, and so also was the amount of rain, though the drainage was, on the average, slightly higher. The loss over the third 5 years was less than over the second, and less than the average, and so also were the average amounts of rain and drainage. Over the last 5 years again, the distinctly lower than average loss of nitrogen in the drainage, was coincident with lower than average rainfall, and generally lower than average drainage, especially in the first and fourth years.

With this general decline in the loss of nitrogen in the later years, there was, on the other hand, in the 8th year of the 20 considerably more than the average loss, in the 9th about the average, and in the 11th, 17th and 20th years considerably more, and in the 18th year rather more than the average; part of the excess in the 17th year being probably due to accumulation during the preceding year of drought. In each of the last four years of the first 15, however, the loss was considerably below the average, and in the 16th year, a year of drought (1892–3), there was, with nearly the lowest rainfall and drainage, also nearly the lowest loss of nitrogen by drainage. Lastly as to the details:—in October of the fifteenth Harvest-year (1891–2), there was, with a great excess of rain and drainage, very much more than the average amount of nitric acid in the drainage of that month. Indeed, in only one month during the preceding 14 years, namely in September 1880, was there more nitric acid passing through the 20-inch gauge than in October 1891. There was, however, in October of the 17th year, 1893–4, and in November of the 19th year, 1895–6, about as much loss of nitrogen as nitric acid as in October 1891. More pertinent still is the fact, that in September of the Harvest-year, 1896–7, which is the 27th of the parallel rain and drainage records, and the 20th of the monthly analysis of the drainage waters, there was, with the heaviest rainfall and drainage ever recorded at Rothamsted for a single month, also the greatest loss of nitrogen as nitric acid by the drainage, in any one month of the 20 years, and this was the case with the 20-, the 40-, and the 60-inch drain-gauges.

Obviously, the loss of nitrogen as nitric acid through the soil-drain-gauges was very directly dependent on the amount, and on the distribution, of the rain, and of the drainage. Indeed, although there seems to be some indication of a decline in the amount of nitric acid formed over the later than over the earlier years, the evidence is certainly not yet very conclusive. Finally, it is estimated that during the 27 Harvest-years ending with August 31, 1897, there has been a loss of nitrogen through the 20-inch gauge of 13¼, through the 40-inch of more than 7, and through the 60-inch of nearly 6¾ per cent., of the total combined nitrogen in the soil and subsoil.

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NUMERICAL SUMMARY OF RESULTS RELATING TO RAINFALL AND DRAINAGE AT ROTHAMSTED.

In the Table (pp. 18–19), are given—the average annual Rainfall over the 19 *Harvest-years*, 1851–2 to 1869–70; that is, from the commencement of the period for which the average produce, of continuous wheat (pp. 30–1), and of continuous barley (pp. 26–7), is given, up to the time when the experiments with the drain-gauges commenced. Next are given the averages of both rainfall and drainage for the first 7 Harvest-years during which drainage as well as rainfall was collected (1870–1 to 1876–7). Up to that time, the nitric acid in the drainage water had only been occasionally determined; but from 1877–8, up to the present time, it has been determined in proportionally mixed samples for each month; and the Table shows, in inches, the rainfall, and the drainage through each of the three soil-drain-gauges, respectively of 20, 40, and 60 inches depth of soil; also the difference (rainfall collected in the large gauge, $\frac{1}{1000}$ acre area, *minus* drainage), approximately representing evaporation. The Table further shows—the amounts of loss of nitrogen, in lb. per acre, in the drainage through each of the three drain-gauges, reckoned both as nitrogen, and as nitrate of soda (commercial, 5 per cent. impurity), for each of the 20 Harvest-years 1877–8 to 1896–7; the maximum and the minimum annual rainfall, with the corresponding drainage, evaporation, and loss of nitrogen, over the 20 Harvest-years; and the averages for each of the four successive five-yearly periods; also the averages for four-monthly periods, and for the total Harvest-year, over the 20 years. There are also given, in the last four divisions of the Table (p. 19)—first the average loss for each month, over the 20 years; secondly, the monthly results for the Harvest-year, 1895–6; thirdly, those for the last complete Harvest-year, 1896–7; and lastly, similar results for the current Harvest-year (1897–8) up to May inclusive.

Harvest-Years. September 1 to August 31.	Rainfall.		Drainage.			Difference (1), evaporated (or retained by soil).			Loss of Nitrogen per Acre in Drainage.					
									Reckoned as Nitrogen.			Reckoned as Nitrate of Soda. (2)		
	5-inch Funnel Gauge.	$\frac{1}{1000}$th Acre Gauge.	Soil 20 ins. deep.	Soil 40 ins. deep.	Soil 60 ins. deep.	Soil 20 ins. deep.	Soil 40 ins. deep.	Soil 60 ins. deep.	Soil 20 ins. deep.	Soil 40 ins. deep.	Soil 60 ins. deep.	Soil 20 ins. deep.	Soil 40 ins. deep.	Soil 60 ins. deep.
	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Av. 19 yrs. 1851–2 to '69–70	23·80	27·04	..	..	..	..	..	..	..	..	..	..	..	..
Av. 7 yrs. 1870–1 to '76–7	28·29	30·26	12·29	12·79	10·86	17·97	17·47	19·40	..	..	..	..	..	..
1877–8	32·11	32·65	14·72	16·44	14·84	17·93	16·21	17·81	44·75	39·53	45·92	286	253	293
1878–9	40·17	41·05	24·44	26·03	24·38	16·61	15·02	16·67	59·36	46·52	60·94	379	297	389
1879–80	20·88	21·36	6·89	7·39	6·50	14·47	13·97	14·86	27·03	17·87	20·19	173	114	129
1880–1	35·85	36·77	22·38	22·84	21·26	14·39	13·93	15·51	57·78	44·22	49·95	369	283	319
1881–2	31·66	32·31	15·81	16·08	14·32	16·50	16·23	17·99	32·93	31·74	35·24	211	203	225
1882–3	33·69	34·71	20·82	21·72	19·72	13·89	12·99	14·99	32·67	36·08	38·26	209	231	244
1883–4	25·29	25·77	11·86	12·00	11·21	13·91	13·77	14·56	29·31	26·85	26·89	187	172	172
1884–5	25·90	26·78	14·82	15·14	13·98	11·96	11·64	12·80	39·55	36·71	33·86	253	235	216
1885–6	29·46	31·02	17·37	18·41	16·57	13·65	12·61	14·45	34·49	32·27	34·36	221	206	220
1886–7	22·63	23·61	10·64	12·58	11·72	12·97	11·03	11·89	25·28	21·88	24·98	161	140	160
1887–8	29·11	30·50	13·96	15·58	14·67	16·54	14·92	15·83	43·10	36·90	35·67	276	236	228
1888–9	28·79	30·09	14·64	15·82	14·33	15·45	14·27	15·76	31·96	29·25	30·50	204	187	195
1889–90	26·73	27·43	13·16	13·60	12·74	14·27	13·83	14·69	27·61	24·94	28·41	176	159	182
1890–1	22·30	23·41	9·95	9·70	9·73	13·46	13·71	13·68	25·70	19·90	22·04	164	127	141
1891–2	28·45	29·68	16·50	17·43	16·47	13·18	12·25	13·21	29·39	28·45	33·43	188	181	214
1892–3	23·11	24·08	11·58	12·35	12·10	12·50	11·73	11·98	22·61	20·40	23·72	144	130	152
1893–4	28·24	29·55	13·36	14·11	14·07	16·19	15·44	15·48	40·94	31·53	34·52	262	202	221
1894–5	27·76	28·94	15·50	16·95	16·31	13·44	11·99	12·63	37·12	33·18	34·36	238	212	220
1895–6	22·98	24·37	9·84	10·75	10·35	14·53	13·62	14·02	23·18	22·77	22·78	148	145	146
1896–7	34·91	37·24	21·88	23·86	22·80	15·36	13·38	14·44	36·62	35·77	41·40	234	229	265
Results for Maximum and Minimum Rainfall (Large Gauge). 20 Harvest-Years, 1877–8 to 1896–7.														
Maximum (1878–9)	40·17	41·05	24·44	26·03	24·38	16·61	15·02	16·67	59·36	46·52	60·94	379	297	389
Minimum (1879–80)	20·88	21·36	6·89	7·39	6·50	14·47	13·97	14·86	27·03	17·87	20·19	173	114	129
Averages for 5, 5, 5, and 5 Harvest-Years (20 Years, 1877–8 to 1896–7).														
5 yrs., 1877–8 to '81–2 ..	32·13	32·83	16·85	17·76	16·26	15 98	15·07	16·57	44·37	35·97	42·45	284	230	271
5 yrs., 1882–3 to '86–7 ..	27·39	28·38	15·10	15·97	14·64	13·28	12·41	13·74	32·26	30·76	31·67	206	196	202
5 yrs., 1887–8 to '91–2 ..	27·07	28·22	13·64	14·42	13·59	14·58	13·80	14·63	31·55	27·89	30·01	202	178	192
5 yrs., 1892–3 to '96–7 ..	27·40	28·83	14·43	15·60	15·12	14·40	13·23	13·71	32·09	28·73	31·36	205	184	200
Mean, 20 years	28·50	29·57	15·00	15·94	14·90	14·57	13·63	14·67	35·07	30·83	33·87	224	197	216
Averages for 4-monthly Periods, and Total Harvest-Years (20 Years, 1877–8 to 1896–7).														
Sept. 1 to Dec. 31	11·19	11·57	7·47	7·72	7·23	4·10	3·85	4·34	20·27	17·30	17·95	129	110	115
Jan. 1 to April 30	7·37	7·76	4·74	5·32	5·01	3·02	2·41	2·75	7·49	7·94	9·57	48	51	61
May 1 to Aug. 31	9·94	10·24	2·79	2·90	2·66	7·45	7·34	7·58	7·31	5·59	6·35	47	36	40
Total Harvest-year	28·50	29·57	15·00	15·94	14·90	14·57	13·63	14·67	35·07	30·83	33·87	224	197	216

(1) Calculated on the Rainfall shown by the $\frac{1}{1000}$th acre gauge.

(2) Commercial—reckoning 5 per cent. impurity.

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NUMERICAL SUMMARY OF RESULTS RELATING TO RAINFALL AND DRAINAGE AT ROTHAMSTED—*continued.*

HARVEST-YEARS. September 1 to August 31.	RAINFALL.		DRAINAGE.			DIFFERENCE (1), evaporated (or retained by soil).			LOSS OF NITROGEN PER ACRE IN DRAINAGE. Reckoned as Nitrogen.			Reckoned as Nitrate of Soda. (2)		
	5-inch Funnel Gauge.	$\frac{1}{1000}$th Acre Gauge.	Soil 20 ins. deep.	Soil 40 ins. deep.	Soil 60 ins. deep.	Soil 20 ins. deep.	Soil 40 ins. deep.	Soil 60 ins. deep.	Soil 20 ins. deep.	Soil 40 ins. deep.	Soil 60 ins. deep.	Soil 20 ins. deep.	Soil 40 ins. deep.	Soil 60 ins. deep.
AVERAGES FOR EACH MONTH. 20 HARVEST-YEARS, 1877–8 TO 1896–7.														
	inches.	inches.	inches.	inches.	inches.	inches.	inches.	inches.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
September	2·53	2·63	1·04	1·02	0·95	1·59	1·61	1·68	3·91	2·73	2·69	25·0	17·5	17·2
October	3·29	3·38	2·07	2·09	1·93	1·31	1·29	1·45	6·38	5·00	5·04	40·7	31·9	32·2
November	3·05	3·14	2·41	2·51	2·37	0·73	0·63	0·77	6·30	5·66	5·86	40·3	36·2	37·4
December	2·32	2·42	1·95	2·10	1·98	0·47	0·32	0·44	3·68	3·91	4·36	23·5	25·0	27·9
January	1·91	2·04	1·67	1·88	1·82	0·37	0·16	0·22	2·57	2·81	3·40	16·4	18·0	21·7
February	1·87	1·95	1·55	1·71	1·58	0·40	0·24	0·37	2·46	2·51	3·00	15·7	16·0	19·1
March	1·77	1·88	1·00	1·15	1·08	0·88	0·73	0·80	1·48	1·67	2·00	9·4	10·6	12·8
April	1·82	1·89	0·52	0·58	0·53	1·37	1·31	1·36	0·98	0·95	1·17	6·3	6·1	7·5
May	2·11	2·17	0·58	0·65	0·57	1·59	1·52	1·60	1·13	1·04	1·19	7·2	6·6	7·6
June	2·26	2·33	0·61	0·65	0·61	1·72	1·68	1·72	1·24	1·09	1·25	7·9	7·0	8·0
July	2·73	2·80	0·73	0·74	0·69	2·07	2·06	2·11	2·07	1·53	1·69	13·3	9·8	10·8
August	2·84	2·94	0·87	0·86	0·79	2·07	2·08	2·15	2·87	1·93	2·22	18·4	12·3	14·2
Total	28·50	29·57	15·00	15·94	14·90	14·57	13·63	14·67	35·07	30·83	33·87	224·1	197·0	216·4
HARVEST-YEAR, 1895–6.														
September	0·97	1·06	0·10	0·12	0·08	0·96	0·94	0·98	0·42	0·27	0·21	2·7	1·7	1·3
October	2·52	2·69	0·82	0·84	0·72	1·87	1·85	1·97	3·30	2·38	2·00	21·1	15·2	12·8
November	4·69	4·96	4·04	4·13	4·16	0·92	0·83	0·80	13·07	10·84	10·55	83·5	69·2	67·4
December	2·14	2·34	1·84	2·04	2·01	0·50	0·30	0·33	2·70	3·98	4·04	17·3	25·4	25·8
January	1·06	1·12	0·70	0·86	0·81	0·42	0·26	0·31	0·81	1·46	1·60	5·2	9·3	10·2
February	0·57	0·59	0·04	0·13	0·11	0·55	0·46	0·48	0·05	0·20	0·20	0·3	1·2	1·3
March	3·62	3·75	2·06	2·20	2·13	1·69	1·55	1·62	2·24	2·94	3·52	14·3	18·8	22·5
April	0·88	0·95	0·02	0·13	0·08	0·93	0·82	0·87	0·03	0·13	0·14	0·2	0·9	0·9
May	0·45	0·48	(0·001)	0·01	0·03	0·48	0·47	0·45	..	0·02	0·04	..	0·1	0·3
June	2·09	2·25	0·07	0·11	0·11	2·18	2·14	2·14	0·15	0·19	0·21	0·9	1·2	1·3
July	1·21	1·27	..	0·01	0·01	1·27	1·26	1·26	..	0 01	0·01	..	0·1	0·1
August	2·78	2·91	0·15	0·17	0·10	2·76	2·74	2·81	0·41	0·35	0 26	2·6	2·2	1·7
Total	22·98	24·37	9·84	10·75	10·35	14·53	13·62	14·02	23·18	22·77	22·78	148·1	145·3	145·6
LAST HARVEST-YEAR, 1896–7.														
September	7·66	8·08	6·14	6·45	6·36	1·94	1·63	1·72	20·43	15·33	16·27	130·5	98·0	103·9
October	3·87	4·13	2·82	3·06	2·99	1·31	1·07	1·14	5·75	5·68	6·23	36·7	36·3	39·8
November	1·30	1·39	0·78	0·92	0·83	0·61	0·47	0·56	0·93	1·47	1·73	6·0	9·4	11·1
December	4·05	4·42	3·83	4·00	3·81	0·59	0·42	0·61	3·72	5·16	6·29	23·8	33·0	40·2
January	1·84	2·03	1·42	1·66	1·59	0·61	0·37	0·44	1·03	1·69	2·04	6·6	10·8	13·1
February	2·74	2·92	3·20	3·58	3·26	−0·28	−0·66	−0·34	1·74	2·83	3·77	11·1	18·1	24·1
March	3·94	4·20	2·54	2·69	2·59	1·66	1·51	1·61	1·67	2·13	3·10	10·7	13·6	19·8
April	1·77	1·91	0·23	0·37	0·32	1·68	1·54	1·59	0·20	0·28	0·41	1·3	1·8	2·6
May	1·63	1·72	0·01	0·05	0·05	1·71	1·67	1·67	0·01	0·04	0·06	0·1	0·2	0·4
June	2·59	2·73	0·77	0·95	0·87	1·96	1·78	1·86	0·88	0·97	1·25	5·7	6·2	8·0
July	0·44	0·47	..	0·02	0·02	0·47	0·45	0·45	..	0·02	0·04	..	0·1	0·2
August	3·08	3·24	0·14	0·11	0·11	3·10	3·13	3·13	0·26	0·17	0·21	1·7	1·1	1·4
Total	34·91	37·24	21·88	23·86	22·80	15·36	13·38	14·14	36·62	35·77	41·40	234·2	228·6	264·6
CURRENT HARVEST-YEAR, 1897–8.														
September	2·29	2·44	0·91	0·96	0·87	1·53	1·48	1·57	2·66	1·76	2·07	17·0	11·3	13·2
October	0·86	0·96	..	(0·001)	(0·001)	0·96	0·96	0·96	..	..	..	..	..	..
November	0·97	1·05	0·22	0·14	0·11	0·83	0·91	0·94	0·54	0·21	0·19	3·4	1·3	1·2
December	3·26	3·50	2·96	3·09	3·06	0·54	0·41	0·44	10·04	7·28	7·82	64·2	46·5	50·0
January	0·76	0·80	0·65	0·83	0·82	0·15	−0·03	−0·02	1·90	1·68	1·82	12·1	10·8	11·6
February	1·01	1·10	0·01	0·05	0·05	1·09	1·05	1·05	0·03	0·07	0·06	0·2	0·4	0·4
March	0·99	1·06	0·36	0·50	0·49	0·70	0·56	0·57	0·94	0·93	0·90	6·0	6·0	5·8
April	1·36	1·44	0·05	0·09	0·08	1·39	1·35	1·36	0·11	0·14	0·14	0·7	0·9	0·9
May	2·73	2·89	0·78	0·95	0·92	2·11	1·94	1·97	1·93	1·77	1·87	12·3	11·3	12·0
June														
July														
August														
Total														

(1) Calculated on the Rainfall shown by the $\frac{1}{1000}$th acre gauge.

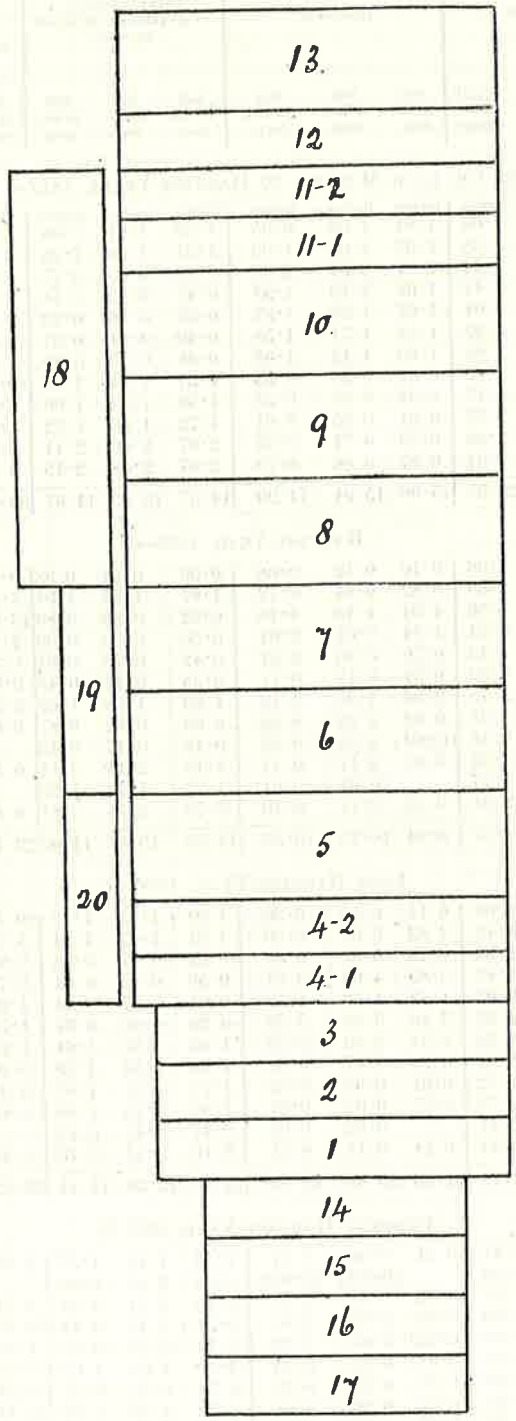
(2) Commercial—reckoning 5 per cent. impurity.

C 2

PLAN OF THE PLOTS IN THE PARK, ON WHICH EXPERIMENTS HAVE BEEN MADE, ON THE MIXED HERBAGE OF PERMANENT GRASS LAND.

43 years, 1856–1898 inclusive.

[For a brief summary of results and conclusions, see opposite page.]



Total area under Experiment about 7 acres.

Area of Plots.
- 1, 2, 3, 4–1, 4–2, 11–1, 11–2, and 12, each ¼ acre.
- 5, 6, 7, 8, 9, 10, 13, and 18, each ½ acre.
- 14, 15, 16, and 17, each ⅛ acre.
- 19 and 20, each ⅛ acre.

[For details of the manuring and produce, see pp. 22 and 23.]

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Results of Experiments made in THE PARK,
On the Mixed Herbage of Permanent Grass-land.

These experiments were commenced in 1856, so that 1898 is the 43rd year of their continuance.

In the experiments with individual crops grown separately, on arable land, it was found, that those of the same natural Order—Wheat, Barley, and Oats, for example—had certain characters and manurial requirements in common; that those of the Leguminous Order had widely different characters and requirements; whilst crops of other Orders, such as Root-crops, Potatoes, &c., exhibited characteristics differing from the Gramineous, and more from the Leguminous crops. Compared with the conditions of growth of such individual crops grown separately, those of the *Mixed Herbage of Grass-land* are extremely complicated. It comprises, besides numerous Gramineous and Leguminous species, representatives of many other Natural Orders; and of some of great prominence and importance as regards their prevalence and distribution in vegetation generally. If, under the influence of characteristically different manures, there are notable differences in the degree of luxuriance, and in the character of development of closely allied plants when each is grown separately, and much greater differences between plants of different Orders when so separately grown it is only what might be expected, that there should be very remarkable variations of result when different manures are applied to an already established Mixed Herbage of perhaps some 50 species growing together, representing perhaps nearly 20 Natural Orders.

Accordingly, even in the early years of the experiments, it was observed that those manures which were the most effective with Wheat, Barley, or Oats—that is with Gramineous species grown separately—were also the most effective in bringing forward the *grasses proper*, in the Mixed Herbage. Again, those manures which were the most beneficial to beans or clover, the most developed the Leguminous species in the Mixed Herbage, and *vice versâ*. There was also great variation in the predominance of individual species among both the grasses, and the representatives of other Orders. And again, there was very great difference in the tendency to produce merely increased leafy vegetation on the one hand, or to develop stem and seed formation on the other, according to the manure employed. Thus, the final product—the *hay*—was one thing when grown under certain manurial conditions, and quite another when grown under others. For example, the unmanured produce on the average included nearly 50 species—about 17 grasses, 4 leguminous plants, and 27 or more of other Orders; whilst the hay contained from 65 to 70 per cent. of gramineous produce, about 7½ of leguminous herbage, and 20 to 25 per cent. of herbage of other Orders. Compared with this, the produce by farmyard manure contained fewer species, a higher proportion by weight of gramineous, and lower of both leguminous and miscellaneous herbage. Or, to take an extreme case, an excessive application of both mineral and nitrogenous manures for many years in succession, has reduced the number of species traceable, to only about 15, whilst gramineous herbage has contributed from 95 to 98 per cent., or even more of the total hay, leguminous herbage has been excluded, and miscellaneous herbage nearly so. It may be said that any manure that increases the luxuriance of some individual plants, more or less reduces the number of species, and of course alters the proportion of the different species in the final product—the hay; whilst there will, according to the conditions, be different proportions of leaf and stem, and different tendencies to maturation. It is obviously, therefore, very difficult to summarise in a few sentences the results of experiments with 20 different conditions of manuring, carried on over a period of more than 40 years.

It may be said, that the effect of purely nitrogenous manures, such as nitrate of soda, and more still, ammonium-salts, is to reduce the total number of species, characteristically to increase the growth of gramineous species, almost to exclude leguminous herbage, and to reduce the number and proportion of miscellaneous species, but to increase the luxuriance of a few of those that remain. Purely mineral manures, supplying abundance of potash and phosphoric acid, in a less degree reduce the total number of species, do not increase the luxuriance, though they favour the stemminess and maturation of the grasses, but reduce the percentage by weight of such herbage in the hay. Such manures, however, greatly increase the luxuriance, and proportion by weight in the hay, of leguminous species; whilst they reduce, both the number of species, and proportion by weight in the hay, of the miscellaneous herbage.

It is thus obvious that the weights of hay per acre yielded under the varying conditions of manuring, do not represent the comparative value of the produce grown under the different conditions. For example, there has been an average of only about 1 ton per acre of first-crop hay without manure, the produce being, however, the most complex of all. With purely mineral manures, containing potash, the average annual yield of first-crop hay has been rather more than 1½ ton; with fewer species, but containing a considerable proportion of leguminous herbage; in fact, the hay grown by such manures, is of better quality than that produced by any other of the manures in the series. With an excess of mineral and nitrogenous manures together, the average yield per acre has been nearly 3 tons of first-crop hay; but the produce has contained no leguminous, and very little miscellaneous herbage, and from 95 to 98 per cent. of gramineous herbage, perhaps 90 per cent., consisting of only 4 to 6 of the most freely growing and coarser species, which have been characterised by great stemminess. Further, it may be stated, that the one ton of the very complex unmanured hay would contain about 7½ lb. of phosphoric acid, about 25 lb. of potash, and about 30 lb. of nitrogen; that the 1½ ton of hay grown by the purely mineral manures, with its ripened grasses, and large proportion of leguminous herbage, would contain about 18 lb. phosphoric acid, 75 lb. of potash, and 50 lb. of nitrogen; whilst the 3 tons of almost exclusively gramineous, and very stemmy hay, grown by excessive amounts of mineral and nitrogenous manures together, would remove about 30 lb. of phosphoric acid, about 145 lb. of potash, and about 108 lb. of nitrogen.

Between the extremes above indicated, the 20 plots afford examples of very great variety, not only in quantity of produce, but also in quality, depending on both the botanical and chemical composition, and on the character of development of the plants. The experiments were not arranged to provide exact examples for practice, but to ascertain the characteristic effects of different manurial agents on the quantity and quality of the Mixed Herbage, and thus to afford data for application in actual practice. The general result has been to show, that if artificial manures are largely or mainly relied upon, certain descriptions of herbage will be unduly forced at the expense of others, and also that the character of development of the plants will be materially affected. In order to maintain a due admixture of herbage on grass-land mown for hay, farmyard or stable dung should be liberally applied; and it is also conducive to the same end to consume the second crop on the land, with cake or corn. The more a good condition of the herbage is induced and maintained by such means, the more safely may some increased luxuriance, and so increased produce, be obtained, by the judicious use of artificial manures. Provided dung be liberally used it will not as a rule be necessary to apply potash artificially; but phosphates may advantageously be used as basic slag, and nitrogenous manure in the form of nitrate of soda, which, however, should seldom be used at the rate of more than 1 cwt., or at most 1½ cwt. per acre.

For details of the manuring and produce of the different plots, see pages 22–23.

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The Land has probably been laid down with Grass for some centuries. No fresh seed has been artificially sown within the last 50 years certainly; nor is there record of any having been sown since the Grass was first laid down. The experiments commenced in 1856, at which time the character of the herbage appeared fairly uniform over all the plots. The present season, 1898, is therefore the 43rd year of the experiments. Excepting as explained in the Table, and in the foot-notes, the same description of Manure has been applied year after year to the same plot.

During the first 19 years of the experiments, 1856–1874, the first crop only, each year, was mown, made into hay, removed from the land, and weighed. As a rule, the second crops were fed-off by sheep having no other food, the object being not to disturb the condition of the manuring. A given number was allotted to each plot, according to the amount of produce, penned upon a portion of it, and the area extended, day by day, until the whole was eaten down. Frequently, however, the animals suffered considerably; and in 1866, 1870, 1873, and 1874, the second crops (and third, if any) were cut, and spread on the respective plots. In the twentieth season, 1875, the second crops being unusually heavy, and the weather favourable, they were, for the first time, cut, weighed as hay, and removed. In 1876 they were cut and spread on the plots. In 1877 and 1878 the second crops were made into hay, weighed, and removed. In 1879, 1882, 1891, 1892, 1894, 1896 and 1897, the second crops were cut, sampled, carted, and weighed, green; the dry matter in the weighed samples was determined, and the produce reckoned into hay by adding one-fourth to the calculated dry matter per acre. In 1880, 1881, 1883, 1886, 1888, 1889, 1890, 1893, and 1895, the second crops were again made into hay, weighed and removed; and it is intended in future to adopt this plan whenever the weather will permit. In 1884, 1885, and 1887, owing to the dryness of the seasons after cutting the first crops, there was but little growth; the second crops were therefore again cut, but spread on the respective plots. Owing to the change in the treatment of the crops, the average produce per annum is given, separately, for the first 20 years, 1856–1875, first crops only; and for the succeeding 20 years, 1876–1895, first and second crops ([13]). On January 7, 1881, coarsely broken chalk, in the

(Area under experiment,

1 acre	= (about)	0·404 Hectare	or	1·585	Prussian Morgen.
1 lb. (pound avoir.) ..	= (about)	0·453 Kilogramme	or	0·907	Zollverein Pfund.
1 cwt. (hundredweight)	= (about)	50·8 Kilogrammes	or	1·016	Centner.
1 ton	= (about)	1015·6 Kilogrammes	or	20·32	Centner.
1 lb. per acre	= (about)	1·12 Kilogramme per Hectare	or	0·572	Zollv. Pfd. per Pr. Morgen.
1 cwt. per acre	= (about)	125·6 Kilogrammes per Hectare	or	0·641	Centner per Pr. Morgen.
1 ton per acre	= (about)	2512 Kilogrammes per Hectare	or	12·82	Centner per Pr. Morgen.

PLOTS.	Manures, per acre, per Annum. [In 1897, and since, 400 lbs. Basic Slag used throughout instead of Superphos.]
1	1856–63, 8 years, 14 tons Farmyard Manure, and 200 lbs. Ammonium-salts ([1]); average produce 49½ cwts. 1864 and since, 200 lbs. Ammonium-salts alone; average produce (12 years, 1864–75) 38⅞ cwts. .. .. ..
2	1856–63, 8 years, 14 tons Farmyard Manure; average produce 42⅞ cwts. 1864 and since, unmanured; average produce (12 years, 1864–75) 32⅞ cwts. .. ..
3	Unmanured, continuously .. ..
4 {1	3½ cwts. Superphosphate of Lime ([2]) .. ..
4 {2	3½ cwts. Superphosphate of Lime, and 400 lbs. Ammonium-salts .. ..
5	400 lbs. Amm.-salts, 42 yrs., 1856–97; 1898, half Unmanured, half 400 lb. Basic Slag, and 500 lb. Sulph. Pot.
([3]) 6	1856–68, 13 years, 400 lbs. Ammonium-salts; average produce 30¼ cwts. .. .. 1869–78, 300 lbs., 1879 and since 500 lbs., Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Magnesia, 3½ cwts. Superphosphate; average produce (7 yrs., 1869–75) 31¼ cwts. .. ..
7	1856–78, 300 lbs., 1879 and since 500 lbs., Sulphate Potash, 100 lbs. ([4]) Sulphate Soda, 100 lbs. Sulphate Magnesia, and 3½ cwts. Superphosphate .. ..
([3]) 8	1856–61, 6 years, 300 lbs. Sulph. Potash, 200 lbs. Sulph. Soda, 100 lbs. Sulph. Magnesia, and 3½ cwts. Superphosphate; average produce 36 cwts. .. .. 1862 and since, 250 lbs. ([5]) Sulphate Soda, 100 lbs. Sulphate Magnesia, and 3½ cwts. Superphosphate; average produce (14 years, 1862–75) 27½ cwts. .. ..
9	1856–78, 300 lbs., 1879 and since 500 lbs., Sulph. Potash, 100 lbs. ([4]) Sulph. Soda, 100 lbs. Sulph. Magnesia, 3½ cwts. Superphosphate, and 400 lbs. Ammonium-salts .. ..
([3]) 10	1856–61, 6 yrs. 300 lbs. Sulph. Potash, 200 lbs. Sulph. Soda, 100 lbs. Sulph. Magnesia, 3½ cwts. Superphosphate, 400 lbs. Ammonium-salts; average produce 55½ cwts. .. .. 1862 and since, 250 lbs. ([5]) Sulph. Soda, 100 lbs. Sulph. Magnesia, 3½ cwts. Superphosphate, 400 lbs. Ammonium-salts; average produce (14 yrs., 1862–75) 42¼ cwts. .. ..
11 {1	1856–78, 300 lbs., 1879 and since 500 lbs., Sulph. Potash, 100 lbs. ([4]) Sulph. Soda, 100 lbs. Sulph. Magnesia, 3½ cwts. Superphosphate, 600 lbs. ([6]) Ammonium-salts .. ..
11 {2	1856–78, 300 lbs., 1879 and since 500 lbs., Sulph. Potash, 100 lbs. ([4]) Sulph. Soda, 100 lbs. Sulph. Magnesia, 3½ cwts. Superphosphate, 600 lbs. ([6]) Ammonium-salts, and 400 lbs. Silicate Soda ([7]) .. ..
12	Unmanured continuously .. ..
13	1856–78, 300 lbs., 1879 and since 500 lbs., Sulph. Potash, 100 lbs. ([4]) Sulph. Soda, 100 lbs. Sulph. Magnesia, 3½ cwts. Superphosphate, 400 lbs. Ammonium-salts, 2000 lbs. Cut Wheat-straw .. ..
14	550 lbs. Nitrate Soda ([8]), 1858–78, 300 lbs., 1879 and since 500 lbs., Sulph. Potash, 100 lbs. ([4]) Sulph. Soda, 100 lbs. Sulph. Magnesia, and 3½ cwts. Superphosphate .. ..
15	1858–75, 18 years, 550 lbs. Nitrate Soda .. .. 1876–78, 300 lbs., 1879 and since 500 lbs., Sulphate Potash, 100 lbs. Sulphate Soda, 100 lbs. Sulphate Magnesia, and 3½ cwts. Superphosphate .. ..
16	275 lbs. Nitrate of Soda, 500 lbs. (300 lbs., 1858–78), Sulph. Potash, 100 lbs. (200 lbs., 1856–63) Sulph. Soda, 100 lbs. Sulph. Magnesia, and 3½ cwts. Superphosphate .. ..
17	275 lbs. Nitrate of Soda .. ..
18	Mixture supplying the quantity of Potash, Soda, Lime, Magnesia, Phosphoric acid, Silica, and Nitrogen, contained in 1 ton of Hay (commencing 1865) .. ..
19	275 lbs. Nitrate of Soda, 290 lbs. Sulphate of Potash, and 3½ cwts. Superphosphate (commencing 1872) ..
20	327 lbs. Nitrate of Potash, and 3½ cwts. Superphosphate (commencing 1872) .. ..

(1) "Ammonium-salts"—in all cases equal parts Sulphate and Muriate of Ammonia of Commerce.

(2) "Superphosphate of Lime," 1856 to 1888 inclusive, made from 200 lbs. Bone-ash, 150 lbs. Sulphuric Acid, Sp. gr. 1·7 (and water); 1889, and since, made from high percentage mineral phosphates, and containing 37 per cent., or more, of soluble phosphate.

(3) Plots 6, 8, and 10, had, besides the Manures specified, 2000 lbs. Sawdust per acre per annum for the first seven years, 1856–1862, but without effect. (4) 200 lbs., 1856–63 inclusive. (5) 500 lbs. in 1862 and 1863.

(6) 800 lbs. 1856–'58; 400 lbs. 1859–'61; 800 lbs. 1862–'81; 600 lbs. 1882 and since.

(7) The application of Silicates did not commence until 1862; 9 years (1862–1870), 200 lbs. Silicate Lime, and 200 lbs. Silicate Soda; 1871, and since, 400 lbs. Silicate Soda. (8) 550 lbs. Nitrate of Soda is reckoned to contain the same amount of Nitrogen as 400 lbs. of "Ammonium-salts."

(9) The Manures specified were first applied in 1859 (previously, 1856–7 and 8, Sawdust only).

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PERMANENT GRASS LAND.

condition of moisture in which it was brought from the pit, was applied at the rate of 2000 lbs. per acre, for a length of 49 links down each of the Plots 1 to 13 inclusive; and on February 26, partially dried and finely ground and sifted chalk, was applied to the same portion of the same plots, at the rate of 1000 lbs. per acre. In November 1883, each plot (1 to 20 inclusive) was divided, and upon one-half of each 2000 lbs. per acre of fresh burnt lime (slacked), was applied, in addition to the ordinary manures as stated in the Table; and in November 1887, the other half of most of the plots also received 2000 lbs. per acre; the exceptions being, that Plot 5 did not receive any in 1887, and that the portions of Plots 11–1 and 11–2, which had received the Lime in 1883, in 1887 received 2000 lbs. per acre more, and the other half which did not receive any in 1883, then (1887) received 4000 lbs. per acre. Lastly, in December 1896, the half of Plot 5, which had not previously received any lime, received 4000 lbs. per acre of freshly burnt lime (slacked); and the other half, which had formerly received 2000 lbs., now received another 2000 lbs. per acre, making in all 4000 lbs., the same as on the other half.

It was not until some years after the application of chalk, early in 1881, to small portions of some of the plots as above referred to, that the effects were sufficiently marked to render it desirable to cut and weigh the produce separately; and it was not until 1884 that it was so treated. The produce of the whole of these chalked portions was, however, excluded from the reckoning of the average produce of the plots, as given in this annual report, in the case of all the first crops of 1881, 1882, 1883, and 1886 to 1897 inclusive. It was also excluded in 1884 and 1885, in the case of the plots where the produce was separately weighed (Plots 6, 7, and 8, 1884, and 3, 6, 7, 8, and 11–1, in 1885), but included in the other cases in those two years. Again, in the case of the second crops, it was only in those of 1881 (a few of those of 1882), 1886, 1891, 1892, 1894 and 1896 (excepting Plots 6, 7, and 8), and 1897, that the produce of the chalked portions was included. In the case of the remaining or main portion of the plots, to one-half of which a dressing of slacked lime was applied in November 1883, and to the other half in November 1887, there has, on some plots, been marked effect, but it is the average produce of the two portions that has each year been given, as the produce of the plots. Below is given, besides the usual averages, the produce for both 1896 and 1897.

For Plan of the Plots, and brief summary of results and conclusions, see pp. 20–21.

about 7 acres.)

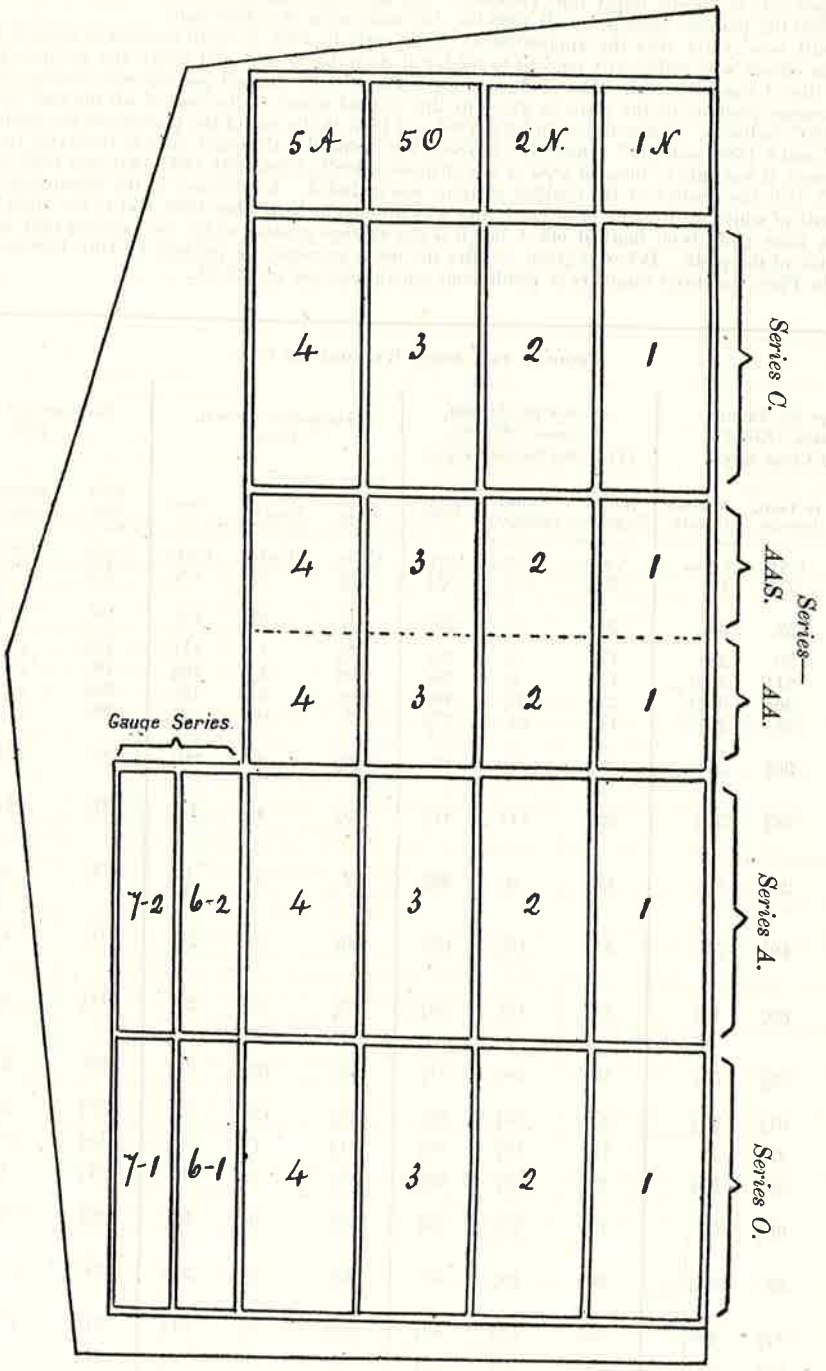
Plots.	Produce per Acre, Weighed as Hay.												Plots.
	Average per Annum, 20 Years, 1856–75. (First Crops only.)			Average per Annum, 20 Years, 1876–95. (First and Second Crops.)			Forty-first Season, 1896.			Forty-second Season, 1897.			
	10 Years, 1856–65.	10 Years, 1866–75.	20 Years, 1856–75.	First Crops(13).	Second Crops(14).	Total.	First Crop.	Second Crop(15).	Total	First Crop.	Second Crop(15).	Total.	
	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	
1	48 3/8	37 3/4	43	26 7/8	11 5/8	38 1/2	16 1/4	3 1/4	19 1/2	25 3/4	(16)	25 3/4	1
2	41 5/8	32	36 7/8	20 5/8	9	29 7/8	11 3/8	0 7/8	12 1/4	18 1/8	(16)	18 1/8	2
3	22 1/2	20	21 1/4	17 1/8	8 3/4	25 7/8	10 1/4	1	11 1/4	15 1/2	(16)	15 1/2	3
4 (1)	23 1/4	21 1/4	22 1/4 (9)	17 3/4	8 7/8	26 3/8	9 3/4	1	10 3/4	19	(16)	19	1
4 (2)	33 7/8	30 1/2	32 1/4 (9)	29 3/4	10 7/8	40 5/8	10 5/8	2	12 5/8	28 3/4	(16)	28 3/4	2 } 4
5	30 1/2	22	26 1/4	17 1/4	10	27 1/4	2	0 3/8	2 3/8	20 5/8	(16)	20 5/8	5
6	31 3/8	30 1/4	30 3/4	28 5/8	12 3/8	41	16 1/8	4 1/8	20 1/4	32 1/8	1 1/2	33 5/8	6
7	33 7/8	36 3/4	35 1/4	29 3/4	14 1/2	44 1/4	15 1/2	4 3/8	19 7/8	31 7/8	1 1/4	33 1/8	7
8	33 5/8	26 1/4	30 1/8	19 1/8	9 5/8	28 3/4	12	1 5/8	13 5/8	21 1/8	0 5/8	21 3/4	8
9	53 5/8	48 1/2	51	44 7/8	15 7/8	60 3/4	20 1/4	8	28 1/4	51 1/8	1 7/8	53	9
10	52 3/4	39 5/8	46 1/8	37 1/8	15 5/8	52 3/4	17 1/8	6 1/4	23 3/8	44 1/2	0 7/8	45 3/8	10
11 (1)	61 3/4	53 5/8	57 5/8	48	26 5/8	74 5/8	32 7/8	10 1/8	43	58 7/8	2	60 7/8	1 } 11
11 (2)	63 1/4	61 3/4	62 1/2	57 7/8	25 1/4	83 1/8	44 3/8	12 5/8	57	60 1/2	2 5/8	63 1/8	2 }
12	25	22 7/8	24	17 5/8	10 3/4	28 3/8	11 1/4	1 1/8	12 3/8	18 1/4	(16)	18 1/4	12
13	55 1/4	59 5/8	57 1/2	49 1/2	20 3/8	69 7/8	18 1/2	8 1/2	27	51 3/4	1 7/8	53 5/8	13
14	53 1/8	60 1/2	57 (10)	49 5/8	13 7/8	63 1/2	39 1/2	6 1/2	46	42 5/8	0 7/8	43 1/2	14
15	36 1/8	35	35 3/8 (10)	26 5/8	10 3/8	37	23 1/4	3 1/2	26 3/4	34 7/8	(16)	34 7/8	15
16	45 1/4	47 5/8	46 1/8 (10)	39 1/2	12 3/4	52 1/4	27 3/4	3 1/2	31 1/4	41	(16)	41	16
17	34 1/4	33 1/2	33 7/8 (10)	28 1/2	10 3/4	39 1/4	21 3/4	3	24 3/4	31 1/4	(16)	31 1/4	17
18	21	33 1/4	32 1/8 (11)	29 3/4	13 1/8	42 7/8	17 3/8	4 1/2	21 7/8	30	1 3/8	31 3/8	18
19	..	..	38 3/4 (12)	37	12 1/8	49 1/8	30	5 1/8	35 1/8	38 3/8	0 3/4	38 5/8	19
20	..	..	36 1/2 (12)	39	11 5/8	50 5/8	38	5 7/8	43 7/8	45 1/4	0 3/8	45 5/8	20

(10) Averages of 8 years, 10 years, and 18 years, as these experiments did not commence until 1858.
(11) Averages of (1 year), 10 years, and 11 years, as the experiment only commenced in 1865. (12) Averages of 4 years only, 1872–75.
(13) In 1888 and 1890, the first crops being got up in bad condition, the weights of hay per acre were corrected by adding one-fifth to the determined dry substance. This corresponds to an uniform amount of 16⅔ per cent. of moisture in the first crops of hay.
(14) As in 1876 the second crops were not removed, those of 1875, which were, are brought in instead; and as also in 1884, in 1885, and in 1887, the second crops were not removed, the aggregate second crops of the 17 years (1875, 1877–83, 1886, and 1888–95) are divided by 20 estimating the average amount of produce of second crops removed per annum over the 20 years. See also Note (15).
(15) In 1897, as in '79, '82, '88, '90, '91, '92, '94, and '96, the second crops being got up in bad condition, the produce of hay per acre was corrected by adding one-fourth to the determined amount of dry substance. This corresponds to an uniform amount of 20 per cent. of moisture in the second crops of hay. (16) On these plots the crop was too small to weigh or remove.

PLAN OF THE PLOTS IN HOOS FIELD, ON WHICH BARLEY HAS BEEN GROWN

for 47 years in succession, 1852 to 1898 inclusive.

[For brief summary of results and conclusions, see opposite page.]



Total area of ploughed land about $5\frac{1}{2}$ acres.

Area of Plots.
- 1, 2, 3, and 4, of Series O, Series A, and Series C, each $\frac{3}{11}$ acre.
- 1, 2, 3, and 4, of Series AA, and Series AAS, each $\frac{1}{11}$ acre.
- 1 N, 2 N, 5 O, and 5 A, each $\frac{1}{11}$ acre.
- 6–1 and 6–2, each about $\frac{1}{8}$ acre (0·137 acre).
- 7–1 and 7–2, each about $\frac{1}{9}$ acre (0·118 acre).

The double lines indicate division paths between plot and plot.

[For details of the manuring and produce, see pp. 26 and 27.]

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RESULTS OF EXPERIMENTS MADE IN HOOS FIELD ON THE GROWTH OF

BARLEY,

for 47 years in succession on the same land—without manure, with Farmyard manure, and with various artificial manures.

The results show, that on the growth of Barley year after year on ordinary arable land, the produce by mineral manures alone is higher than that without manure; that nitrogenous manures alone give more produce than mineral manures alone; and that mixtures of both mineral and nitrogenous manures give much more than either used alone—indeed, generally twice, or more than twice, as much as mineral manures alone. Of mineral constituents, whether used alone or in mixture with nitrogenous manures, phosphates were much more effective than mixtures of salts of potash, soda, and magnesia. The averages show that, under all conditions of manuring (excepting with farmyard manure), the produce was less over the later than over the earlier periods of the experiments—a result partly due to the seasons. But the average produce for 40 years of continuous growth of Barley was, in all cases where nitrogenous and mineral manures (containing phosphates) were used together, much higher than the average produce of the crop grown in ordinary rotation in the United Kingdom; and very much higher than the average in most other countries when so grown.

Barley is appropriately sown in a lighter soil than Wheat; and whilst Wheat is usually sown in the autumn, Barley is as a rule sown in the spring; and hence it relies in a much greater degree on the stores of the *surface* soil. Accordingly, it is more susceptible to exhaustion of the surface-soil in nitrogenous, and especially in mineral supplies; and hence, in the common practice of agriculture, it more generally requires the direct application of mineral manures, especially phosphatic manures, than does Wheat when grown under equal soil conditions. The exhaustion induced by both crops is, however, characteristically that of available nitrogen; and when, under the ordinary conditions of manuring and cropping, artificial manure is still required, nitrogenous manures are as a rule requisite for both crops; and for the spring sown Barley more generally than for Wheat, phosphatic manures also. It is not recommended that Barley should in practice be grown year after year on the same land by artificial manures as in these experiments; but, in addition to the lighter soils on which it is more appropriately grown in ordinary rotation, it may be grown, both in full quantity per acre and of good quality, after Wheat, or other grain crop, on the heavier soils, when the land is clean enough for a second cereal crop.

For details of the manuring and produce of the different plots, see pages 26 and 27.

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EXPERIMENTS ON THE GROWTH OF **BARLEY** YEAR AFTER YEAR ON THE

Previous Cropping—1847, Swedish Turnips, with Dung and Superphosphate of Lime, the Roots carted off; 1848, Barley (with clover); 1849, Clover; 1850, Wheat; 1851, Barley manured with Amm.-salts. First Experimental Barley Crop in 1852. Barley every year since. The crop of the present year, 1898, is, therefore, the 47th Barley crop in succession. Unless stated to the contrary in the Table, or in the foot-notes, the same Manure has been applied year after year to the same Plot. Description of

(Area under experiment,

1 acre	= (about)	0·404 Hectare	or	1·585 Prussian Morgen.
1 bushel	= (about)	0·364 Hectolitre	or	0·662 Prussian Scheffel.
1 lb. (pound avoir.)	= (about)	0·453 Kilogramme	or	0·907 Zollverein Pfund.
1 cwt. (hundredweight)	= (about)	50·8 Kilogrammes	or	1·016 Centner.
1 bushel per acre	= (about)	0·9 Hectolitre per Hectare	or	0·418 Pr. Scheffel per Pr. Morgen.
1 lb. per acre	= (about)	1·12 Kilogramme per Hectare	or	0·572 Zollv. Pfd. per Pr. Morgen.
1 cwt. per acre	= (about)	125·6 Kilogrammes per Hectare	or	0·641 Centner per Pr. Morgen.

PLOTS.	Manures, per acre, per annum. [In 1898, 400 lbs. Basic Slag was used throughout instead of Superphosphate.]
1 O.	Unmanured continuously
2 O.	3½ cwts. Superphosphate of Lime (1)
3 O.	200 lbs. (2) Sulphate Potash, 100 lbs. (3) Sulphate Soda, 100 lbs. Sulphate Magnesia
4 O.	200 lbs. (2) Sulphate Potash, 100 lbs. (3) Sulphate Soda, 100 lbs. Sulphate Magnesia, 3½ cwts. Superphosphate
1 A.	200 lbs. Ammonium-salts (4)
2 A.	200 lbs. Ammonium-salts, and 3½ cwts. Superphosphate
3 A.	200 lbs. Ammonium-salts, 200 lbs. (2) Sulph. Potash, 100 lbs. (3) Sulph. Soda, 100 lbs. Sulph. Magnesia
4 A.	200 lbs. Ammonium-salts, 200 lbs. (2) Sulph. Potash, 100 lbs. (3) Sulph. Soda, 100 lbs. Sulph. Magnesia, 3½ cwts. Superphosphate
(5) 1 AA.	275 lbs. Nitrate Soda
(5) 2 AA.	275 lbs. Nitrate Soda, and 3½ cwts. Superphosphate
(5) 3 AA.	275 lbs. Nitrate Soda, 200 lbs. (2) Sulph. Potash, 100 lbs. (3) Sulph. Soda, 100 lbs. Sulph. Magnesia
(5) 4 AA.	275 lbs. Nitrate Soda, 200 lbs. (2) Sulph. Potash, 100 lbs. (3) Sulph. Soda, 100 lbs. Sulph. Magnesia, 3½ cwts. Superphosphate
(6) 1 AAS.	275 lbs. Nitrate Soda, 400 lbs. Silicate Soda (6)
(6) 2 AAS.	275 lbs. Nitrate Soda, 400 lbs. Silicate Soda, and 3½ cwts Superphosphate (1)
(6) 3 AAS.	275 lbs. Nitrate Soda, 400 lbs. Silicate Soda, 200 lbs. (2) Sulph. Potash, 100 lbs. (3) Sulph. Soda, 100 lbs. Sulph. Magnesia
(6) 4 AAS.	275 lbs. Nitrate Soda, 400 lbs. Silicate Soda, 200 lbs. (2) Sulph. Potash, 100 lbs. (3) Sulph. Soda, 100 lbs. Sulph. Magnesia, and 3½ cwts. Superphosphate
(7) 1 C.	1000 lbs. Rape-cake
(7) 2 C.	1000 lbs. Rape-cake, and 3½ cwts. Superphosphate
(7) 3 C.	1000 lbs. Rape-cake, 200 lbs. (2) Sulph. Potash, 100 lbs. (3) Sulph. Soda, 100 lbs. Sulph. Magnesia
(7) 4 C.	1000 lbs. Rape-cake, 200 lbs. (2) Sulph. Potash, 100 lbs. (3) Sulph. Soda, 100 lbs. Sulph. Magnesia, 3½ cwts. Superphosphate
(8) 1 N.	275 lbs. Nitrate Soda
(8) 2 N.	275 lbs. (9) Nitrate Soda
5 O.	200 lbs. (2) Sulphate Potash, 3½ cwts. Superphosphate (10)
5 A.	200 lbs. (2) Sulphate Potash, 3½ cwts. Superphosphate, and 200 lbs. (11) Ammonium-salts
M.	100 lbs. Sulphate Soda, 100 lbs. Sulphate Magnesia, and 3½ cwts. Superphosphate
6 1	Unmanured continuously
6 2	Ashes (burnt soil and turf)
7 1	Farmyard Manure 14 tons, 20 yrs., 1852–71; unmanured since
7 2	Farmyard Manure 14 tons, every year

(1) "Superphosphate of Lime," 1852 to 1887 inclusive, made from 200 lbs. Bone-ash, 150 lbs. Sulphuric acid, sp. gr. 1·7 (and water); 1888, and since, made from high percentage mineral phosphates, and containing 37 per cent., or more, of soluble phosphate.

(2) 300 lbs. per annum for the first six years, 1852–7.

(3) 200 lbs. per annum for the first six years, 1852–7.

(4) The "Ammonium-salts"—in all cases (excepting in 1887), equal parts Sulphate and Muriate of Ammonia of Commerce. In 1887 Sulphate Ammonia only, 225 lbs. per acre, equal in Nitrogen to the "Ammonium-salts" of previous years.

(5) First 6 years, 1852–7, instead of Nitrate of Soda, 400 lbs. Ammonium-salts per annum; next 10 years, 1858–67, 200 lbs. Ammonium-salts per annum; 1868, and since, 275 lbs. Nitrate of Soda per annum. 275 lbs. Nitrate of Soda is reckoned to contain the same amount of Nitrogen as 200 lbs. "Ammonium-salts."

(6) The application of Silicates did not commence until 1864; in 1864-5-6 and 7, 200 lbs. Silicate of Soda and 200 lbs.

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FIELD.

SAME LAND, WITHOUT MANURE, AND WITH DIFFERENT DESCRIPTIONS OF MANURE.

Barley—29 years, 1852–1880, Chevalier; 10 years, 1881–1890, Archer's Stiff Straw; 7 years, 1891–1897, Carter's Paris Prize; 1898, Archer's Stiff Straw. In the spring of 1894 permanent division paths were laid out between plot and plot. Below is given, besides the usual averages, the produce for both 1896 and 1897.

For Plan of the Plots, and brief summary of results and conclusions, see pp. 24–25.

about 4¼ acres.)

Plots.	Produce per Acre.															Plots.
	Dressed Grain.									Total Straw.						
	Quantity.					Weight per Bushel.										
	Averages.			45th Year, 1896.	46th Year, 1897.	Averages.			45th Year, 1896.	46th Year, 1897.	Averages.			45th Year, 1896.	46th Year, 1897.	
	22 Yrs. 1852–73.	22 Yrs. 1874–95.	44 Yrs. 1852–95.			22 Yrs. 1852–73.	22 Yrs. 1874–95.	44 Yrs. 1852–95.			22 Yrs. 1852–73.	22 Yrs. 1874–95.	44 Yrs. 1852–95.			
	Bush.	Bush.	Bush.	Bush.	Bush.	lbs.	lbs.	lbs.	lbs.	lbs.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	
1 O.	19¼	13	16⅛	11¾	5	52⅜	52	52⅛	54	48	11¼	7	9⅛	8	5⅛	1 O.
2 O.	24⅞	17½	21¼	13⅞	6¼	53¼	53¼	53¼	54	50¼	12⅜	8½	10⅜	8¼	5⅝	2 O.
3 O.	21½	13⅛	17⅜	11	3	53⅛	52⅝	52⅝	54¼	49⅝	11¾	7⅛	9⅜	7½	4	3 O.
4 O.	26½	17	21¾	14¼	5¼	53½	52⅞	53⅛	54⅛	50¼	13⅞	8½	11¼	8⅝	5½	4 O.
1 A.	32¼	23⅞	28	14¼	12	52¾	52⅛	52⅛	53⅜	47	18¼	12⅞	15½	10⅛	11⅞	1 A.
2 A.	46⅞	37	42	20¼	16	53½	52¼	52⅞	50⅜	47⅜	27¼	19⅜	23⅜	14⅜	15⅜	2 A.
3 A.	34⅜	26⅜	30¾	21	17½	52⅞	52⅜	52¾	54	49½	20⅜	14⅞	17⅝	14¼	14⅜	3 A.
4 A.	45⅞	41	43½	41¼	30½	54	54¼	54⅛	54¾	51⅜	28¼	23⅛	25⅝	21⅛	21¾	4 A.
1 AA.	36½	27¼	31⅞	21¼	17⅛	52⅛	52¼	52⅛	52⅝	49⅛	21⅝	15⅜	18½	17⅜	14¼	1 AA.
2 AA.	48¾	42	45⅜	37⅜	32¾	53⅜	53½	53⅜	54⅜	51⅛	30	23⅜	26⅝	20⅞	24¼	2 AA.
3 AA.	36⅞	28½	32¾	25¼	21¼	52½	52⅞	52⅝	53¾	51⅛	23⅜	17⅜	20¼	18⅝	18⅝	3 AA.
4 AA.	48¾	41¼	45	35	30¼	53½	54⅛	53¾	54⅝	51⅝	31¾	24⅝	28⅛	22⅛	23½	4 AA.
1 AAS.	37½	33¾	34⅞	33	24⅝	54¼	53½	53⅞	53⅝	51¼	21⅝	19⅛	19⅞	20⅞	21⅛	1 AAS.
2 AAS.	47½	44¼	45¾	39	31¼	55½	54	54½	55⅛	51¾	28¾	25¼	26¼	22⅜	27½	2 AAS.
3 AAS.	42	36¼	(12) 38	36	24⅛	54⅞	54	(12) 54¼	54¾	52⅛	25	20⅞	(12) 22¼	22⅝	19⅞	3 AAS.
4 AAS.	48⅞	45	46¼	41⅛	30	55⅜	54¾	54⅞	55½	52⅜	30¾	27¾	28⅝	23⅛	22⅝	4 AAS.
1 C.	44⅝	36½	40⅝	36⅜	26⅛	53¾	54⅛	53⅞	55⅛	51½	26¼	20	23⅛	19½	18¼	1 C.
2 C.	46¼	39⅞	42⅝	40¼	31½	53⅞	54½	54⅛	55½	52⅛	27¾	21½	24⅝	20⅛	20¼	2 C.
2 C.	43	35¼	39	32¾	25¾	53¾	54¼	54	54¼	51⅜	26⅜	20	23⅛	18⅜	16⅝	3 C.
4 C.	46¾	38½	42½	37¼	29⅜	53⅝	54⅜	54	56	52	28⅞	21⅞	25⅜	20⅛	19½	4 C.
1 N.	37⅜	30⅝	(13) 34	30¾	15⅜	52¾	52⅞	(13) 52¾	55⅜	49¾	22¾	17¼	(13) 19⅞	18¾	17¾	1 N.
2 N.	41⅛	35	38	36½	23½	52¾	53¼	53	56⅛	50¾	25⅝	20⅛	22⅞	22¼	20¾	2 N.
5 O.	22	14¾	(13) 18¼	13⅝	5⅜	53½	53¼	(13) 53⅜	55⅛	49⅛	11⅞	8¼	(13) 10	9⅞	6	5 O.
5 A.	43¾	33¾	38¾	31⅜	17⅜	53⅞	53¾	53⅞	56⅝	52¼	27⅝	20⅝	24⅛	18⅜	15	5 A.
M.	20	18½	(14) 19¼	(15)	(15)	53½	53¼	(14) 53⅜	(15)	(15)	11¾	9⅞	(14) 10¾	(15)	(15)	M.
6 1	21¼	14½	17⅞	12⅝	2¾	52½	52½	52½	53¾	49⅞	11⅞	7¾	9⅞	8⅞	5⅜	1 6
6 2	21⅜	15¾	18½	13⅜	4¾	52¾	52½	52⅜	54⅛	49⅞	11¾	8	9⅞	8⅞	5½	2 6
7 1	47¾	28⅛	38	22½	12⅞	54¼	54	54⅛	55⅛	51¾	27¾	15¾	21⅜	14⅜	11	1 7
7 2	48⅛	49¼	48¾	53⅞	42	54¼	54⅜	54⅜	54¾	53¾	28¼	30½	29⅜	27⅞	29⅝	2 7

Silicate of Lime were applied per acre, but in 1868, and since, 400 lbs. Silicate of Soda, and no Silicate of Lime. These plots ("AAS") comprise, respectively, one half of the original "AA" plots, and, excepting the addition of the Silicates, have been, and are, in other respects, manured in the same way as the "AA" plots.

(7) 2000 lbs. Rape-cake per annum for the first six years, and 1000 lbs. only, each year since.

(8) 300 lbs. Sulphate of Potash, and 3½ cwts. Superphosphate of Lime, without Nitrate of Soda, the first year (1852); Nitrate alone each year since.

(9) 550 lbs. Nitrate of Soda for 1853-4-5-6, and 7; and 275 lbs. only, each year since.

(10) Ammonium-salts also the first year, but not since.

(11) By mistake 400 lbs. in 1880.

(12) Averages of 10, 22, and 32 years, 1864–95.

(13) Averages of 21, 22, and 43 years, 1853–95.

(14) Averages of 16, 18, and 34 years, 1858–78, and 1880–92. The produce of 1879 was not weighed, owing to the foulness of the plot, from the wet season.

(15) Not recorded.

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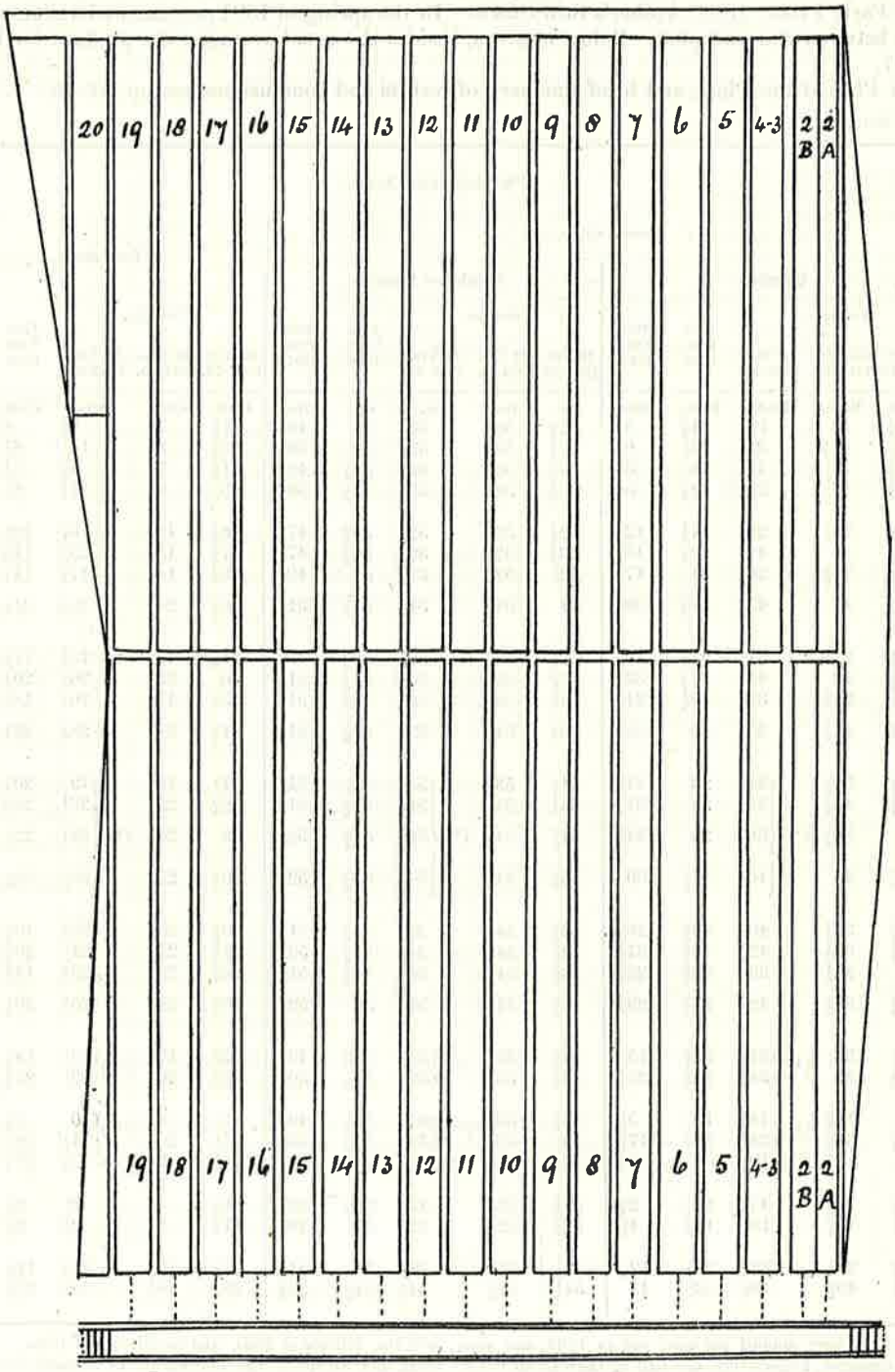
PLAN OF THE PLOTS IN BROADBALK FIELD, ON WHICH WHEAT HAS BEEN GROWN

for 55 years in succession, 1843–4 to 1897–8 inclusive.

[For brief summary of results and conclusions, see opposite page.]



Brick Trench for collecting the Pipe Drainage from each Plot.

Total area of ploughed land about 11 acres.

Area of Plots 3–4, 5, 6, 7, 8, 9, 10, 11 12, 13, 14, 15, 16, 17, 18, and 19, each $\frac{1}{2}$ acre.
Area of Lands A and B of Plot 2, each $\frac{3}{10}$ acre.
Area of Plot 20, about $\frac{1}{6}$ acre.

The double lines indicate division paths between plot and plot; also a path across the centre of each plot.

[For details of the manuring and produce, see pp. 30 and 31.]

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RESULTS OF EXPERIMENTS IN BROADBALK FIELD ON THE GROWTH OF WHEAT,

for 55 years in succession on the same land—without manure, with Farmyard manure, and with various artificial manures. During the first 8 years, 1844–1851, various mineral and nitrogenous manures were applied, but not as a rule the same from year to year on the same plot. But from 1851–2 to the present time, the same manures have, with few exceptions, been applied year after year on the same plots.

The results show that, unlike Leguminous crops such as Beans or Clover, Wheat may be successfully grown for many years in succession on ordinary arable land, provided suitable manures be applied, and the land be kept clean. Even without manure, the average produce over 44 years, 1852–1895, was nearly 13 bushels per acre; or more than the average of the whole of the United States of America, including their rich Prairie lands; in fact, about the average yield per acre of the Wheat lands of the whole world. Mineral manures alone gave very little increase; nitrogenous manures alone gave considerably more than mineral manures alone; but the mixture of the two gave very much more than either separately. Indeed, in one case the average produce by mixed mineral and nitrogenous manure was more than that by the annual application of Farmyard manure; and in 8 out of the 11 cases in which such mixtures were used, the average yield per acre was from 2 to 8 bushels more than the average yield of the United Kingdom (which is rather less than 28 bushels), under ordinary rotation.

It is estimated that the reduction in yield of the unmanured plot over the 40 years, 1852–91, after the growth of the crops without manure during the 8 preceding years, was, provided it had been uniform throughout, equivalent to a decline of one-sixth of a bushel from year to year due to exhaustion; that is irrespectively of fluctuations due to season.

For details of the manuring and produce of the different plots, see pages 30–31.

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EXPERIMENTS ON THE GROWTH OF WHEAT YEAR AFTER YEAR ON THE

Previous Cropping—1839, Turnips, with Farmyard Manure; 1840, Barley; 1841, Peas; 1842, Wheat; 1843, Oats; the last four Crops Unmanured.

First Experimental Wheat Crop in 1844. Wheat every year since; and, with some exceptions, nearly the same description of Manure on the same Plots each year—especially during the last 47 years (1852 and since). The Crop of the present year, 1898, is, therefore, the 55th Wheat Crop in succession. From the commencement of the experiments in 1843–4 up to 1876–7 inclusive, the mineral manures, the ammonium-salts, and rape-cake, &c., if any, were sown in the autumn, before the seed; excepting in 1845 and 1853, when, owing to the preceding wet autumn and winter, both seed and manures were spring sown; and for the crops of 1873, 4, 5, 6, and 7, the ammonium-salts applied to Plot 15 were top-dressed in the spring. Nitrate of soda has, however, always been sown in the spring. But, in consequence of the ascertained great loss of the nitrogen of the manures by drainage, especially in wet winters, it was decided to apply only the mineral manures (and Farmyard-manure) in the autumn, and the ammonium-salts, as well as the nitrate, in the spring; excepting on Plot 15, where, for comparison, the ammonium-salts are sown in the autumn. This plan was adopted for the crops of 1878, 1879, 1880, 1881, 1882, and 1883; but for the crop of 1884 and since, each ammonium-plot (except 15) has received 100 lbs. of ammonium-salts in the autumn with the mineral manures, and the balance of their ammonium-salts as a top-dressing in the spring: Plot 15, as already stated, receiving the whole of its ammonium-salts in the autumn.

The description of seed sown was:—for the first 5 years, 1843–4 to 1847–8, "Old Red Lammas"; for the next 4 years, 1848–9 to 1851–2, "Red Cluster"; for the next 29 years, 1852–3 to 1880–1, "Red Rostock"; and for 1881–2, and since, "Club" or "Square Head" (Red).

Notwithstanding very much labour annually bestowed on hand-hoeing, the land had, partly owing to the characters of the seasons, become very foul, *Alopecurus agrestis* (slender fox-tail) being the most prominent and troublesome weed. For the crop of 1889, therefore, down one half the length of the plots (the top), only alternate rows of wheat were sown, in order, as far as possible, to eradicate this and some other plants; the other half (the bottom) being sown in the usual way. For the crop of 1890, on the other hand, the full number of rows was sown on the top half, and only alternate rows on the bottom half of each plot, in order the better to clean that portion. For the crops of 1891 and since, however, the full number of rows have again been sown over the whole length of each plot.

(Area under experiment.

1 acre .. .. .. = (about)	0·404 Hectare .. .. or 1·585 Prussian Morgen.
1 bushel .. .. = (about)	0·364 Hectolitre .. .. .. or 0·662 Prussian Scheffel.
1 lb. (pound avoir.) = (about)	0·453 Kilogramme .. .. .. or 0·907 Zollverein Pfund.
1 cwt. (hundredweight) = (about)	50·8 Kilogrammes .. .. .. or 1·016 Centner.
1 bushel per acre .. = (about)	0·9 Hectolitre per Hectare .. or 0·418 Pr. Scheffel per Pr. Morgen.
1 lb. per acre .. = (about)	1·12 Kilogramme per Hectare or 0·572 Zollv. Pfd. per Pr. Morgen.
1 cwt. per acre .. = (about)	125·6 Kilogrammes per Hectare or 0·641 Centner per Pr. Morgen.

PLOTS.	Manures, per acre, per annum.
2 { Land 1	Farmyard Manure 14 tons (commencing '84–5) (10) .. ..
2 { Land 2	Farmyard Manure 14 tons (1843–4 and every year since) .. ..
3	Unmanured continuously .. ..
4	Unmanured for Crop of 1852, and since; previously Superphosphate (made with Muriatic Acid), and Sulph. Amm.
5 (*a* and *b*)	200 lbs. (1) Sulphate Potash, 100 lbs. (2) Sulph. Soda, 100 lbs. Sulphate Magnesia, 3½ cwts. Superphosphate (3) ..
6 (*a* and *b*)	200 lbs. (1) Sulph. Potash, 100 lbs. (2) Sulph. Soda, 100 lbs. Sulph. Mag., 3½ cwts. Superphos., 200 lbs. Amm.-salts (4)
7 (*a* and *b*)	200 lbs. (1) Sulphate Potash, 100 lbs. (2) Sulph. Soda, 100 lbs. Sulph. Mag., 3½ cwts. Superphos., 400 lbs. Amm.-salts
8 (*a* and *b*)	200 lbs. (1) Sulphate Potash, 100 lbs. (2) Sulph. Soda, 100 lbs. Sulph. Mag., 3½ cwts. Superphos., 600 lbs. Amm.-salts
9 { *a*	200 lbs. (1) Sulph. Potash, 100 lbs. (2) Sulph. Soda, 100 lbs. Sulph. Mag., 3½ cwts. Superphos., 275 lbs. Nitrate Soda (5)
9 { *b*	275 lbs. Nitrate of Soda (5). (For the Crops of 1894 and since, Plot 9*b* has received the same manures as Plot 9*a*.)
10 { *a*	400 lbs. Ammonium-salts alone, for 1845, and each year since; Mineral Manure in 1844 .. ..
10 { *b*	400 lbs. Ammonium-salts alone, for '45, and each year since (except '46 and '50); Mineral Manure '44, '48, '50 ..
11 (*a* and *b*)	400 lbs. Ammonium-salts, 3½ cwts. Superphosphate .. ..
12 (*a* and *b*)	400 lbs. Ammonium salts, 3½ cwts. Superphosphate, and 366½ lbs. (6) Sulphate of Soda .. ..
13 (*a* and *b*)	400 lbs. Ammonium-salts, 3½ cwts. Superphosphate, and 200 lbs. (6) Sulphate of Potash .. ..
14 (*a* and *b*)	400 lbs. Ammonium-salts, 3½ cwts. Superphosphate, and 280 lbs. (6) Sulphate of Magnesia .. ..
15 { *a*	200 lbs. (1) Sul. Pot., 100 lbs. (2) Sul. Sod., 100 lbs. Sul. Mag., 3½ cwts. Super. (7); 400 lbs. Amm.-salts, in Autm. (8)
15 { *b*	200 lbs. (1) Sul. Pot., 100 lbs. (2) Sul. Sod., 100 lbs. Sul. Mag., 3½ cwts. Super. (7); 400 lbs. Amm.-salts, in Autm. (9)
16 (*a* and *b*)	1852–64, 13 years, 200 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag., 3½ cwts. Superphos., and 800 lbs. Ammonium-salts; average produce 39½ bush. Grain, 46⅝ cwts. Straw .. .. 1865–1883, 19 years unmanured; average produce (19 years, 1865–83) 14⅝ bushels Grain, 12½ cwts. Straw .. 1884 and since, 200 lbs. Sul. Potash, 100 lbs. Sul. Soda, 100 lbs. Sul. Mag., 3½ cwts. Super., 550 lbs. Nitrate Soda
11) { 17 (*a* and *b*)	400 lbs. Ammonium-salts .. ..
11) { 18 (*a* and *b*)	200 lbs. (1) Sulphate Potash, 100 lbs. (2) Sulphate Soda, 100 lbs. Sulphate Mag., and 3½ cwts. Superphosphate ..
19	1878-9 to '81–2, 1700 lbs., '83 and since 1889 lbs. Rape-cake, in Autumn. Previously, '52-78, 3½ cwts. Superph. Lime (12), 300 lbs. Sul. Am., and 500 lbs. Rape-cake; av. prod. (27 yrs., '52–78) 29¼ bush. Grain, 27⅛ cwts. straw
(13)20	Unmanured continuously .. ..
21	Mixed Mineral Manures as Plot 5, and 100 lbs. Mur. Amm. 1852–'83—then discontinued .. ..
22	Mixed Mineral Manures as Plot 5, and 100 lbs. Sulp. Amm. 1852–'83—then discontinued .. ..

(1) 300 lbs. per annum for Crop of 1858, and previously. (2) 200 lbs. per annum for Crop of 1858, and previously.

(3) "Superphosphate of Lime," up to 1887–8 inclusive, made from 200 lbs. Bone-ash, 150 lbs. Sulphuric acid sp. gr. 1·7 (and water); 1888–9, and since, made from high percentage mineral phosphates, and containing 37 per cent., or more, of soluble phosphate.

(4) The "Ammonium-salts," in all cases (excepting for the crop of 1887), equal parts Sulphate and Muriate of Ammonia of Commerce. For the season 1886–7 the same quantity of Nitrogen was applied, but mostly as Sulphate Ammonia.

(5) 9*a*, 475 lbs. Nitrate Soda in 1852, 275 lbs. in 1853 and 1854, 550 lbs. each year from 1855 to 1884. No Sulphate of Potash, Soda, or Magnesia, or Superphosphate, in 1852, 1853, or 1854. 9*b*, 475 lbs. Nitrate in 1852, 550 lbs. each year from 1853 to 1884. 550 lbs. Nitrate is reckoned to contain the same amount of Nitrogen as 400 lbs. "Ammonium-salts."

(6) For 1858, and previously—1¼ time as much. (7) For 1872 and previously, made with Muriatic instead of Sulphuric Acid.

(8) For 1872 and previously, 400 lbs. Sulphate Ammonia, sown in the Autumn; for 1873–4–5–6 and 7, 400 lbs. Ammonium-salts, sown in the Spring; for 1878 and since, 400 lbs. Ammonium-salts, sown in the Autumn.

(9) For 1872 and previously, 300 lbs. Sulphate Ammonia and 500 lbs. Rape-cake, sown in the Autumn; for 1873–4–5–6 and 7, 400 lbs. Ammonium-salts, sown in the Spring; for 1878 and since, 400 lbs. Ammonium-salts, sown in the Autumn.

(10) From 1849 to 1883 one half of this land was unmanured, and the other half received Sulphates of Potash, Soda, and Magnesia; in 1884 the one half was wheat, and the other half fallow.

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FIELD.

SAME LAND; WITHOUT MANURE, AND WITH DIFFERENT DESCRIPTIONS OF MANURE.

The amount of produce recorded in 1890 for 1889, was that obtained on the full sown, lower, or worst yielding half of the plots, and was doubtless somewhat too low. That recorded in 1891 for 1890, was that obtained on the full sown, upper, and better yielding half of the plots, which had also been thin sown, and hoed almost up to harvest, in fact, partially fallowed, the year before, and hence, although the season was undoubtedly a high yielding one, there can be no doubt that the produce as recorded was decidedly too high; and, on careful consideration of the results, the mean of the produce of the thick and thin sown portions of the plots has been adopted for the crop of 1890. Lastly, the produce for 1891, being that of the whole of each of the plots, half of which had been thin sown, that is, partially fallowed in 1890, and the other half in 1889, was again doubtless somewhat too high. Thus, the produce adopted for 1889 was undoubtedly somewhat too low; that for 1890 probably very near the truth; and that for 1891 somewhat too high. The average produce for the three years together is, however, probably very near the truth; and the averages since taken for the second 20, and for the 40 years, to 1891 inclusive, as given in the *Memoranda* for 1893, those given for the second 21, and for the 42 years, to 1893 inclusive, as given in the *Memoranda* for 1895 and 1896, and those now given for the second 22, and for the 44 years, in the Table below, are quite immaterially vitiated by the unavoidable irregularities above referred to.

After the crop of the 50th year (1893) was taken off, the two lands "*a*" and "*b*" were thrown together, and permanent division paths made between plot and plot. In a few cases in 1894, 1895, 1896, and 1897, however, the crops on the two halves (*a* and *b*) were kept separate at harvest, and the amount of produce grown on each recorded. Below is given, besides the usual averages, the produce for both 1896 and 1897.

A plan of the plots as now arranged is given on p. 28, and a brief summary of the results on p. 29. It should be explained that for many years there were, besides the plots indicated on the plan, the manuring and produce of which are recorded in the Table below, two others, namely, Plots 0 and 1, which were under experiment up to 1883 inclusive, and the manuring and produce of which have been recorded in the *Memoranda* up to 1895, but have since been excluded from the plan and from the annual record. For the manuring and produce of these plots see previous issues of the *Memoranda*; also the Appendix Tables in No. 66 (Series 1) in the list of papers at p. 13.

about 11 acres.)

PRODUCE PER ACRE.

PLOTS.	Dressed Grain. Quantity. Averages. 22 Yrs., 1852–73.	22 Yrs., 1874–95.	44 Yrs., 1852–95.	53rd Year, 1896.	54th Year, 1897.	Dressed Grain. Weight per Bushel. Averages. 22 Yrs., 1852–73.	22 Yrs., 1874–95.	44 Yrs., 1852–95.	53rd Year, 1896.	54th Year, 1897.	Total Straw. Averages. 22 Yrs., 1852–73.	22 Yrs., 1874–95.	44 Yrs., 1852–95.	53rd Year, 1896.	54th Year, 1897.	PLOTS.
	Bush.	Bush.	Bush.	Bush.	Bush.	lbs.	lbs.	lbs.	lbs.	lbs.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	
2 {1	..	..	..	40	32	..	..	..	63¾	61⅜	..	..	..	40⅝	29½	2 {1
2 {2	35¼	34⅞	35	44	37¼	60	60⅞	60⅜	64	61⅝	33⅜	32	32¾	44¼	34⅛	2 {2
3	14¼	11½	12⅞	16¾	8⅛	57⅝	59¼	58½	61⅜	60¼	12⅝	8½	10½	11¾	7¾	3
4	15½	11½	13½	16¼	9¾	58¼	59⅛	58¾	61⅝	59¼	13⅜	8¼	10⅞	11⅞	8⅜	4
5	16½	13¾	15	20¼	12⅞	58⅜	59½	59⅛	61½	59¼	14⅝	9¾	12¼	15	10⅜	5
6	25¾	22¾	24¼	29⅞	19⅜	59⅛	60⅛	60	62¼	60⅞	24	19⅜	21⅝	17	6	
7	34½	31¾	33⅛	37¼	28⅝	59¼	60⅝	60	63⅞	61¼	34½	31⅝	33	33⅜	28¼	7
8	37¾	35½	36⅝	44⅛	37·	59	60½	59¾	64¼	61¾	40⅝	39⅜	40⅛	45⅛	39	8
9 {a	37	32½	34¾	32½	25¾	58⅜	60¼	59¼	62	60¾	42	34¾	38⅜	28⅝	26	9 {a
9 {b	25¾	19½	22⅝	33¼	23¾	56½	57⅜	57	62¼	60½	28	17⅞	22⅞	28⅜	23⅜	9 {b
10 {a	22¼	17	19½	21¾	17½	57	57⅝	57⅜	62¼	58⅜	21⅜	14	17⅝	18½	15⅞	10 {a
10 {b	25¼	18⅜	21¾	22⅞	16½	57¾	57¾	57¾	62⅛	58¼	24⅛	15⅝	19⅞	19⅛	16¾	10 {b
11	27⅝	21¾	24⅜	24	16	57⅜	58⅛	57¾	62⅛	57⅝	26	20⅜	23¼	22⅞	18⅛	11
12	33⅛	27½	30¼	34	21⅞	59⅛	59½	59¼	62¾	59	31¾	25⅜	28½	29⅝	21⅜	12
13	33¼	30	31⅝	34	27¾	59⅝	60¾	60¼	63½	60¾	33¼	29½	31⅜	30⅛	27¼	13
14	33¼	28½	30⅞	29⅜	19½	59¼	59½	59⅜	63	59¼	32¼	26⅝	29⅜	25⅝	20⅛	14
15 {a	32¾	28¾	31	30¾	20½	59⅝	60½	60	62¼	60⅝	32⅜	26¾	30	26⅝	19¼	15 {a
15 {b	33⅞					59⅝					33¾					15 {b
16	30⅝	24¾	27¾	37¾	27½	58⅞	59½	59⅛	63⅜	60½	33⅞	24¾	29⅜	35¼	32⅞	16
17	30⅞	29¾	(14)30¼	35¾	11 (16)	59½	60½	(14) 60	63¾	59⅝(16)	30⅜	27¼	(14) 28⅞	31⅜	10⅛ (16)	17
18	17¼	13½	(15)15¼	17	30½(17)	58⅞	59⅜	(15) 59⅛	61¼	61⅝(17)	15¾	11	(15) 13⅝	13¼	29¼(17)	18
19	30⅛	26⅛	28⅛	36	22	58⅝	59⅜	59	61½	60½	28⅝	23	25¾	32¼	21	19
20(13)	14¼	13⅛	(18) 13⅓	14	8	57¾	58¾	(18)58¼	61¼	61⅛	13⅝	10	(18)11½	9¾	8	20 (13)
21	21¼	16⅞	(19)19	..	..	58⅜	58¾	(19) 58⅝	..	..	19¾	13⅞	(19) 16⅞	..	..	21
22	21	17¾	(19)19⅜	..	..	58¼	58⅜	(19) 58⅜	..	..	19½	14⅝	(19) 17⅛	..	..	22

(11) The Manures of Plots 17 and 18 are, year by year, transposed.
(12) Made with Muriatic instead of Sulphuric Acid.
(13) After the Crop of 1893 had been removed, this plot was joined to Plot 19, and a new Plot 20 was made from land adjoining, which had been unmanured for many years; growing wheat up to 1883 inclusive; and again in 1887 and 1891; Potatoes, 1889; and left fallow 1884, '5, '6, '8, '90, '92 and '93.
(14) Averages of Ammonium-salts, alternated with Mineral Manures.
(15) Averages of Mineral Manures, alternated with Ammonium-salts.
(16) Plot 17 had the Mineral Manure for the Crop of 1897.
(17) Plot 18 had the Ammonium-salts for the Crop of 1897.
(18) Averages of 21, 22, and 43 years only; as, in 1868, owing to a mistake in carting, the produce could not be ascertained.
The Plots marked "(*a* and *b*)" were, up to 1893 inclusive, divided into duplicate portions, "*a*" and "*b*," respectively, and were manured alike; excepting that, for the crops of 1864-5-6 and 7, the "*a*" portions of Plots 5, 6, 7, 8, 9, 16, and 17 (or 18), received a mixture of soluble Silicates in addition to the other Manures, but, hitherto, without any material effect; and for the crops of 1868 to 1879 inclusive, cut straw (that produced in the previous season) was applied (instead of Silicates) on the "*a*" portions of Plots 5, 6, 7, 8, 11, 12, 13, 14, and 17 (or 18); also for the crop of 1874, and each succeeding crop to 1879 inclusive, the straw of the previous season was cut up and applied to the "*a*" portion of Plot 15. For the crop of 1880 and since the return of the straw has been discontinued.
(19) Averages of 16, 16, and 32 years, 1852–83.

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EXPERIMENTS ON WHEAT ALTERNATED WITH FALLOW, AND WHEAT GROWN CONTINUOUSLY.

The results given in the following Table show the produce of Wheat obtained on the Rothamsted soil for many years in succession, after bare fallow, compared with that of wheat grown continuously year after year on the same land, without the intervention of fallow; in both cases without manure.

Hoos-field, in which the experiments on alternate wheat and fallow are conducted, adjoins *Broadbalk-field*, in which wheat has now been grown continuously without manure (also with different descriptions of manure), for 55 years in succession; and the produce of the unmanured plot of that field, is compared with that grown in alternation with fallow, also without manure, in Hoos-field.

The description of seed sown has been the same in the two fields in the corresponding years; namely—for the crop of 1852 "Red Cluster"; for 28 years, 1854 to 1881 inclusive, "Red Rostock"; and for 1882, and since, "Club" or "Square Head" (Red).

During the first or preliminary period of 5 years, 1851–1855, the cropping of the acre set apart for the experiment on wheat alternated with fallow was as follows:—1851, Fallow (after wheat in 1850); 1852, Wheat; 1853, Fallow; 1854, Wheat; 1855, half Fallow, and half Wheat. From that time to the present the respective halves have been alternately fallow and wheat, giving therefore a crop of wheat succeeding fallow, on half the acre each year.

In the upper division of the Table are given the results for each of the five years of the preliminary period; and in the main division are recorded the results for each individual year of the exact experiment, from 1856 up to the present time.

In the first column of each main vertical division of the Table is given the produce *per acre*, on the half acre of wheat after fallow; and in the second column the produce per acre obtained in the adjoining field (Broadbalk), where wheat is grown year after year on the same land. Lastly, in the third column of each of the vertical divisions is given the amount of produce after fallow, + or − that grown year after year on the same land.

The results for the individual years show that during the earlier years of the experiments on alternate wheat and fallow, when the accumulations due to previous treatment were less exhausted, the produce after fallow was more in excess of that grown in the adjoining field year after year on the same land than afterwards. Referring to the two sets of averages at the foot of the Table, it is seen that if (as in the upper of the two divisions), the produce after fallow is reckoned at the yield per acre of the half in crop each year, it gives on the average several bushels more grain, and also more straw, per acre per annum, than where the crop is grown continuously. On the other hand, if the produce after fallow is reckoned (as in the bottom division) at the yield per acre of the whole area, half in crop and half fallow, it gives several bushels less grain, and also less straw, per acre per annum, than where the crop is grown year after year on the same land.

The conclusion to be drawn is, that although there is an increase of produce after fallow compared with that of wheat grown continuously, it is obtained at the sacrifice of a crop every other year; and that *a given area of land* yields more when the crop is grown year after year than when alternated with fallow. The explanation doubtless is, that much of the nitrogen brought into an available condition under the influence of the fallow, is lost by drainage during the long period that the land is without a crop.

(Area under experiment, 1 acre.)

	Dressed Grain.			Weight per Bushel.		Total Grain.			Total Straw.			Total Produce (Grain and Straw).			
	Wheat after Fallow each year.	Wheat after Wheat each year.	After Fallow + or − after Wheat.	Wheat after Fallow each year.	Wheat after Wheat each year.	Wheat after Fallow each year.	Wheat after Wheat each year.	After Fallow + or − after Wheat.	Wheat after Fallow each year.	Wheat after Wheat each year.	After Fallow + or − after Wheat.	Wheat after Fallow each year.	Wheat after Wheat each year.	After Fallow + or − after Wheat.	
Preliminary Period.															
	Bushels.	Bushels.	Bushels.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	
1851	Fallow	15 7/8	−15 7/8	Fallow	61·1	Fallow	1083	−1083	Fallow	1627	−1627	Fallow	2710	−2710	1851
1852	37	13 3/4	+23 1/4	53·0	56·6	2088	860	+1228	4934	1597	+3337	7022	2457	+4565	1852
1853	Fallow	5 3/4	− 5 3/4	Fallow	45·9	Fallow	359	− 359	Fallow	1413	−1413	Fallow	1772	−1772	1853
1854	42	21	+21	60·5	60·6	2709	1359	+1350	4545	2137	+2408	7254	3496	+3758	1854
1855	17 3/8	17	+ 0 3/8	54·0	59·2	1080	1072	+ 8	1734	1787	− 53	2814	2859	− 45	1855
Period of Exact Comparison.															
1856	21 3/4	14 1/2	+ 7 1/4	60·0	54·3	1388	892	+ 496	2113	1558	+ 555	3501	2450	+1051	1856
1857	38	20	+18	58·4	58·3	2299	1236	+1063	3075	1577	+1498	5374	2813	+2561	1857
1858	25 3/4	18	+ 7 3/4	60·6	60·4	1630	1141	+ 489	2468	1670	+ 798	4098	2811	+1287	1858
1859	34	18 1/4	+15 3/4	55·0	52·5	1976	1051	+ 925	3686	2175	+1511	5662	3226	+2436	1859
1860	12 1/8	12 7/8	− 0 3/4	54·8	52·6	697	738	− 41	1226	1459	− 233	1923	2197	− 274	1860
1861	17 7/8	11 1/4	+ 6 3/8	58·8	57·4	1145	736	+ 409	2072	1254	+ 818	3217	1990	+1227	1861
1862	22 7/8	16	+ 6 7/8	57·1	57·8	1361	996	+ 365	2294	1713	+ 581	3655	2709	+ 946	1862
1863	32 7/8	17 1/4	+15 5/8	61·4	62·7	2090	1127	+ 963	2900	1600	+1300	4990	2727	+2263	1863
1864	31 3/8	16 1/2	+14 7/8	61·7	62·0	2005	1078	+ 927	2746	1350	+1396	4751	2428	+2323	1864
1865	24 1/4	13 1/4	+11	57·6	60·6	1440	828	+ 612	2150	1033	+1117	3590	1861	+1729	1865

1866	10¾	12⅛	− 1⅜	58·5	61·3	653	777	− 124	1146	1269	− 123	1799	2046	− 247	1866
1867	9⅛	8⅞	+ 0¾	58·2	56·1	616	532	+ 84	1126	973	+ 153	1742	1505	+ 237	1867
1868	25	16⅝	+ 8⅜	63·4	61·0	1656	1054	+ 602	2398	973	+1425	4054	2027	+2027	1868
1869	10¼	14¼	− 4	60·1	56·1	655	848	− 193	1019	1350	− 331	1674	2198	− 524	1869
1870	17¼	15	+ 2¼	62·5	61·8	1101	956	+ 145	1282	1046	+ 236	2383	2002	+ 381	1870
1871	9¼	9¼	0	58·5	54·8	605	615	− 10	1287	1100	+ 187	1892	1715	+ 177	1871
1872	12¾	10¾	+ 2	58·3	59·0	780	705	+ 75	1307	1152	+ 155	2087	1857	+ 230	1872
1873	2¾	11¾	− 9	42·0	57·0	181	701	− 520	875	902	− 27	1056	1603	− 547	1873
1874	21½	11½	+10	60·0	58·3	1370	694	+ 676	2000	990	+1010	3370	1684	+1686	1874
1875	16⅛	8⅝	+ 7½	57·2	60·0	993	567	+ 426	1725	1008	+ 717	2718	1575	+1143	1875
1876	10¼	8⅛	+ 2⅛	58·7	59·0	635	500	+ 135	790	642	+ 148	1425	1142	+ 283	1876
1877	10½	8⅞	+ 1⅝	60·5	58·9	649	543	+ 106	829	748	+ 81	1478	1291	+ 187	1877
1878	19¾	12¼	+ 7⅜	57·9	59·0	1171	776	+ 395	1654	1081	+ 573	2825	1857	+ 968	1878
1879	6	4¾	+ 1¼	55·6	52·5	379	330	+ 49	808	763	+ 45	1187	1093	+ 94	1879
1880	15¼	11½	+ 3¾	58·7	56·9	937	689	+ 248	1665	1149	+ 516	2602	1838	+ 764	1880
1881	12¼	13¾	− 1½	54·6	58·0	748	863	− 115	897	1146	− 249	1645	2009	− 364	1881
1882	11¾	11	+ 0¾	58·6	58·7	719	679	+ 40	1085	1095	− 10	1804	1774	+ 30	1882
1883	18⅛	13¾	+ 4⅜	61·2	61·2	1160	872	+ 288	1301	1006	+ 295	2461	1878	+ 583	1883
1884	20¼	13	+ 7¼	60·2	62·1	1240	824	+ 416	1544	905	+ 639	2784	1729	+1055	1884
1885	23	15⅜	+ 7⅝	57·9	59·0	1351	925	+ 426	1812	1137	+ 675	3163	2062	+1101	1885
1886	9¼	9	+ 0¼	62·2	61·5	588	564	+ 24	657	570	+ 87	1245	1134	+ 111	1886
1887	19	14⅜	+ 4⅝	59·9	59·8	1153	906	+ 247	1212	895	+ 317	2365	1801	+ 564	1887
1888	12¾	10	+ 2¾	56·1	58·8	735	614	+ 121	1239	901	+ 338	1974	1515	+ 459	1888
1889	13	12¼	+ 0¾	59·5	59·8	796	743	+ 53	916	902	+ 14	1712	1645	+ 67	1889
1890	17¾	14	+ 3¾	59·8	59·4	1088	849	+ 239	1657	1004	+ 653	2745	1853	+ 892	1890
1891	23⅛	13¾	+ 9⅜	58·9	57·4	1404	828	+ 576	2241	1314	+ 927	3645	2142	+1503	1891
1892	11¾	9⅜	+ 2⅜	60·2	59·6	731	589	+ 142	1108	836	+ 272	1839	1425	+ 414	1892
1893	13⅛	9¾	+ 3¾	62·4	62·7	870	642	+ 228	854	609	+ 245	1724	1251	+ 473	1893
1894	15½	18	− 2½	59·7	60·2	953	1121	− 168	1483	1487	− 4	2436	2608	− 172	1894
1895	15½	10	+ 5½	62·2	62·5	978	664	+ 314	1151	720	+ 431	2129	1384	+ 745	1895
1896	16⅛	16¾	− 0⅝	60·7	61·4	1020	1087	− 67	1312	1309	+ 3	2332	2396	− 64	1896
1897	7	8⅞	− 1⅞	59·5	60·3	460	592	− 132	710	867	− 157	1170	1459	− 289	1897
AVERAGES—PRODUCE AFTER FALLOW RECKONED AT THE YIELD PER ACRE OF THE HALF IN CROP EACH YEAR.															
5 yrs. 1851–'55	19¼	14¾	+ 4½	55·8	56·7	1175	947	+ 228	2243	1712	+ 531	3418	2659	+ 759	5 yrs. 1851–'55
10 yrs. 1856–'65	26⅛	15⅞	+10¼	58·5	57·9	1603	982	+ 621	2473	1539	+ 934	4076	2521	+1555	10 yrs. 1856–'65
10 yrs. 1866–'75	13½	11⅞	+ 1⅝	57·9	58·5	861	745	+ 116	1417	1076	+ 341	2278	1821	+ 457	10 yrs. 1866–'75
10 yrs. 1876–'85	14¾	11¼	+ 3½	58·4	58·5	899	700	+ 199	1238	967	+ 271	2137	1667	+ 470	10 yrs. 1876–'85
10 yrs. 1886–'95	15⅛	12⅛	+ 3	60·1	60·2	930	752	+ 178	1252	924	+ 328	2182	1676	+ 506	10 yrs. 1886–'95
40 yrs. 1856–'95	17⅜	12¾	+ 4⅝	58·7	58·8	1073	795	+ 278	1595	1127	+ 468	2668	1921	+ 747	40 yrs. 1856–'95
AVERAGES—PRODUCE AFTER FALLOW RECKONED AT THE YIELD PER ACRE OF THE WHOLE AREA, HALF IN CROP AND HALF FALLOW.															
5 yrs. 1851–'55	9⅝	14¾	− 5⅛			587	947	− 360	1122	1712	− 590	1709	2659	− 950	5 yrs. 1851–'55
10 yrs. 1856–'65	13	15⅞	− 2⅞			802	982	− 180	1236	1539	− 303	2038	2521	− 483	10 yrs. 1856–'65
10 yrs. 1866–'75	6¾	11⅞	− 5⅛			430	745	− 315	709	1076	− 367	1139	1821	− 682	10 yrs. 1866–'75
10 yrs. 1876–'85	7⅜	11¼	− 3⅞			449	700	− 251	619	967	− 348	1068	1667	− 599	10 yrs. 1876–'85
10 yrs. 1886–'95	7½	12⅛	− 4⅝			465	752	− 287	626	924	− 298	1091	1676	− 585	10 yrs. 1886–'95
40 yrs. 1856–'95	8⅜	12¾	− 4⅛			536	795	− 259	798	1127	− 329	1334	1921	− 587	40 yrs. 1856–'95

D

GEESCROFT

EXPERIMENTS ON THE GROWTH OF OATS YEAR AFTER YEAR ON THE SAME

Previous Cropping—1847 and 1848, Clover, Experimental Manures; 1849—1859, Beans, Experimental Manures; 1860, Fallow; 1861 and 1862, Wheat, Unmanured; 1863, Fallow; 1864, Beans, Dunged; 1865, Wheat, Unmanured; 1866, Beans, Unmanured; 1867 and 1868, Wheat, Unmanured.

(Area under experiment,

PLOTS.	MANURES, PER ACRE, PER ANNUM.	PRODUCE PER ACRE. 1ST SEASON, 1869. Dressed Grain. Quantity.	Weight per Bushel.	Total Straw.	2ND SEASON, 1870. Dressed Grain. Quantity.	Weight per Bushel.	Total Straw.
		Bushels.	lbs.	cwts.	Bushels.	lbs.	cwts.
1	Unmanured	36⅝	36¾	19¼	16⅜	35	9⅛
2	200 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, 100 lbs. Sulphate Magnesia, and 3½ cwts. Superphosphate of Lime (1)	45	38½	24½	19⅛	35⅛	9⅝
3	400 lbs. Ammonium-salts (2)	56⅛	37½	36⅞	30	34⅞	17¼
4	400 lbs. Ammonium-salts, 200 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, 100 lbs. Sulphate Magnesia, and 3½ cwts. Superphosphate ..	75¼	39¼	54	50⅝	36	28⅝
5	550 lbs. Nitrate of Soda (3)	62¼	38½	42¾	36½	35¼	23
6	550 lbs. Nitrate of Soda, 200 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, 100 lbs. Sulphate Magnesia, and 3½ cwts. Superphosphate ..	69⅜	38½	49⅞	50	35¾	28¾

SECOND 5 YEARS; MINERAL MANURES AS BEFORE,

		6TH SEASON, 1874.			7TH SEASON, 1875.		
		Bushels.	lbs.	cwts.	Bushels.	lbs.	cwts.
1	Unmanured	12	31½	7	12½	29⅜	5⅞
2	200 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, 100 lbs. Sulphate Magnesia, and 3½ cwts. Superphosphate of Lime (1)	13⅝	31¼	6½	13⅛	29¾	6⅞
3	200 lbs. Ammonium-salts (2)	37¼	33¼	22⅞	30⅜	32⅝	15⅜
4	200 lbs. Ammonium-salts, 200 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, 100 lbs. Sulphate Magnesia, and 3½ cwts. Superphosphate ..	46⅜	34⅝	24⅝	30⅝	34⅞	20¼
5	275 lbs. Nitrate of Soda (3)	35⅛ (4)	30 (4)	16½ (4)	23½ (4)	31¼ (4)	11⅜ (4)
6	275 lbs. Nitrate of Soda, 200 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, 100 lbs. Sulphate Magnesia, and 3½ cwts. Superphosphate ..	28½ (4)	33½ (4)	16⅝ (4)	28⅝ (4)	33⅝ (4)	14½ (4)

(1) "Superphosphate of Lime"—in all cases, made from 200 lbs. Bone-ash, 150 lbs. Sulphuric Acid sp. gr. 1·7 (and water).
(2) "Ammonium-salts"—in each case, equal parts Sulphate and Muriate of Ammonia of Commerce.
(3) 550 lbs. Nitrate of Soda is reckoned to contain the same amount of Nitrogen as 400 lbs. "Ammonium-salts."
(4) On these plots, where large quantities of Nitrate of Soda had been applied year after year, the land, though more worked, was so wet that it could not be got into favourable condition for sowing, and the plant was very irregular.

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FIELD.

Land; without Manure, and with different descriptions of Manure.

The first Experimental Oat Crop was in 1869; the last in 1878, since which, owing to the wetness and the foulness of the land for several years, it was left fallow; and the experiment is now discontinued. Description of Oats—Black Tartarian every year excepting 1874, when White Tartarian were sown.

¾ acre.)

Produce per Acre.

3rd Season, 1871.			4th Season, 1872.			5th Season, 1873.			Average per Annum 5 Years, 1869–1873.		
Dressed Grain.		Total Straw.	Dressed Grain.		Total Straw.	Dressed Grain.		Total Straw.	Dressed Grain.		Total Straw.
Quantity.	Weight per Bushel.		Quantity.	Weight per Bushel.		Quantity.	Weight per Bushel.		Quantity.	Weight per Bushel.	
Bushels.	lbs.	cwts.	Bushels.	lbs.	cwts.	Bushels.	lbs.	cwts.	Bushels.	lbs.	cwts.
20½	33½	11¼	15	36¼	7⅛	10¾	27⅛	5⅜	19⅞	33¾	10⅜
22	35¼	13½	19½	37¾	10⅜	17	28⅝	8⅝	24½	35	13⅜
57⅛	36⅜	40⅝	55¾	37½	30⅝	36½	32⅝	16¾	47	35⅞	28½
58⅝	35⅜	50	62⅜	39½	45⅛	48¼	34¾	27⅝	59	37	41⅛
55	36⅝	34¾	42⅛	36⅝	20⅝	39¾	30¼	16½	47⅛	35½	27½
60¼	33¾	48⅜	44⅝	37¼	24	63⅝	33⅝	24	57½	35¾	35

Ammonium-salts and Nitrate of Soda only half as much as previously.

8th Season, 1876 (5).			9th Season, 1877 (6). Fallow.			10th Season, 1878.			Average per Annum 4 Years, 1874, '5, '6, and '8.		
Bushels.	lbs.	cwts.	Bushels.	lbs.	cwts.	Bushels.	lbs.	cwts.	Bushels.	lbs.	cwts.
8⅛	32	2⅝	..	..	..	22¼	32	8⅜	13¾	31¼	6
7¾	30	2⅝	..	..	..	17¾	35¼	8½	13⅛	31⅝	6⅛
17⅝	34⅛	6	..	..	..	30	32¾	12⅜	28⅞	33¼	14⅛
29¼	35½	12½	..	..	..	45⅜	37	22½	38	35½	20
12¾	30⅞	3⅞	..	..	..	34⅛	34¼	12½	26⅜	31⅝	11⅛
19⅝	33¼	8	..	..	..	37	36¼	17½	28½	34⅛	14

(5) Owing to the extremely wet condition of the land, especially on the Nitrate plots, it was not sown until April 6, and then with a very unfavourable seed bed; and, there being a heavy fall of snow a week later, the plant came up very irregularly, and much of it perished from standing surface-water.

(6) Owing to the very wet winter, 1876–7, the land could not be worked in time for sowing, and was therefore left fallow in 1877; no manures being applied.

The experiments were discontinued after 1878.

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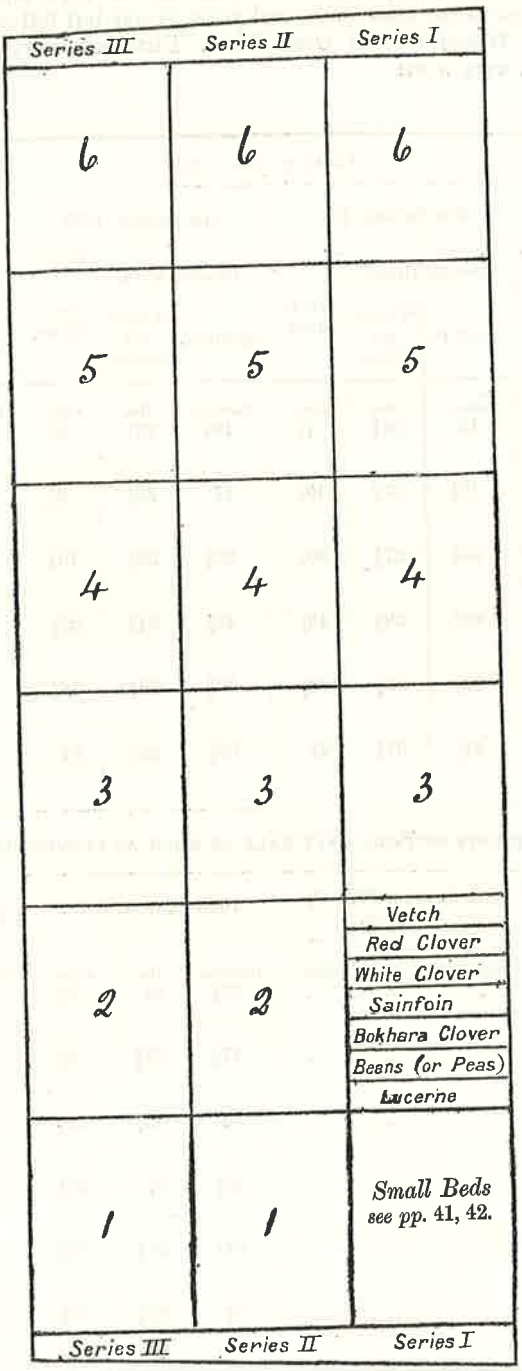
PLAN OF THE PLOTS IN HOOS FIELD, ON WHICH EXPERIMENTS HAVE BEEN MADE ON LEGUMINOUS PLANTS.

50 years, commencing 1849.

[For brief summary of results and conclusions, see opposite page.]



Total area under experiment about 3 acres, divided into 3 Series.
Each Series about 1 acre, divided into 6 differently manured plots.
Series I. Mineral Manures only;
Series II. The Mineral Manures, and Nitrate of Soda;
Series III. The Mineral Manures, and Ammonium-salts or Rape-cake, etc.

There are now 7 different Leguminous plants growing on *each* plot, namely—Lucerne, Beans (or Peas), Bokhara Clover, Sainfoin, White Clover, Red Clover, and Vetch; as indicated on Plot 2, Series I.

In the spring of 1898, owing to the growing foulness of the plots in recent years, Plot 1 of Series I. (Small Beds), and all the Plots (1–6), of Series II. and Series III., were ploughed up for thorough cleaning; after which the future treatment of them will be considered. At present the experiments are confined to Plots 2, 3, 4, 5, and 6, of Series I.

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RESULTS OF EXPERIMENTS MADE IN HOOS FIELD ON THE GROWTH OF VARIOUS LEGUMINOUS CROPS,

year after year on the same land, with mineral, and with mineral and nitrogenous manures, commencing in 1848–9. Clover seed was sown 12 times in 29 years, and the plant failed 8 times out of the last 10 trials. The results showed that when Red Clover was thus sown frequently on the same land, there was almost uniform failure. In fact, after the first few years practically no crop was obtained. In 1878, after the cessation of the trials with Red Clover, various other Leguminous plants, of different habits of growth, and especially of different character and range of roots, were sown on the, so to speak, Clover-exhausted land. The result was that whilst Red Clover, which was included in the list of the new experiments, still failed, giving an average of only 22 lbs. of nitrogen per acre per annum in 5 years of crop over 7 years, the more weakly-rooted and more weakly-growing White Clover, which had not been grown on the land for many years, gave an average of 47 lbs. in 6 years of crop over 9 years; the more freely-growing, and deeper-rooting Vetch an average of 75 lbs. over 14 years; Bokhara Clover, 64 lbs. per annum in 11 years of crop over 12 years; and the very deeply, and very powerfully-rooting Lucerne an average of 160 lbs. of nitrogen over 12 years. Here, then, when various other Leguminous plants followed on the Red Clover-exhausted land, they grow luxuriantly, and yielded much larger, and in some cases very large, amounts of nitrogen. Further, the surface-soils gained rather than lost nitrogen.

Experiments have also been made with Leguminous crops in Geescroft Field. Thus, Beans were grown year after year on the same land, without manure, with mineral manures, and with mineral and nitrogenous manures—commencing 1847. The results showed considerable increase in the produce, and coincidently in the yield of nitrogen, by the use of mineral manures containing potash, and but little further increase by the addition of nitrogenous manures; notwithstanding that Beans, like other Leguminous crops, contain a much higher percentage of nitrogen, and yield much more nitrogen per acre, than grain crops. Further, on the growth of Beans thus year after year on the same land, the amount of produce and the yield of nitrogen, declined considerably, both being much less under all conditions of manuring in the later than in the earlier years. The results further showed, however, that, as in the case of the growth of various other Leguminous crops on the Clover-exhausted land (in Hoos Field), so now after the failure of the Beans and decline in the yield of nitrogen in them, on sowing Red Clover with its very different character and range of roots, on the Bean-exhausted land, very large crops of Clover, containing very large amounts of nitrogen, were obtained. Not only was so much nitrogen removed in the Clover crops, but the surface-soil became determinably richer in nitrogen, due to accumulation of nitrogenous crop-residue.

In view of the failure to grow Red Clover continuously on ordinary arable land, it is a fact of much interest that it has been grown for forty years in succession on rich garden-soil. There was, however, a much reduced persistence of the plant, a considerably reduced amount of produce, and of nitrogen in it, and with this a considerable reduction of the stock of nitrogen in the soil, in the later than in the earlier years. Nevertheless, the amount of produce over the 40 years, 1854–1893, corresponded to an average yield of nearly 3 tons of Clover hay, containing about 160 lbs. of nitrogen, per acre per annum; quantities which exceed the average produce of the crop grown once in 8 or more years, in rotation on ordinary arable land.

The results, as a whole, indicate a soil source of failure on the arable land, and a soil source of success on the rich garden-soil.

Lastly, recent experiments at Rothamsted confirm those of others in showing that, by adding to a sterilised sandy soil growing Leguminous plants, a small quantity of the watery extract of a soil containing the appropriate organisms, a marked development of the so-called leguminous nodules on the roots is induced; and that there is, coincidently, increased growth, and gain of nitrogen.

It is concluded that in the growth of Leguminous crops, such as Clover, Vetches, Peas, Beans, Sainfoin, Lucerne, &c., at any rate some, and sometimes much, of the large amount of nitrogen which they contain, and of the large amount which they frequently leave as nitrogenous residue in the soil for future crops, is due to atmospheric nitrogen brought into combination by the agency of lower organisms. But it is still a question—how far the failure of Clover, or of other Leguminous crops, may be due to the exhaustion of available combined nitrogen, or of mineral constituents, within the range of the roots, and how far to the exhaustion of the organisms necessary for the bringing about of the fixation of free nitrogen.

For further particulars, see pages 7 and 38–47; also Section III. in Nos. 92 and 93, in Series I. of the list of papers at page 14.

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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 it in time for sowing.

In the months of May and June 1881, the land was ploughed, scuffled, and harrowed, and again on July 9–12; since this time, however, the experiments with beans have been finally abandoned.

On February 1–4, 1882, the land was ploughed and cleaned, and on September 6–7 was harrowed, rolled, and sown with grass-seeds. These germinated satisfactorily, but owing probably to the extreme wetness of the succeeding winter months, the plant almost entirely died off.

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Experiments on the Growth of Leguminous Crops—*continued.*

In April 1883, samples of soil were taken from many of the plots, generally to a depth of 27 inches, but in selected cases to a depth of 72 inches from the surface, and at that time very few grass plants could be seen. After the soil sampling, the whole field was scuffle-harrowed, and sown with Barley and Clover. In order to test the condition of the soil of the different plots of the continuous Bean and the alternate Wheat and Bean land, they were left unmanured; the remaining portion of the field, not recently under exact experiment, receiving 2 cwts. Nitrate Soda, and 2 cwts. Superphosphate per acre.

Notwithstanding the repeated failure of the Beans, though on the other hand the land had practically been fallow since 1878, the Clover came up very well, grew very rapidly, and on many of the plots to a great extent smothered the Barley; so that at harvest (1883) there was a very unusual proportion of Clover in the crop. The Clover plant remained strong through the mild winter, and gave heavy crops in June, and in August 1884; the two crops in many cases approaching, and in some exceeding, 4 tons of hay per acre. In 1885, a good plant remained on most of the plots, yielding a cutting on June 23, which in several cases approached, and in one exceeded, 2 tons of hay per acre. In fact, from several of the plots of this bean-exhausted land, the nitrogen in the surface soil of which had been much reduced, and was very low, more than 6 tons of clover-hay per acre, containing more than 300 lbs. of nitrogen, have been taken. It may be added, that the total yield has been greater on some of the previously continuous bean-plots than on those which had grown beans and wheat alternately. (See below.) After the cutting in 1885, the greater part of the land was thrown into the park for permanent grass; only the previously continuous bean-plots being still reserved for future experiment.

The general result of the experiments with Beans has been that mineral constituents used as manure (more particularly potash), increased the produce very much during the early years; and, to a certain extent, afterwards, whenever the season was favourable for the crop. Ammonium-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 Cereal one grown under similar conditions as to soil, &c. Nitrate of soda has, however, produced more marked effects. But when the same description of Leguminous crop is grown too frequently on the same land it seems 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 continued so up to September, 1882 when it was sown with grass-seeds; since which time it has been treated exactly as the continuous Bean Land. (See the bottom of the preceding page, and the top of this.)

In alternating Wheat with Beans, the remarkable result was 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 also had to be abandoned.

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Experiments on the Growth of Leguminous Crops—*continued.*

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 1848–9, 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 potash) considerably increased the crops in the early years. Ammonium-salts had little or no beneficial effect, and were sometimes injurious. It may be added, that the beneficial effects of long previous applications of potash 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 re-sown, 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.

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, and 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 Farmyard 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. In 8 out of the last 10 trials the plant died off in the winter and spring succeeding the sowing of the seed; in 4 of these without giving any crop at all, and in the other 4, only very small cuttings.

In 1878, the land was devoted to experiments with *various Leguminous plants*, differently manured, and these experiments are still in progress (1898); for further particulars see pp. 46–7.

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 of soil from 24 to 16 inches, one-third from 16 to 8 inches, and the remainder from 8 inches

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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.

In the winter of 1867-8, a number of small beds, each 3 yards × 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 potash, 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 an adjoining portion of which Clover had been grown successfully since 1854 (see pp. 42–4).

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 potash 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 these 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 potash 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 potash, 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).

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

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 potash, 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 potash, 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 on May 12 (1881), all the small beds were 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, which came up well, but in most cases became very thin during the winter and spring of 1881–82. A small cutting was, however, taken on June 20, and another on August 18, 1882.

In May 1883, the beds were dug up, and sown with *Lucerne* without further manuring, but it gave no crop in that year. On April 3, 1884, the usual Nitrate Plots received Nitrate of Soda at the rate of 1000 lbs. per acre as a top-dressing. From all the plots, three cuttings were taken, viz. on June 27, August 16, and October 7. On March 9, 1885, the Nitrate plots received Nitrate of Soda at the rate of 500 lbs. per acre as a top-dressing; and three cuttings were taken, viz. on June 3, July 22, and October 10. In 1886 three cuttings were taken from all the plots, viz. on June 28, August 11, and December 3; and after the first cutting the usual Nitrate Plots received, on July 13, Nitrate Soda at the rate of 1000 lbs. per acre as a top-dressing. In 1887, three cuttings were taken, viz. on July 2, Aug. 15, and Oct. 12; and in 1888 two cuttings, viz. on July 6 and Sept. 26. In 1889 the usual Nitrate Plots received a solution of Nitrate of Lime, at the rate of 1490 lbs. per acre (= 86 lbs. of Nitrogen per acre); and two cuttings were taken from all the plots, one on July 5, and the other on August 31. In 1890, the plants on the garden-soil plots had almost entirely died off, and these beds were therefore dug up and re-sown with Lucerne on May 2; two cuttings were taken from each of the other plots, on July 5 and Sept. 2; and one cutting from the garden-soil plots on Sept. 2. In 1891, two cuttings were taken, viz. on July 8 and Sept. 15; in 1892, two cuttings, on June 27 and Aug. 30. In 1893, three cuttings, viz. on June 23, Aug. 3, and Oct. 5; in 1894, two cuttings, on July 9 and Oct. 28; in 1895, two cuttings, on May 30 and Aug. 2; in 1896, three cuttings, viz. on May 26, July 11, and Sept. 29; and in 1897, one cutting on June 8. After the cutting in June, there was a thin plant on most of the beds. In recent years they have required a great deal of hand-hoeing to keep down the weeds. The growth has usually been the more luxuriant where either Potash or Nitrate of Soda has been applied, but especially where the two were used together.

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 kitchen garden, maintained a plant of clover, and yielded better crops than the artificially manured beds, yet they finally failed quite as much as the rest.

In 1898, owing to the thinness of the plant, and the great prevalence of weeds, the whole of the small beds were ploughed up, and the experiment was abandoned. (See plan and foot-note, p. 36.)

2.—*Experiments on rich garden-soil.*

In view of the failures in the attempt to grow Clover continuously on ordinary arable land it is a fact of much interest, that in 1854 Red Clover was sown in a garden, scarcely half-a-mile distant from the experimental field, on soil which had been under ordinary kitchen garden cultivation for probably two or three centuries, and it has shown very luxuriant growth almost every year since.

From the produce of the seed sown in 1854 (March 29), two cuttings were taken in 1854, three in 1855, two in 1856, three in 1857, two in 1858, and two in 1859.

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

In 1856, the plot was divided into three equal portions, one being left without manure, another receiving gypsum, and the third a mixed mineral manure containing potash. In 1857 the surface-soil was sampled to a depth of 9 inches.

Seed was re-sown in 1860 (end of May); and yielded one cutting in October of that year, two in 1861, two in 1862, two in 1863, and two in 1864.

Seed was again sown in 1865 (April 22); and this sowing yielded one cutting in September of that year, two in 1866, two in 1867, and one very small cutting in April 1868.

Gypsum and the mixed mineral manure were again applied; and seed was re-sown, April 29, 1868; and from this sowing there were obtained two cuttings in 1869, and one in 1870.

The same manures were again applied March 30, and fresh seed was sown April 10, 1871; yielding one cutting in August of that year, two cuttings in 1872, and two in 1873.

Notwithstanding some injury from Dodder in 1873, there still remained too much plant to break up in the spring of 1874; and accordingly fresh seed was sown *between the rows* on May 4, and this failing, again on July 7, 1874. The manures had been applied between the rows on April 16. Three very small cuttings were taken in 1874 (in June, July, and September); and a small cutting again in June, 1875.

In 1875 (July 13), the old plants were dug in, and seed again sown, and this failing, seed was re-sown September 22. In spring 1876 there was luxuriant growth, but deficient plant, which yielded two small cuttings, on June 26, and August 7.

In 1876 (September 1), the beds were dug up, and re-sown with seed, which came up fairly, but the plant suffered during the winter, and in May 1877 it was dug up and re-sown. From this sowing a small cutting was taken on September 5, 1877; and three cuttings in 1878 (on June 10, July 26, and November 1).

In May 1879, there remained some fairly vigorous plants, but not nearly enough for a crop, so the ground was dug up (the soil sampled to a depth of 18 inches), the plants then dug in, and fresh seed was sown, on May 21. From this sowing a cutting was taken on September 13.

Owing to injury from Dodder in the autumn (1879), and the subsequent severity of the winter, the plant again died off, and seed was sown afresh on April 17, 1880. From this sowing two cuttings were taken in that year (August 5 and September 24).

In April 1881, there being too much plant to break up, but not enough to cover the ground, the blanks in the rows were re-sown with seed (April 29), and two small cuttings were afterwards taken, on June 23 and August 16.

On April 6, 1882, there being again many blanks in the rows, these were re-sown with seed. Three cuttings were afterwards taken—on June 14, August 8, and October 20, of the same year.

On April 18, 1883, the same manures were sown on the same portions as in 1874, and the ground was dug, the old plants being dug in. Fresh seed was sown on May 17, which gave one cutting on August 13, 1883; three cuttings in 1884, viz. on June 17, August 11, and October 6; and three cuttings in 1885, viz. on June 2, July 16, and August 31.

Owing probably in great part to the severe winter of 1885–6, the plants nearly all died, and on April 14, 1886, the few that remained were dug in, and fresh seed sown, without further manure, from which one cutting was taken on August 11. In 1887, owing to some destruction of the plant by a mole, a portion of the Unmanured Plot was re-sown with seed on April 21. Two cuttings were taken, viz. on July 8 and August 29.

The plant died during the winter, fresh seed was sown on April 13, 1888, the rows were mended on June 12, and a small cutting was taken on September 6. In April 1889, the rows were again mended, after which two cuttings were taken, viz. on June 21 and October 25.

In April 1890, the plants had almost entirely died off; and the beds were therefore dug up and re-sown with seed, which gave one crop, on August 12. Later in the autumn, however, many plants were destroyed by a dog after mice, so that the rows had to be mended with fresh seed, in May 1891, and cuttings were taken on July 15 and September 25.

During the winter of 1891–2 most of the plants died, the ground was therefore dug up and re-sown with seed on May 7, 1892. The seed germinated well, but some of the young plants were destroyed by "Fly," and the rows were mended on May 27, and one cutting was taken on August 26.

During the winter of 1892–3 some of the plants died, and the rows were accordingly mended on April 20, 1893, and cuttings were obtained on June 24, and on August 22.

In 1894 the rows were again mended on April 19 and gave two cuttings on July 9 and September 4. The plants had now become exceedingly thin and the soil covered with seed-weeds; the beds were therefore dug up later in the autumn, left fallow during the winter, and

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re-sown with seed on April 19, 1895. The seed germinated well, but was afterwards destroyed by "Fly," and was again sown on May 20; but owing to drought and heat the seed did not germinate, and a third sowing was made on July 2; no crop was, however, obtained in1895.

During the winter of 1895, and early spring of 1896, most of the plants died, the plots were therefore cleaned from weeds, and prepared for re-sowing. On April 23, 1896, the soil was sampled at two places on each of the three portions. Each sample taken was $4 \times 4 \times 9$ inches deep; and a similar sample was taken of the second 9 inches of depth. The top 9 inches of soil of each of the three portions was then taken out, a mixed mineral manure was then dug into the second 9 inches, and a similar quantity of the same mineral manure was mixed with the surface soil, which was then returned to its position. Seed was sown on July 1, which, however, gave no crop.

Most of the plants died during the winter of 1896–7. The beds were accordingly dug up in April 1897, and seed was resown on April 29, and gave two cuttings, viz., Aug. 7, and Oct. 27.

At the beginning of the winter of 1897, there was a strong and even plant; but it gradually declined, and in January, 1898, failure was very marked. On January 27 the plots were microbe-seeded, with the watery extract of the rich kitchen garden soil at Rothamsted. This did not, however, arrest the failure. Many of the plants were covered with a white fungus; the foliage was destroyed, and the crowns blackened and rotted away, very few plants remaining healthy. Early in March specimens of the plants were forwarded to Mr. Carruthers, who decided that they had suffered from the attack of the fungus "*Sclerotinia Trifoliorum.*" Eventually, all the diseased plants were taken up and removed. The surface soil was also, little by little, removed, very carefully examined, the Sclerotia carefully picked out, and then the soil was returned. About 6 ozs. of the Sclerotia were thus picked out from the surface-soil of an area of not quite 10 square yards. It was thought desirable, however, to apply a fungicide to the soil before resowing with clover-seed, and bisulphide of carbon was selected for the purpose, as leaving less permanent residue than others. Accordingly, a small dressing of this was applied on May 7, and it was immediately raked in. It was hoped that by the application any remaining Sclerotia would be killed, and that the Leguminous nodule-microbes might not be injuriously affected. On June 2, that is nearly 4 weeks after the application of the bisulphide, clover-seed was again sown.

This (1898) is the 45th season of the growth of Clover, year after year, on this plot of rich garden ground. From the foregoing statements, it will be seen that seed was sown in 1854, 1860, 1865, 1868, 1871, 1874 (twice—between the rows), 1875 (twice), 1876, 1877, 1879, 1880, 1883, 1886, 1888, 1890, 1892, 1895 (3 times), 1896, 1897, and 1898; and in addition, the blanks in the rows were filled up in 1881, 1882, 1887, 1888, 1889, 1891, 1892, 1893, and 1894. Including the partial sowings to mend the rows, seed has been sown thirty-three times in the 45 years; only five times in the first 20 years, but 28 times in the last 25. It is obvious, therefore, that the plants stood very much longer in the earlier, than in the later years. It may be added that the produce of the first five sowings (1854, 1860, 1865, 1868, and 1871) was rather more than one and a-half time as much as has been obtained since. Lastly, the reduced persistence of the plant, and the reduced produce, have been coincident with a considerable reduction in the stock of nitrogen in the soil. Still, there has frequently been very luxuriant growth, even in the later years; and the produce over 40 years, to 1893 inclusive, was equivalent to an average of nearly 3 tons of clover hay per acre per annum.

Conclusions; Fixation of Free Nitrogen, &c.

The general result of the experiments on ordinary arable land in the field has been—that neither organic matter rich in carbon as well as other constituents, nor ammonium-salts, nor nitrate of soda, nor mineral constituents, nor a complex mixture, supplied as manure, availed to restore the clover-yielding capabilities of the land; though, where some of these were applied in large quantity, and at considerable depths, the result was better than when they were used in only moderate quantities, and applied only on the surface.

On the other hand, it is clear that the soil in the garden, which at the commencement contained in its upper layers about four times as much nitrogen as the arable land, and would doubtless be correspondingly rich in other constituents, has supplied the conditions under which clover can be grown year after year on the same land for many years in succession.

The results obtained on the soil in the garden seem to show that what is called "clover-sickness," cannot be due to the injurious influence of excreted matters upon the immediately succeeding crop.

That Clover frequently fails coincidently with injury from parasitic plants, or insects,

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cannot be disputed; but it may be doubted whether such injury should be reckoned as the cause, or merely the concomitant, and an aggravation, of the failing condition.

The results of the experiments seem, therefore, to exclude the supposition that the *primary* cause of failure is either destruction by parasitic plants or insects, injury from excreted matters, or the shade of a corn-crop, and to indicate that it must be looked for in exhaustion of some kind within the range of the roots.

Still there remain several open questions. Is it exhaustion of certain organic matters rich in carbon, of nitrogenous food, or of mineral constituents? Again: is there an absolute deficiency in the soil of some of the substances in question, or only an unfavourable condition of combination, or, so to speak, of *soil-digestion* of them, for the requirements of Leguminous plants? Or, is there only an unfavourable distribution of them within the soil, considered in relation to the extent and character of the root-range of the crop? Or, lastly, is the failure connected with the condition, the distribution, or the exhaustion, of the organisms, the development of which in symbiosis with leguminous plants, has been shown by recent experiments to be associated with the fixation of free nitrogen? For futher reference to this point, see next page, also page 7.

In reference to these various questions, it is a fact of much significance that from October 1857 to May 1879, the diminution in the amount of nitrogen in the garden-soil to the depth of 9 inches only, represented approximately two-thirds as much as was estimated to have been taken out in the crops of the 21 intermediate seasons; and it was concluded that there had been reduction in the lower depths also.

The subject cannot be further considered within the limits of this brief notice, which may be concluded by the following quotation from Rothamsted papers ('Journal of the Royal Agricultural Society of England,' vol. xxi. Part I. p. 178; and 'Journal of the Royal Horticultural Society of London,' vol. iii. p. 86, 1872):—

"When land is not what is called 'clover-sick,' the crop of clover may frequently be increased by top-dressings of manure containing potash and superphosphate of lime; but the high price of salts of potash, and the uncertainty of the action of manures upon the crop, render the application of artificial manures for clover a practice of doubtful economy.

"When the land is what is called 'clover-sick,' none of the ordinary manures, whether 'artificial' or natural, can be relied upon to secure a crop.

"So far as our present knowledge goes, the only means of insuring a good crop of Red Clover is to allow some years to elapse before repeating the crop upon the same land."

Recent experiments at Rothamsted have confirmed those of others, in showing that by adding to a sterilised sandy-soil growing leguminous plants, a small quantity of the watery extract of a soil containing the appropriate organisms, a marked development of the so-called leguminous nodules on the roots is induced, and that there is, coincidently, increased growth, and gain of nitrogen. There is no evidence that the leguminous plant itself assimilates free nitrogen; the supposition is rather, that the gain is due to the fixation of nitrogen in the growth of the lower organisms in the root-nodules, the nitrogenous compounds so produced, being taken up and utilized by the leguminous plant.

It would seem, therefore, that in the growth of leguminous crops, such as clover, vetches, peas, beans, sainfoin, lucerne, &c., at any rate some of the large amount of nitrogen which they contain, and of the large amount which they frequently leave as nitrogenous residue in the soil for future crops, may be due to atmospheric nitrogen brought into combination by the agency of lower organisms. It has yet to be ascertained, however, under what conditions a greater or less proportion of the total nitrogen of the crop will be derived—on the one hand from nitrogen-compounds within the soil, and on the other from such fixation. It might be supposed, that the amount due to fixation would be the less in the richer soils, and the greater in soils that are poor in combined nitrogen, and which are open and porous. On the other hand, recent results obtained at Rothamsted, indicate that, at any rate with some leguminous plants, there may be more nodules produced, and presumably more fixation, with a soil rich in combined nitrogen, than in one poor in that respect.

In conclusion, as referred to above, the question remains—how far the failure of clover, and other leguminous crops, may be due to the exhaustion of available combined nitrogen, or mineral constituents, within the range of the roots, and how far to the exhaustion of the organisms necessary for the bringing about of the fixation of free nitrogen?

For further particulars on the Question of the Fixation of Free Nitrogen, see No. 92, Series I. (in the list of papers at page 14), pages 119–145; or, No. 93, Series I., pages 137–166.

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EXPERIMENTS WITH VARIOUS LEGUMINOUS PLANTS.—HOOS FIELD.

The arable land (in Hoos Field) 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, 1898, is the twenty-first 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 Leguminosæ 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 are given, in a Tabular form, lists of the Plants grown in previous years, and now growing (June 1898); and below the Table, the dates of sowing seed are given.

As the details show, there were at first 14 descriptions of Leguminous Plant grown, but that some of these, which more or less failed, have been given up; whilst others have been transferred from one plot to another. Indeed, the object during the last few years has been to reduce the number from 14 to 7, taking two plots instead of one for each description. The land had, however, notwithstanding much hand-hoeing, become very foul, and after cutting the crops of 1892, all but the Medicago sativa plots were ploughed up, thoroughly cleaned, and re-arranged; with one exception (9 and 10), two of the original plots being ploughed into one, and permanent paths of separation left, between the now larger plots; and in 1896, the Medicago sativa on No. 10 having failed, the two lands (9 and 10) were then thrown together, and devoted to Trifolium repens.

As the tabular statement shows, the arrangement at the present time (1898), is as follows:—

Nos. 1 and 2, Medicago sativa (Lucerne).
Nos. 3 and 4, Pisum arvense (Field Peas), or Faba vulgaris arvensis (Field Beans), alternately.
Nos. 5 and 6, Melilotus leucantha (Bokhara Clover).
Nos. 7 and 8, Onobrychis sativa (Sainfoin).
Nos. 9 and 10, Trifolium repens (White or Dutch Clover).
Nos. 11 and 12, Trifolium pratense (Red Clover).
Nos. 13 and 14, Vicia sativa (Common Tare or Vetch).

Below, is also given a Table showing the description and quantities of the manures applied to the different plots. Up to 1897 inclusive there were 3 "*Series*": Series 1, comprising 5 plots, and Series 2 and 3 each 6 plots. The same mineral manure (if any) has been applied to the same plot of each of the 3 *Series*:—*Series* 1, mineral manures only; *Series* 2, the same mineral manures, and nitrate of soda or lime; *Series* 3, the same mineral manures, with ammonium-salts, or rape-cake, or cows' urine, in addition. The manures have been applied in the quantities per acre stated in the Table, and the foot-notes thereto.

The general result is—that very much more nitrogen has been removed in some of the other plants than in the Red Clover; the average annual yield in which over the 5 years of the 8 (1878–85), when there was any crop, was only about 22 lbs. per acre, giving over the 8 years an average of only 14 lbs. of nitrogen. Against this, Melilotus leucantha yielded in 1879 about 130 lbs., in 1882 about 145 lbs., and over the 8 years (1878–85) an average of about 70 lbs. per acre; Vicia sativa gave over 3 years (1882-84) an average of 120 lbs., and over the 8 years (1878–85) an average of about 84 lbs.; and, lastly, Medicago sativa yielded, in 1884 nearly 340 lbs., in 1885 about 270 lbs., and over the 6 years (1880–85), an average of about 153 lbs., of nitrogen; and over the 12 years ending 1891, it gave an average of 160 lbs. of Nitrogen per acre per annum. Further, as late as 1895 even red clover yielded very fair produce under some conditions of manuring, and sainfoin and Bokhara clover much more; whilst in 1897, Bokhara clover yielded very large crops.

Notwithstanding these remarkable results, there has, in recent years, been a tendency to failure, especially of the weaker plants; due largely to the difficulty of keeping the land clean. It was, therefore, decided early in 1898 to reduce the area from 3 acres to less than one acre; and it is hoped that with so much less land it may be possible to keep it properly cultivated and cleaned, and so obviate one serious source of failure—foulness. The plots of Series 1, with the mineral manures which have yielded the most important results, being retained, the manure, crop, and soil history is substantially continued. (See Plan and footnotes thereto at p. 36.)

(Area under Experiment, about 3 acres; each Plot about $\frac{1}{6}$th acre.)

PLANTS GROWN ON EACH PLOT. There were originally 14 Plants on each Plot; but the number is now reduced to 7.

Years.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	Years.
1878								Trifolium procumbens (*Yellow Trefoil or Hop Clover*).	1878
1879								Trif. tardiflora incarnatum (*Late Red Clover*).	1879
1880	Trifolium pratense (*Common Red or Broad Clover*).	Trif. prat. perenne (*Perennial Clover or Cow-grass*).	Trif. prat. hybridum (*Suttons' Hybrid—Cow Clover*).		Trif. rep. perenne (*Giant perennial White Clover*).		Trifolium incarnatum (*Early Red or Crimson Clover*).	Trif. tardiflora album (*Late White Clover*).	1880
1881								Trifolium minus (*Yellow Suckling Clover*).	1881
1882				Trifolium repens (*Common White or Dutch Clover*).					1882
1883						Trifolium hybridum (*Alsike Clover*).	Lupinus hirsutus (*Blue Lupin*).	Lupinus luteus (*Yellow Lupin*).	1883
1884									1884
1885									1885
1886	Lupinus hirsutus (*Blue Lupin*).	Lupinus luteus (*Yellow Lupin*).			Faba vulg. arvensis (*Field Beans*).		Trifolium pratense (*Common Red or Broad Clover*).	Trifolium pratense perenne (*Perennial Clover or Cow-grass*).	1886
1887	Medicago sativa (*Lucerne or Purple Medick*).								1887
1888	,, ,, ,,		Pisum arvense (*Field Grey Peas*).						1888
1889	,, ,, ,,								1889
1890	,, ,, ,,			Fallow.		Melilotus leucantha.	Onobrychis sativa (*Sainfoin*).		1890
1891	,, ,, ,,			Faba vulg. arvensis (*Field Beans*).	Melilotus leucantha (*Bokhara Clover.*)			,,	1891
1892	,, ,, ,,				,,			,,	1892
1893			Pisum arvense (*Field Grey Peas*).						1893
1894	,, ,, ,,		Faba vulg. arvensis (*Field Beans*).		,,			,,	1894
1895	,, ,, ,,		Pisum arvense (*Field Grey Peas*).		,,			,,	1895
1896	,, ,, ,,		Faba vulg. arvensis (*Field Beans*).		,,			,,	1896
1897	,, ,, ,,		Pisum arvense (*Field Grey Peas*).		,,			,,	1897
1898	,, ,, ,,		Faba vulg. arvensis (*Field Beans*).		,,			,,	1898

EXPERIMENTS WITH VARIOUS LEGUMINOUS PLANTS.—HOOS FIELD—*continued.*

Years.	No. 9.	No. 10.	No. 11.	No. 12.	No. 13.	No. 14.	Years.
1878		(Not sown).				Lathyrus pratensis (*Meadow Vetchling*).	1878
1879	Medicago lupulina (*Black Medick or Non-such*).			Lotus corniculatus (*Bird's-foot Trefoil*).			1879
1880							1880
1881							1881
1882							1882
1883			Melilotus leucantha (*Bokhara Clover*).		Vicia sativa (*Common Tare or Vetch*).	Onobrychis sativa (*Sainfoin*).	1883
1884							1884
1885							1885
1886				Melilotus leucantha (*Bokhara Clover*).			1886
1887	Vicia sativa (*Common Tare or Vetch*).	Medicago sativa (*Lucerne or Purple Medick*).					1887
1888							1888
1889							1889
1890			Trifolium pratense (*Common Red or Broad-leaved Clover*).			Fallow.	1890
1891			,,		Vicia sativa (*Common Tare or Vetch*).		1891
1892	Trifolium repens (*Common White or Dutch Clover*).		,,		,,		1892
1893			,,		,,		1893
1894			,,		,,		1894
1895			,,		Fallow (Plant failed).		1895
1896	Trifolium repens (*Common White or Dutch Clover*).		,,		Vicia sativa (*Common Tare or Vetch*).		1896
1897	,,		,,		,,		1897
1898	,,		,,		,,		1898

DATES OF SOWING SEED, &c.

No. 1. Trifolium pratense—May '78; May '80; April '81; March '82; April '83; April '84; Lupinus hirsutus—May '86. **No. 2.** Trifolium pratense perenne—May '78; May '80; April '81; March '82; April '83; April '84; Lupinus luteus—May '86.

Nos. 1 and 2 together. Medicago sativa—April '87; May '96; June '98.

No. 3. Trifolium pratense hybridum—May '78; May '80; April '81; March '82; April '83; Pisum arvense—Feb. '84; March '85; March '86; Feb. '87; April '88; Feb. '89; Feb. '90; March '91; Feb. '92. **No. 4.** Trifolium repens—May '78; May '80; April '81; April '83; April '84; April and June '88; April '89; Faba vulgaris arvensis—March '91; Feb. '92.

Nos. 3 and 4 together. Pisum arvense—March '93; Faba vulg. arvensis—March '94; Pisum arvense—March '95; Faba vulg. arvensis—Feb. '96; Pisum arvense—March '97; Faba vulg. arvensis—April '98.

No. 5. Trifolium repens perenne—May '78; May '80; April '81; April '83; Faba vulgaris arvensis—Feb. '84; March '85; March '86; March '87; April '88; Feb. '89; Feb. '90. **No. 6.** Trifolium hybridum—May '78; May '79; May '80; April '81; March '82; April '83; April '84; May '86; April '87 (mended); April and June '88; April '89; Melilotus leucan.—May '90.

Nos. 5 and 6 together. Melilotus leucantha—(No. 6, April '90, and No. 5, April '91);—April '93; April '94; June '96; June '98.

No. 7. Trifolium incarnatum—May '78; May '79; May '80; April '81; Jan. and Sept. '82; Lupinus hirsutus—April '83; April '84; April '85; Trifolium pratense—May '86; April '89. **No. 8.** Trifolium procumbens—May '78; May '79; Trif. tardiflora incarn.—May '80; April '81; Trif. tard. album—May '81; Trif. minus—Oct. '81; Trif. incarn.—Sept. '82; Lupinus luteus—April '83; April '84; April '85; Trif. prat.—May '86; April '89.

Nos. 7 and 8 together. Onobrychis sativa.—May '90; April '93; April '94; June '98.

No. 9. Medicago lupulina—May '78; May '79; May '80; April '81; Vicia sativa—Sept. '82; Oct. '83; Sept. '84; Sept. '85; Oct. '86; Sept. '87; Oct. '88; Oct. '89; Trifolium repens—April '91; April '93; April '94. **No. 10.** Medicago sativa—May '79; May '80; April '81; April '83 (mended).

Nos. 9 and 10 together. Trifolium repens—May '96; May '97; June '98.

No. 11. Melilotus leucantha—May '78; May '80; April '81; April '83; April '84 (mended); March '85 (mended); May '86; May and June '88 (mended); April '89. **No. 12.** Lotus corniculatus—May '78; May '79; May '80; April '81; Melilotus leucantha—Sept. '82; April '83; April '84 (mended); March '85 (mended); May '86; May and June '88 (mended); April '89.

Nos. 11 and 12 together. Trifolium prat.—May '90; April '93; April '94; May '97; June '98.

No. 13. Vicia sativa—May '78; May '79; May '80; April '81; Sept. '82; April '83 (mended); Oct. '83; Sept. '84; Sept. '85; Oct. '86; Sept. '87; Oct. '88; Oct. '89. **No. 14.** Lathyrus pratensis—May '78; Onobrychis sativa—May '79; May '80; April '81; April '83 (mended); April '84 (mended); April '85 (mended); May '86 (mended); April '89. [April '98.

Nos. 13 and 14 together. Vicia sativa—Sept. '90; Sept. '91; Sept. '92; Sept. '93; Oct. '94; Sept. '95; Oct. '96,

MANURES; QUANTITIES PER ACRE.

Plots.	Series 1; 5 Lands.(1) Without Manure, or with Mineral Manure only. The Mineral Manures were applied in the quantities stated below, or in half the quantities in the years given in parentheses, in 1878, 1880, (1882), (1883), (1884), (1885), 1887, (1889), 1893, and 1898. In October 1883, 2000 lbs. of fresh-burnt Lime (slacked) were applied per Acre over all the Plots of Series 1.(5) [In 1898, 400 lb. Basic Slag throughout used instead of Superphosphate.]	Series 2. 5 Lands (1); Each Plot as Series 1, and—	Series 3; 5 Lands. 2 lands (2); Each Plot as Series 1, and—	 3 Lands (3); Each Plot as Series 1, and—
1	Without Mineral Manure. (Series 1, portion devoted to the experiments on "Small Beds," 1867–8, and since. See pp. 31–2)	Nitrate of Soda, 550 lbs. in 1878, '82, and '84; 275 lbs. in 1879, '80, '81, '85, '86, and 1887. 1889. (6)	Ammonium-salts, 400 lbs. in 1878, '82, and '84; 200 lbs. in 1879, '80, and '81; 225 lbs. Sulph. Amm., 1887.	Rape Cake, 2000 lbs. in 1878, 1880, 1882, and 1884; 500 lbs. in 1885; 1000 lbs. in 1887.
2	5 cwts. Superphosphate of Lime(4)			
3	1000 lbs. Sulphate Potash			
4	1000 lbs. Sulphate Potash, 5 cwts. Superphosphate..			
5	1000 lbs. Sulph. Potash, 250 lbs. Chloride Sodium (in 1884–5 and '87 Sulph. Soda instead), 250 lbs. Sulph. Lime, 250 lbs. Sulph. Magnesia			
6	1000 lbs. Sulph. Potash, 250 lbs. Chlor. Sod. (in 1884–5 and '87 Sulph. Soda instead), 250 lbs. Sulph. Lime, 250 lbs. Sulph. Mag., 5 cwts. Superph.			

(1) In November 1879, Lime was applied to the fifth land of Series 1, and to the adjoining land of Series 2, in addition to the other manures.

(2) One of the two lands had received Cows' Urine, 6120 lbs. per acre in 1879; and in 1885 both lands received Cows' Urine, at the rate of 21,500 lbs. per acre.

(3) In 1880, the Rape-cake was applied on only two lands (2nd and 3rd of the 3), Cows' Urine, at the rate of 6120 lbs. per acre, having been applied to the 1st of the 3 lands in 1879.

(4) "Superphosphate of Lime," 1878 to 1887 inclusive, made from 300 lbs. Bone-ash, 225 lbs. Sulphuric acid sp. gr. 1·7 (and water); 1889, made from high percentage mineral phosphates, and containing 37 per cent., or more, of soluble phosphate.

(5) In November 1887, fresh-burnt Lime (slacked), at the rate of 1000 lbs. per acre, was applied over the whole of the three Series. In November 1893, 2 tons of Chalk (crushed) per acre was applied over the whole of the three Series.

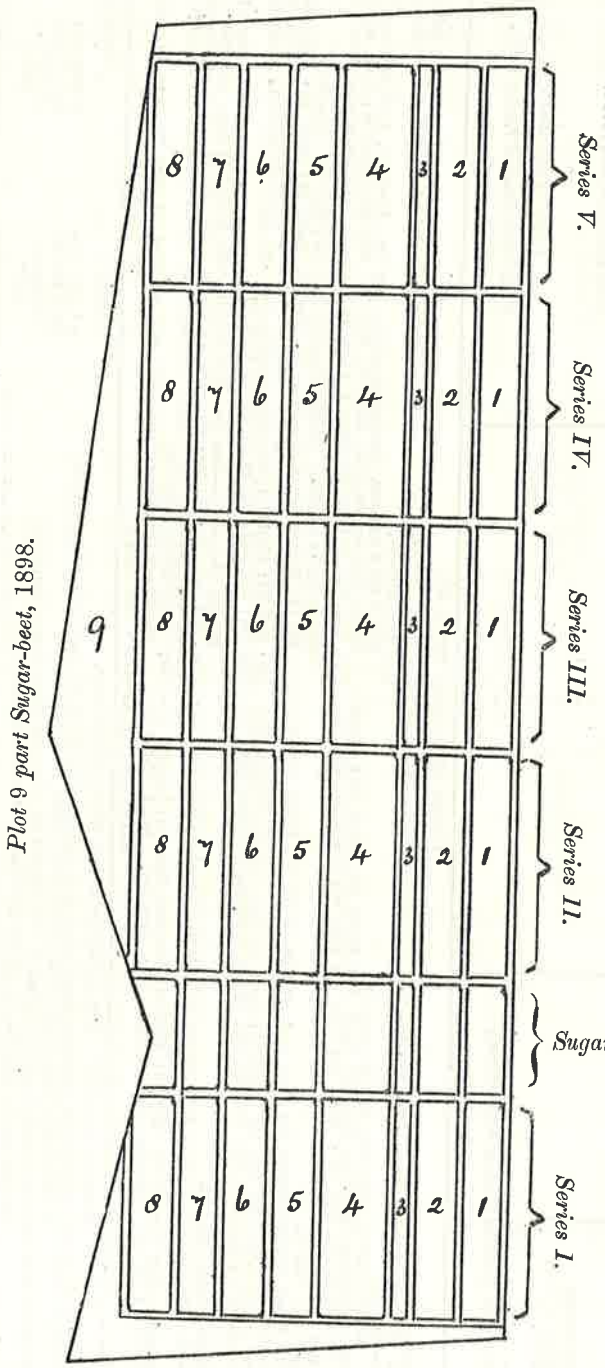
(6) On September 13, 1889, instead of Nitrate of Soda, a solution of Nitrate of Lime (1490 lbs. per acre), corresponding to 550 lbs. Nitrate of Soda, and to 86 lbs. Nitrogen per acre.

NOTE.—In addition to the manures above described, a top-dressing of 550 lbs. Nitrate of Soda, 400 lbs. Ammonium-salts, or 2000 lbs. Rape-cake, per acre, was applied to the respective portions of **No. 10** (Medicago sativa), **No. 11** (Melilotus leucantha), and **No. 14** (Onobrychis sativa), on September 20, 1882. In 1898, all sown in rows; Beans 20 inches apart; Vetches 12 inches; Lucerne, Melilotus, Sainfoin, White Clover, and Red Clover, each 11 inches apart.

Plan of the Plots in Barn Field, on which Experiments have been made with Root-Crops.

56 years, commencing 1843.

[For brief summary of results and conclusions, see opposite page.]



Total area of ploughed land about 8 acres.

Area of Plots. { 1, 2, 5, 6, 7, and 8, of each Series, rather over $\frac{1}{7}$ acre (0·14598 acre)
3, of each Series about $\frac{1}{27}$ acre (0·03649 acre).
4, of each Series about $\frac{1}{5}$ acre (0·20074 acre).
9, rather over $\frac{4}{10}$ acre (0·42 acre).

The double lines indicate division paths between plot and plot.

[For particulars of manuring and produce, etc., see pp. 50–75.]

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RESULTS OF EXPERIMENTS MADE IN BARN FIELD ON THE GROWTH OF ROOT-CROPS,

for many years in succession on the same land, without manure, with Farmyard-manure, and with various artificial manures—commencing in 1843 ;

Norfolk White Turnips, 6 years, 1843-48 ;

Swedish Turnips, 4 years, 1849-52 ;

(Barley 3 years, 1853-55, without manure, to exhaust as far as possible the residue from previous manuring, and so to equalize the condition of the plots, before re-arrangement of them) ;

Swedish Turnips, 15 years, 1856-70 ;

Sugar-Beet, 5 years, 1871-75 ;

Mangel Wurzel, 23 years, 1876-98. (In 1898, small areas were devoted to Sugar-beet—See Plan p. 48 ; also p. 73.)

Root-crops are grown in most Rotations in Europe. Their growth affords an excellent opportunity for cleaning the land ; and they are generally considered to be in a sense restorative crops. But they depend for luxuriant growth on an abundance of nitrogenous as well as mineral constituents within the soil ; and they are generally highly manured. Indeed, when grown in ordinary soil without manure, either for a few years in succession, or even in rotation, they soon revert to the uncultivated condition. The restorative effects of their growth in rotation are in fact due—to the large amount of manure applied for their growth ; to the large residue of the manure left in the soil for future crops ; to the large amount of matter at once returned as manure again in the leaves ; to the large amount of food produced, and the small amount of the most important manurial constituents of the roots which is retained by the animals consuming them—the rest returning as manure again.

Feeding-roots are essentially *Sugar crops*. The *percentage* of sugar is the greater the more mature the roots, and is consequently as a rule the greater in the roots of the smaller crops. But the amount of sugar *produced per acre* is much the greater in the larger crops. The amount of crop, and of Sugar produced, depends greatly on the amount of Nitrogen taken up. The percentage of nitrogen in Feeding-roots is comparatively low, but it is the higher the greater the available supply within the soil, and the more luxuriant and less ripe the crop. A large, but variable, proportion of the nitrogen is non-albuminoid ; the more, the less ripe the crop. The proportion of albuminoid matter to non-nitrogenous food material is very much lower than in ripened products, such as cereal grains for example. The amount of crop, and the percentage and actual amount of nitrogen in the roots, depend very directly on the amount of nitrogen available within the soil ; and it is quite fallaceous to suppose that root-crops gain a large amount of their nitrogen from atmospheric sources by means of their extended leaf-surface.

For particulars of the manuring and produce, and to some extent of the composition of the different descriptions of roots grown on the different plots, see pages 50–75.

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EXPERIMENTS ON ROOT-CROPS.—BARN FIELD.

Experiments with Turnips were commenced in 1843. Eight acres, divided into numerous Plots, were set apart for the purpose, and the crop was grown for ten consecutive years on the same land; "Norfolk Whites" 1843–1848, and "Swedes" 1849–1852; on some Plots without manure, and on others with different descriptions of manure.

Barley was then grown for three consecutive seasons, 1853–1855, without manure, in order to test the comparative corn-growing condition of the different Plots, and also to equalise their condition, as far as possible, by the exhaustion of some of the most active and immediately available constituents supplied by the previous manuring.

A new series of experiments with Swedes was arranged in 1856, having regard to the character of the manures previously applied on the different Plots, and to the results previously obtained. This second series was continued for fifteen years, namely from 1856 to 1870 inclusive.

The results obtained in the first three years, 1843, 1844, and 1845, were published in the 'Journal of the Royal Agricultural Society of England,' vol. viii. Part II., 1847. In the upper division of the Table below, there is shown the produce obtained Without Manure, and with Farmyard Manure, in the first 3 years, 1843, '44, and '45; and in the subsequent divisions there are given abstracts of the results obtained Without Manure, and with Different Manures, from 1845 to 1870 inclusive.

During the five years, 1871–1875, the land was devoted to experiments with Sugar-Beet, for particulars of which see pp. 52–55.

In 1876 experiments with Mangel-wurzel were substituted, and are still in progress; see pp. 56–75. (In 1898, small areas were devoted to Sugar-beet—See Plan p. 48; also p. 73.)

(Area under experiment about 8 acres; quantities, average per acre, per annum.)

NORFOLK WHITE TURNIPS, WITHOUT MANURE, AND WITH FARMYARD MANURE.

YEAR.	Roots per Acre.		Leaves per Acre.	
	Without Manure.	With Farmyard Manure.	Without Manure.	With Farmyard Manure.
	Tons. cwts.	Tons. cwts.	Tons. cwts.	Tons. cwts.
1843	4 4	9 10	not weighed	not weighed
1844	2 4	10 15		
1845	0 14	17 1	0 14	7 8

NORFOLK WHITE TURNIPS; FOUR SEASONS, 1845–1848; Roots and Leaves carted off the Land.

PLOTS.	STANDARD MANURES.	SERIES 1. Standard Manures only.		SERIES 2.	SERIES 3. Standard Manures, and Cross-dressed with 160 lbs. Sulphate Ammonia. 75 lbs. Muriate Ammonia.		SERIES 4. Standard Manures, and Cross-dressed with 160 lbs. Sulphate Ammonia. 75 lbs. Muriate Ammonia. 1840 lbs. Rape-cake.		SERIES 5. Standard Manures, and Cross-dressed with 1840 lbs. Rape-cake.	
		Average Produce, per Acre, per Annum.								
		Roots.	Leaves.		Roots.	Leaves.	Roots.	Leaves.	Roots.	Leaves.
		Tons. cwts.	Tons. cwts.		Tons. cwts.	Tons. cwts.	Tons. cwts.	Tons. cwts.	Tons. cwts.	Tons. cwts.
3	Gypsum 1845; without Manure 1846 and since (average 1846, 7, 8)	1 4	0 17		1 7	1 0	5 10	3 19	6 11	3 3
4	Superphosphate, each year; Potash, Soda, and Magnesia, 1847 and '48	8 1	2 15		9 15	4 3	10 5	6 1	11 2	4 12
5	Superphosphate, each year	8 16	2 19		9 18	4 8	10 1	6 3	10 18	4 15
6 } 7 }	Superphosphate, each year; and Potash 1847 and 1848	8 0	2 10		9 16	4 8	10 7	6 6	10 17	4 13

SWEDISH TURNIPS; FOUR SEASONS, 1849-1852; Roots and Leaves carted off the Land (excepting 1849, when the Leaves were too small to weigh or remove).
Average Produce per acre per annum.

Plots.	Standard Manures.	Series 1. Standard Manures only. Roots.	Series 1. Standard Manures only. Leaves.	Cross-dressed, as under, in 1849 and 1850. No Cross-dressing in 1851 and 1852. Series 2.	Series 3. Standard Manures, and Cross-dressed with 200 lbs. Ammonium-salts. Roots.	Series 3. Leaves.	Series 4. Standard Manures, and Cross-dressed with 200 lbs. Ammonium-salts and 2000 lbs. Rape-cake. Roots.	Series 4. Leaves.	Series 5. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake. Roots.	Series 5. Leaves.
		Tons. cwts.	Tons. cwts.		Tons. cwts.	Tons. cwts.	Tons. cwts.	Tons. cwts.	Tons. cwts.	Tons. cwts.
3	Without Manure, 1846 and since	2 6	0 6		3 17	0 6	7 0	0 17	7 14	0 13
4	Superphosphate, Sulphates Potash and Magnesia, and Soda-ash	7 17	0 10		9 9	0 11	13 1	0 18	12 7	0 15
5	Superphosphate	7 9	0 11		8 14	0 13	11 4	1 1	10 10	0 17
6 } 7 }	Superphosphate, and Sulphate Potash	6 16	0 9		8 14	0 10	12 8	0 17	11 14	0 14

BARLEY, without Manure (after Roots manured as above); THREE SEASONS, 1853–1855. Average Produce per acre per annum.

Plots.	Series 1. Dressed Grain.	Series 1. Straw.	Series 2.	Series 3. Dressed Grain.	Series 3. Straw.	Series 4. Dressed Grain.	Series 4. Straw.	Series 5. Dressed Grain.	Series 5. Straw.
	Bushels.	Cwts.		Bushels.	Cwts.	Bushels.	Cwts.	Bushels.	Cwts.
3	18¾	12½		20½	12⅝	24½	15⅜	25⅞	16
4	20¾	12¼		22½	13	25	14¾	25¼	14⅞
5	21	11⅞		23	12¾	26¾	15	27	15½
6 } 7 }	18¾	10⅞		20½	11⅞	25	14⅜	25	14⅞

SWEDISH TURNIPS; FIFTEEN SEASONS, 1856–1870.(1) Roots and Leaves carted off the Land. Average Produce per acre per annum.

Plots.	Standard Manures.	Series 1. Standard Manures only. Roots.	Series 1. Standard Manures only. Leaves.	Series 2. Standard Manures, and Cross-dressed with— 5 years, 1856–1860, 3000 lbs. Saw-dust, and 328 lbs. Nitric Acid. 10 years, 1861–1870, 550 lbs. Nitrate Soda. Roots.	Series 2. Leaves.	Series 3. Standard Manures, and Cross-dressed with— 5 years, 1856–1860, 200 lbs. Ammonium-salts. 10 years, 1861–1870, 400 lbs. Ammonium-salts. Roots.	Series 3. Leaves.	Series 4. Standard Manures, and Cross-dressed with— 5 years, 1856–1860, 200 lbs. Ammonium-salts, and 3000 lbs. Sawdust. 10 years, 1861–1870, 400 lbs. Ammonium-salts, and 2000 lbs. Rape-cake. Roots.	Series 4. Leaves.	Series 5. Standard Manures, and Cross-dressed with— 5 years, 1856–1860, 3000 lbs. Sawdust. 10 years, 1861–1870, 2000 lbs. Rape-cake. Roots.	Series 5. Leaves.
		Tons. cwts.	Tons. cwts.	Tons. cwts.	Tons. cwts.	Tons. cwts.	Tons. cwts.	Tons. cwts.	Tons. cwts.	Tons. cwts.	Tons. cwts.
1	Farmyard Manure, 14 tons	6 4	0 17	7 9	1 2	8 8	1 4	8 16	1 9	8 0	1 4
2	Farmyard Manure, 14 tons, and Superphosphate	6 7	0 16	7 13	1 3	8 5	1 5	8 14	1 9	7 16	1 2
3	Without Manure, 1846, and since	0 11	0 3	0 19	0 4	0 13	0 3	3 6	0 14	3 8	0 13
4	Superphosph., each year; Sulph. Potash, Soda, and Magnesia, 1856–60	2 16	0 8	5 2	0 16	4 12	0 14	6 12	1 5	5 8	0 17
5	Superphosphate, each year	2 12	0 9	4 13	0 18	3 16	0 15	5 16	1 7	5 0	0 19
6	Superphosphate, each year; Sulphate Potash, 1856–1860	2 7	0 7	4 11	0 14	4 5	0 13	6 6	1 2	5 3	0 16
7	Superphosph., each year; Sulph. Potash, and 36½ Amm.-salts, 1856–60	2 12	0 7	4 13	0 14	4 12	0 14	6 15	1 4	5 9	0 17
8	Unman. 1853, and since: previously part Unman.; part Superphosph.	1 3	0 4	1 13	0 5	1 2	0 5	3 19	0 18	3 14	0 19

NOTE.—"Sulphate of Ammonia" is estimated to contain 23 per cent. Ammonia, and "Muriate of Ammonia" 27 per cent. "Ammonium-salts," in each case, equal parts Sulphate and Muriate of Ammonia of commerce; and the mixture is estimated to contain 25 per cent. Ammonia. The 328 lbs. Nitric Acid (Sp. gr. 1·35), mixed with sawdust, and used as a cross-dressing on the Plots of Series 2, from 1856–1860, were estimated to contain Nitrogen = 50 lbs. Ammonia.

(1) The crops of 1859 and 1860 failed, and were ploughed in; but, as the manures were applied, and there would be accumulation within the soil for the succeeding crops, the average produce is calculated as for 15 years, that is the produce of the 13 years is, in each case, divided by 15.

EXPERIMENTS ON SUGAR BEET (VILMORIN'S GREEN-TOP WHITE SILESIAN).—BARN FIELD.

GROWN YEAR AFTER YEAR ON THE SAME LAND, WITHOUT MANURE, AND WITH DIFFERENT DESCRIPTIONS OF MANURE, 5 YEARS, 1871-'75.

Previous Cropping:—1843–'48 (6 Seasons), experiments on Norfolk White Turnips, with different descriptions of Manure.

1849–'52 (4 Seasons), experiments on Swedish Turnips, with different descriptions of Manure.

1853–'55 (3 Seasons), Barley without Manure (with a view as far as possible to equalise the condition of the Plots).

1856–'70 (15 Seasons), experiments on Swedish Turnips, with different descriptions of Manure, in which the arrangement of the Plots was the same, and that of the Manures very similar—in fact, exactly the same during the last 10 years—as in the first year of Sugar Beet, excepting that, during those 10 years, the Alkalies were omitted for the Swedes. For the second and subsequent years of Sugar Beet slight alterations in the Mineral Manures were made, and in the fourth and fifth years the Farmyard Manure, Nitrate of Soda, Ammonium-salts, and Rape-cake were omitted, as will be seen below. In 1871, the seed was dibbled on ridges, in rows 26 inches apart, and 10 inches apart in the rows; in 1872–'75, seed dibbled on the flat; in rows 22 inches apart, and 11 inches apart in the rows; plants moulded up afterwards. Roots all carted off, Leaves weighed, spread on the respective Plots, and ploughed in.

Below are given the Manures and Produce for the 5 Seasons, 1871–'75.

Area under experiment, about 8 acres. The experiments are arranged as under, in 5 Series, each of which comprises 8 Plots.

Plots.	Standard Manures.	Manures, per Acre, per Annum. Series 1. Standard Manures only.	Series 2. Standard Manures, and Cross-dressed with 550 lbs. Nitrate Soda.	Series 3. Standard Manures, and Cross-dressed with 400 lbs. "Ammonium-salts."	Series 4. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake, and 400 lbs. "Ammonium-salts."	Series 5. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake.
	First Season, 1871. Seed dibbled April 13 and 14; Crop taken up November 30–December 19.					
		Produce per Acre (Roots trimmed as for feeding, not as for Sugar-making).				
		Roots. Tons. cwts. / Leaves. Tons. cwts.	Roots. Tons. cwts. / Leaves. Tons. cwts.	Roots. Tons. cwts. / Leaves. Tons. cwts.	Roots. Tons. cwts. / Leaves. Tons. cwts.	Roots. Tons. cwts. / Leaves. Tons. cwts.
1	Farmyard Manure (14 tons)	18 3 / 3 5	27 13 / 6 19	22 1 / 5 6	26 4 / 6 14	28 18 / 5 14
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	14 13 / 2 14	25 16 / 5 15	21 15 / 4 6	25 2 / 6 7	25 4 / 5 5
3	Without Manure (1846, and since)	7 11 / 2 0	22 3 / 5 12	15 6 / 4 16	19 18 / 7 0	20 16 / 4 12
4	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 200 lbs. Sulphate Soda, 100 lbs. Sulphate Magnesia	7 11 / 1 5	22 15 / 4 8	17 10 / 3 5	22 15 / 6 3	21 7 / 3 19
5	3½ cwts. Superphosphate	5 12 / 1 8	20 19 / 3 14	15 4 / 3 19	19 18 / 7 12	18 19 / 4 5
6	3½ cwts. Superphos., 300 lbs. Sulph. Potash	5 1 / 1 4	21 5 / 3 13	17 4 / 3 4	23 11 / 6 11	21 0 / 3 11
7	3½ cwts. Superphos., 300 lbs. Sulph. Potash, 36½ lbs. Amm.-salts (2)	5 18 / 1 5	20 19 / 3 18	18 8 / 4 3	21 0 / 5 0	21 7 / 3 17
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	7 10 / 1 14	21 13 / 3 16	16 2 / 4 15	17 19 / 7 11	20 7 / 4 9
	Second Season, 1872. Seed dibbled May 1–3; Crop taken up November 12–28.					
1	Farmyard Manure (14 tons)	15 13 / 4 2	23 9 / 7 19	22 14 / 9 0	26 8 / 9 11	22 5 / 6 1
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	16 0 / 3 18	24 6 / 8 16	22 0 / 7 16	25 9 / 9 14	20 15 / 5 11
3	Without Manure (1846, and since)	7 17 / 1 13	21 7 / 6 6	15 3 / 4 13	20 8 / 10 1	16 3 / 3 11
4	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	6 14 / 1 10	20 2 / 5 19	15 10 / 3 7	23 8 / 7 13	17 18 / 3 15
5	3½ cwts. Superphosphate	6 17 / 1 8	19 6 / 6 4	14 5 / 4 13	18 11 / 10 4	15 18 / 3 16
6	3½ cwts. Superphos., 500 lbs. Sulph. Potash	6 6 / 1 5	16 16 / 5 14	14 7 / 3 19	22 16 / 9 9	15 17 / 3 14
7	3½ cwts. Superphos., 500 lbs. Sulph. Potash, 36½ lbs. Amm.-salts (2)	6 15 / 1 8	17 0 / 6 1	15 9 / 3 19	23 9 / 9 10	15 10 / 3 15
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	5 4 / 1 5	15 6 / 5 19	13 10 / 4 1	19 12 / 9 17	15 0 / 4 6

THIRD SEASON, 1873. Seed dibbled May 9–11; Crop taken up November 19–December 2.

1	Farmyard Manure (14 tons)	15 2	5 12	20 5	10 9	22 2	9 18	22 15	12 10	23 10	7 8
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	14 6	5 2	21 10	11 0	19 4	8 9	23 7	13 6	21 18	6 18
3	Without Manure (1846, and since)	5 1	1 11	14 5	6 11	9 3	3 16	15 12	9 11	14 13	4 1
4	{3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia .. .. ..}	5 2	1 13	16 9	6 11	12 10	3 10	20 3	8 0	16 1	3 8
5	3½ cwts. Superphosphate	5 5	1 11	18 8	5 13	10 19	5 0	14 15	9 8	13 19	4 9
6	3½ cwts. Superphos., 500 lbs. Sulph. Potash	4 12	1 5	15 17	4 4	12 18	3 12	20 2	9 5	14 14	3 11
7	3½ cwts. Superphos., 500 lbs. Sulph. Potash, 36½ lbs. Amm.-salts (2)	5 19	1 12	16 14	5 3	13 0	4 15	19 16	9 0	15 17	4 4
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	4 11	1 7	12 9	5 18	8 8	2 19	15 2	9 8	12 2	3 16

FOURTH SEASON, 1874 (3). Mineral Manures as in 1872 and 1873; but no Farmyard Manure, or cross-dressings of Nitrate Soda, Ammonium-salts, or Rape-cake. Seed dibbled April 30 and May 1; Crop taken up November 13–19.

1	Without Manure, 1874 and 1875 (Farmyard Manure in '71, '72, '73)	10 16	5 6	11 14	8 9	11 7	8 3	13 7	9 17	14 10	7 8
2	3½ cwts. Superphosphate (with Farmyard Manure, '71, '72, '73) ..	13 3	5 9	7 9	4 16	9 5	5 17	12 5	7 7	13 1	6 4
3	Without Manure (1846, and since)	5 2	1 5	3 2	2 6	3 7	2 2	2 11	2 10	3 19	2 9
4	{3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia .. .. ..}	6 10	1 8	8 16	3 6	7 10	2 0	10 12	4 16	8 2	3 11
5	3½ cwts. Superphosphate	5 19	1 7	7 10	3 6	7 6	2 8	7 15	5 4	5 17	3 6
6	3½ cwts. Superphos., 500 lbs. Sulph. Potash	5 11	1 5	8 1	2 14	8 1	1 18	9 10	4 13	7 13	3 2
7	3½ cwts. Superphos., 500 lbs. Sulph. Pot., and Amm.-salts, '71, '72, '73	6 14	1 3	9 5	2 11	8 15	1 14	11 14	4 11	8 4	3 9
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	5 0	1 2	7 13	2 16	6 10	2 0	7 6	4 7	3 12	2 1

FIFTH SEASON, 1875. Mineral Manures as in 1872, 1873, and 1874; but no Farmyard Manure, or cross-dressings of Nitrate Soda, Ammonium-salts, or Rape-cake. Seed dibbled April 29 and 30; Crop taken up November 23–30.

1	Without Manure, 1874 and 1875 (Farmyard Manure in '71, '72, '73)	17 5	2 11	19 18	2 14	21 0	3 6	22 7	3 12	19 13	2 11
2	3½ cwts. Superphosphate (with Farmyard Manure, '71, '72, '73) ..	15 11	2 2	19 18	2 18	18 17	2 18	20 9	3 5	18 10	2 1
3	Without Manure (1846, and since)	5 9	1 1	9 5	1 12	8 0	1 3	14 1	2 13	11 17	1 10
4	{3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia .. .. ..}	5 9	1 0	9 8	1 7	7 16	1 1	12 14	1 14	10 3	1 7
5	3½ cwts. Superphosphate	5 11	1 2	9 19	1 10	7 16	1 4	13 17	2 8	11 2	1 14
6	3½ cwts. Superphos., 500 lbs. Sulph. Potash	5 4	1 0	8 4	1 4	7 1	1 2	12 8	2 3	10 2	1 9
7	3½ cwts. Superphos., 500 lbs. Sulph. Pot., and Amm.-salts '71, '72, '73	5 11	1 1	8 2	1 6	7 6	1 1	11 17	1 17	10 6	1 11
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	4 15	1 0	7 4	1 2	6 1	1 4	12 2	2 11	11 12	2 13

(1) "Superphosphate of Lime"—in all cases made from 200 lbs. Bone-ash, 150 lbs. Sulphuric Acid, sp. gr. 1·7 (and water).
(2) "Ammonium-salts"—in each case equal parts Sulphate and Muriate of Ammonia of Commerce.
(3) Owing to the deficiency of Rain for some time after sowing, a large proportion of the plants failed. Some were transplanted on Plots 1, but not on the other plots; and eventually the plant was (excepting on Plots 1) upon the whole very deficient and irregular, the remaining plants being larger than usual.

EXPERIMENTS ON SUGAR BEET.—BARN FIELD—*continued.*

SUMMARY OF THE COMPOSITION OF THE SUGAR-BEET ROOTS.

An abstract of the analytical results obtained illustrating the influence of different manures, and different seasons, on the composition of Sugar-beet, is given below. In interpreting the figures it must be borne in mind that with forty different experiments each year, and in each year four, or five, or more times as much produce on some Plots as on others, it would be impossible to sample each at its best, and all in the same condition of ripeness. Each year the seed was sown on all the Plots at the same time; and the samples (each consisting of the vertical fourths of 10 or 15 roots) were taken from all within a period of about a week, beginning with the ripest. It is obvious, however, that the smaller crops would be much riper than the larger ones. The dry matter, ash, and nitrogen, as given in the Table, are determined in the roots themselves; but they have generally been determined in the expressed juice also.

The sugar was determined in the expressed juice, and calculated into its percentage in the roots in accordance with the methods adopted at the time the experiments were made (1871–75), which were founded on the estimate of the percentage of juice in the roots, reckoned from the determined percentage of dry matter in the juice and in the roots. The results showed an average of about 95 per cent. of juice, and this figure was adopted in calculating the amount of sugar in the roots from that determined in the juice. In 1879, however, Scheibler published results obtained by determining the sugar in Sugar-beet, both directly in the roots by extraction with dilute alcohol, and also in the juice in the ordinary way. Whilst the old method indicated an average of about 95 per cent. of juice, the new one showed only about 90 per cent. Scheibler concluded that water equal to the difference (about 5 per cent.) existed in combination with the marc, and this he termed "colloid water," as distinguished from the water of the juice. In the Rothamsted "Memoranda" for 1881, attention was called to Scheibler's new results and conclusions, and it was pointed out that if they were confirmed the percentages of sugar annually recorded in the Tables of the Rothamsted results should be reduced by about $\frac{1}{18}$ or $\frac{1}{20}$. Subsequently, further evidence, and especially results obtained by Maercker, by the extraction of the sugar in the roots by alcohol, left no doubt that the amount of juice in Sugar-beet averages more nearly 90 than 95 per cent.; and having in 1895 to re-consider the subject for a paper on "Root-crops," the previously annually recorded percentages of sugar in the experimentally grown Sugar-beet, were then corrected on the assumption that the amount of juice will on the average be only 90 per cent., and the results as so corrected are given in the Table below. It is obvious, however, that with roots varying so much in character of growth, size, and ripeness, the percentage of juice would not be the same in all. Nevertheless, it was considered that the results calculated on the assumption of 95 per cent. of juice, approximately and usefully represented the actual and relative amounts of sugar in the various roots; and now that only 90 per cent. of juice is assumed, it may be supposed that the results will be actually nearer the truth than before, and relatively as near.

It need only further be observed that although, in comparable cases, the larger crops generally give a juice containing a lower percentage of sugar, and higher percentages of mineral matter and of nitrogen, yet the larger crops yielded very much more sugar per acre.

Plots.	Manures, per Acre, per Annum, unless otherwise stated (see below).																			
	Abbreviated Description of Standard Manures. For details, see pp. 52–3.	Series 1. Standard Manures only.				Series 2. Standard Manures, and Cross-dressed with 550 lbs. Nitrate Soda.				Series 3. Standard Manures, and Cross-dressed with 400 lbs. "Ammonium-salts."				Series 4. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake, and 400 lbs. "Ammonium-salts."				Series 5. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake.			
First Season, 1871. (Results in all cases the means of determinations made on two samples, collected at the end of October, and the end of November, respectively.)																				
		Mean Per Cent. Total Dry Matter, Sugar, Mineral Matter (Crude Ash), and Nitrogen in the Roots.																		
		Dry Matter.	Sugar.	Ash.	Nitrogen.	Dry Matter.	Sugar.	Ash.	Nitrogen.	Dry Matter.	Sugar.	Ash.	Nitrogen.	Dry Matter.	Sugar.	Ash.	Nitrogen.	Dry Matter.	Sugar.	Ash.	Nitrogen.
		Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.
1	Farmyard Manure	17·04	11·16	0·821	0·142	14·83	9·25	0·945	0·184	16·07	10·46	0·934	0·199	14·73	8·87	1·021	0·271	15·44	9·71	0·892	0·191
2	Farmyard Manure, & Super. ..	17·24	11·29	0·826	0·146	15·03	9·28	0·970	0·199	15·12	9·43	0·977	0·212	14·80	8·75	0·988	0·249	16·11	10·24	0·909	
3	Unmanured (1846, & since) ..	17·47	11·86	0·711		15·36	9·82	0·861		17·75	10·40	0·901		16·71	9·15	0·915		16 95	11·10	0·758	
4	Super., & Pot., Sod., & Mag. ..	18·07	12·31	0·738	0·100	15·72	10·24	0·828	0·157	18·68	11·74	0·907	0·170	16·87	9·38	1·002	0·244	16·61	11·08	0·767	0·138
5	Superphosphate	17·89	12·53	0·746	0·101	15·93	10·49	0·787	0·130	16·36	10·83	0·754	0·176	14·63	8·79	0·843	0·251	16·84	11·22	0·722	0·155
6	Super., & Potash	18·09	12·32	0·778	0·098	15·29	9·92	0·856	0·137	16·33	10·91	0·843	0·148	15·28	9·20	0·956	0·273	17·05	11·44	0·812	0·146
7	Super., Pot., & 36½ lb. Am.-slts.	17·97	12·47	0·762		15·86	9·98	0·901		16·71	10·89	0·826		15·99	9·69	0·904		17·57	11·65	0·782	
8	Unmanured (1853, & since) ..	18·32	12·33	0·791		15·98	10·48	0·856		16·08	10·30	0·764		14·90	8·84	0·806		16·73	11·29	0·747	

SECOND SEASON, 1872. (Samples collected early in November.)

1	Farmyard Manure	18·23	12·29	0·874		17·07	11·40	0·973		17·07	11·32	0·962		17·17	11·43	0·930		17·75	11·70	0·925	
2	Farmyard Manure, & Super. ..	18·07	12·36	0·822		15·97	10·53	1·000		16·04	9·88	0·982		17·07	11·29	0·965		17·95	12·14	0·875	
3	Unmanured (1846, & since) ..	19·22	13·26	0·767		17·83	12·11	0·823		19·62	13·63	0·691		17·87	11·93	0·720		19·12	13·21	0·683	
4	Super., & Pot., Sod., & Mag. ..	19·08	13·41	0·778	0·110	16·97	11·55	0·860	0·148	18·55	12·62	0·800	0·128	18·49	12·00	0·965	0·184	18·67	12·67	0·795	0·139
5	Superphosphate	18·67	13·19	0·712	0·101	16·37	10·58	0·866	0·167	18·40	12·34	0·734	0·167	15·82	9·86	0·918	0·250	18·07	12·53	0·705	0·159
6	Super., & Potash	18·83	13·09	0·772	0·098	17·08	11·26	0·891	0·167	18·70	12·75	0·837	0·166	17·38	11·51	0·879	0·173	18·41	12·47	0·780	0·162
7	Super., Pot., & 36½ lb. Am.-slts.	19·03	13·20	0·742		16·66	10·63	0·937		18·71	12·65	0·787		17·98	12·15	0·797		19·01	13·32	0·809	
8	Unmanured (1853, & since) ..	18·69	..	0·701		16·84	..	0·911		..	..	0·790		18·00	..	0·738		18·95	..	0·685	

THIRD SEASON, 1873. (Samples collected from November 10 to November 14.)

1	Farmyard Manure	17·62	12·06	0·924		16·64	10·61	0·947		16·76	10·74	0·965		18·80	9·68	1·267		16·88	11·03	0·887	
2	Farmyard Manure, & Super. ..	18·49	12·34	0·847		16·35	10·19	0·973		16·54	10·98	0·951		13·39	9·75	0·905		16·33	10·92	0·960	
3	Unmanured (1846, & since) ..	18·96	13·11	0·710		16·97	11·27	0·843		18·76	12·38	0·762		16·00	10·65	0·755		17·94	13·46	0·735	
4	Super., & Pot., Sod., & Mag. ..	18·80	13·09	0·796	0·132	17·97	11·42	0·934	0·181	18·31	12·42	0·877	0·161	16·67	10·62	0·974	0·187	18·30	12·48	0·861	0·149
5	Superphosphate	19·25	13·52	0·679	0·121	16·89	10·90	0·847	0·184	18·24	12·47	0·604	0·186	16·66	11·03	0·734	0·227	18·93	12·77	0·664	0·160
6	Super., & Potash	19·64	13·60	0·757	0·119	17·94	11·84	0·810	0·169	18·42	12·52	0·894	0·140	17·56	11·27	0·906	0·212	18·22	12·29	0·845	0·148
7	Super., Pot., & 36½ lb. Am.-slts.	19·63	13·67	0·747		17·42	11·10	0·907		18·81	13·00	0·858		17·68	11·48	0·870		19·00	12·40	0·852	
8	Unmanured (1853, & since) ..	20·22	13·89	0·742		16·50	10·32	0·917		18·47	12·50	0·756		16·54	10·26	0·782		18·06	12·38	0·695	

FOURTH SEASON, 1874 (1). Mineral Manures as in 1872 and 1873; but no Farmyard Manure, or cross-dressings of Nitrate Soda, Ammonium-salts, or Rape-cake. (Samples collected in the middle of November.)

1	Farmyard Manure, '71, '72 & '73	14·66	10·57	1·100		14·27	9·62	1·089		14·35	9·27	1·112		13·53	9·70	1·029		14·39	10·28	0·972	
2	Farmyd. Manure, & Super. '71–'3	15·00	12·08	1·022		13·84	9·41	1·082		14·24	9·58	1·081		14·59	9·58	0·970		14·34	10·31	0·933	
3	Unmanured (1846, & since) ..	17·45	12·51	0·792		15·60	9·63	0·990		16·05	11·07	0·863		15·54	10·84	0·861		15·04	10·53	0·864	
4	Super., & Pot., Sod., & Mag. ..	18·54	12·41	0·721		14·00	9·22	0·840		16·70	11·75	0·921		17·17	11·01	1·026		14·98	11·89	1·027	
5	Superphosphate	18·06	12·32	0·668		14·91	9·26	0·898		16·87	11·76	0·833		14·89	10·94	0·746		16·26	10·25	0·796	
6	Super., & Potash	17·83	12·30	0·752		15·95	9·95	0·859		16·70	12·97	0·865		15·30	11·41	0·938		16·29	10·46	0·879	
7	Super., Pot., & 36½ lb. Am.-slts.	16·88	..	0·730		15·56	..	0·903		17·74	..	0·784		16·08	..	0·907		15·50	..	0·868	
8	Unmanured (1853, & since) ..	18·76	..	0·726		15·30	..	0·890		17·35	..	0·771		15·48	..	0·841		16·51	..	0·772	

FIFTH SEASON, 1875. Mineral Manures as in 1872, 1873, and 1874; but no Farmyard Manure, or cross-dressings of Nitrate Soda, Ammonium-salts, or Rape-cake. (Samples collected in the middle of November.)

1	Farmyard Manure, '71, '72 & '73	16·02	11·10	0·749		16·16	11·22	0·751		16·33	10·91	0·814		16·29	11·39	0·840		16·13	10·96	0·780	
2	Farmyd. Manure, & Super. '71–'3	16·08	11·11	0·784		15·67	10·63	0·687		15·43	10·21	0·863		15·70	10·32	0·770		15·92	11·10	0·793	
3	Unmanured (1846, & since) ..	17·29	12·11	0·671		15·66	10·92	0·720		17·52	12·12	0·675		15·90	10·85	0·652		16·48	11·48	0·641	
4	Super., & Pot., Sod., & Mag. ..	16·67	11·48	0·773	0·103	16·10	11·42	0·751	0·112	17·07	11·67	0·755		16·56	11·27	0·758	0·125	16·24	11·07	0·775	0·121
5	Superphosphate	16·94	12·30	0·686	0·107	16·53	11·46	0·722	0·125	16·55	11·45	0·683	0·122	15·34	10·61	0·682	0·152	15·86	11·19	0·622	0·123
6	Super., & Potash	18·04	12·00	0·782	0·127	16·78	11·82	0·762	0·123	16·19	11·57	0·752	0·136	16·21	10·97	0·777	0·158	16·53	11·46	0·759	0·141
7	Super., Pot., & 36½ lb. Am.-slts.	17·51	..	0·730		16·22	..	0·874		16·50	..	0·802		15·88	..	0·856		16·38	..	0·866	
8	Unmanured (1853, & since) ..	16·81	..	0·770		16·01	..	0·812		16·56	..	0·767		15·96	..	0·768		15·86	..	0·658	

(1) Owing to the deficiency of Rain for some time after sowing, a large proportion of the plants failed. Some were transplanted on Plots 1, but not on the other plots, and eventually the plant was (excepting on Plots 1) upon the whole very deficient and irregular, the remaining plants being larger than usual.

EXPERIMENTS ON **MANGEL WURZEL.**—BARN FIELD (after SUGAR-BEET); commencing 1876.

Below are given the particulars of the Manures and Produce in each of the first 5 Seasons, 1876–1880; also the average Produce of those first 5 Seasons. For continuation, see pp. 60–1, 64–5, 68–9, and 72–73.

The arrangement of the Plots is precisely the same as previously for Sugar-beet, excepting that Plot 9, which was unmanured for Sugar-beet, and also previously for Swedes, is now added as a manured Plot. With this exception, the manures are also substantially the same as previously for Sugar-beet; in fact, precisely the same as for the Sugar-beet in 1872 and 1873. Seed, Yellow Globe; dibbled on ridges, rows 26 inches apart; plants 11 inches apart in the rows (3). Roots all carted off; Leaves weighed, spread on the respective Plots, and ploughed in.

(Area under experiment about 8 acres.)

PLOTS.	STANDARD MANURES.	MANURES PER ACRE PER ANNUM. SERIES 1. Standard Manures only.	SERIES 2. Standard Manures, and Cross-dressed with 550 lbs. Nitrate Soda.	SERIES 3. Standard Manures, and Cross-dressed with 400 lbs. "Ammonium-salts."	SERIES 4. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake and 400 lbs. "Ammonium-salts."	SERIES 5. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake.
	FIRST SEASON, 1876. Seed dibbled, May 22–26. Crop taken up, Nov. 3–17.					
		PRODUCE PER ACRE.				
		Roots. Tons. cwts. / Leaves. Tons. cwts.	Roots. Tons. cwts. / Leaves. Tons. cwts.	Roots. Tons. cwts. / Leaves. Tons. cwts.	Roots. Tons. cwts. / Leaves. Tons. cwts.	Roots. Tons. cwts. / Leaves. Tons. cwts.
1	Farmyard Manure (14 tons)	19 12 / 4 9	25 2 / 7 5	29 19 / 7 12	31 9 / 10 5	24 9 / 5 19
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	19 13 / 4 6	27 13 / 7 3	29 8 / 7 10	30 18 / 9 16	29 19 / 6 12
3	Without Manure (1846, and since)	6 10 / 1 14	20 13 / 5 12	14 3 / 4 10	19 19 / 7 7	17 4 / 4 15
4	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	8 8 / 1 15	25 1 / 6 0	19 19 / 4 9	30 8 / 8 13	25 8 / 5 10
5	3½ cwts. Superphosphate	7 10 / 1 14	21 0 / 5 14	13 10 / 5 1	17 2 / 7 14	17 17 / 5 17
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash	6 16 / 1 12	21 2 / 5 8	17 15 / 4 13	26 8 / 9 0	20 10 / 5 4
7	3½ cwts. Superphos., 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (2)	8 13 / 2 3	22 11 / 5 14	19 2 / 5 11	27 2 / 9 9	20 12 / 5 15
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	5 9 / 1 10	15 16 / 5 3	11 17 / 4 16	18 2 / 7 11	15 12 / 4 18
9	Farmyard Manure (14 tons), 3½ cwts. Superphosphate (3)	.. / ..	.. / ..	25 14 / 7 6	.. / ..	.. / ..
	SECOND SEASON, 1877. Seed dibbled, June 4–6 (Plots 8 and 9, June 11th). Crop taken up, Nov. 14–23.					
1	Farmyard Manure (14 tons)	15 7 / 2 1	24 13 / 3 14	27 1 / 4 4	30 5 / 5 5	25 18 / 3 4
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	16 14 / 1 19	26 8 / 3 12	26 18 / 4 6	28 15 / 5 9	24 12 / 2 19
3	Without Manure (1846, and since)	5 9 / 1 0	16 17 / 3 14	8 16 / 3 0	13 9 / 3 19	13 17 / 2 10
4	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	6 16 / 1 3	21 10 / 3 10	16 10 / 2 2	27 9 / 3 8	21 14 / 1 17
5	3½ cwts. Superphosphate	6 1 / 0 19	20 5 / 3 1	12 2 / 2 10	15 3 / 3 8	15 3 / 2 2
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash	5 8 / 0 18	20 19 / 2 18	15 6 / 1 16	24 18 / 3 16	19 3 / 1 12
7	3½ cwts. Superphos., 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (2)	7 0 / 1 3	22 2 / 3 16	16 13 / 2 7	25 15 / 5 0	20 13 / 2 8
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	3 19 / 1 3	9 17 / 5 4	7 4 / 3 10	11 9 / 4 11	10 3 / 3 3
9	Farmyard Manure (14 tons), 3½ cwts. Superphosphate (3)	.. / ..	.. / ..	13 17 / 4 0	.. / ..	.. / ..

THIRD SEASON, 1878. Seed dibbled, June 8–9 (Plot 9, June 11th). Crop taken up, Nov. 7–20.

1	Farmyard Manure (14 tons)	13	5	2	16	18	15	4	4	20	11	5	6	22	4	6	3	17	1	3	13
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1) ..	14	16	2	19	21	4	4	15	19	15	5	3	20	18	5	17	18	17	3	15
3	Without Manure (1846, and since)	3	10	1	4	10	2	2	16	4	7	2	11	6	11	3	7	6	3	2	17
4	{3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia .. .. ..}	5	9	1	7	18	10	4	6	14	3	2	12	21	2	4	14	15	19	3	2
5	3½ cwts. Superphosphate	4	14	1	8	14	11	3	18	8	2	3	6	8	4	3	3	8	1	3	6
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash	3	18	1	3	15	1	3	7	12	0	2	14	15	3	4	11	12	5	3	3
7	3½ cwts. Superphos., 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (2)	5	8	1	9	13	18	3	1	11	18	2	18	14	0	4	5	11	19	3	8
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	2	13	1	4	11	19	4	7	6	13	3	5	6	12	4	10	6	4	3	5
9	Farmyard Manure (14 tons), 3½ cwts. Superphosphate (3)	..		..		..		..		15	17	5	9	..		..		..		..	

FOURTH SEASON, 1879. Seed dibbled, May 13–15. Crop taken up, Nov. 11–20.

1	Farmyard Manure (14 tons)	6	3	1	15	9	8	2	9	12	6	3	11	13	16	3	15	10	14	2	12
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1) ..	6	13	1	16	11	11	2	18	11	12	3	9	14	1	3	17	9	18	2	11
3	Without Manure (1846, and since)	1	12	0	12	4	17	1	19	3	12	2	4	7	17	3	3	6	8	1	17
4	{3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia .. .. ..}	2	2	0	14	8	13	2	8	7	10	1	15	12	10	2	19	7	7	1	14
5	3½ cwts. Superphosphate	1	18	0	14	8	5	2	9	5	0	1	16	9	13	3	5	6	11	1	12
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash	1	15	0	13	7	16	2	7	6	9	1	12	11	11	3	5	7	17	1	13
7	3½ cwts. Superphos., 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (2)	1	18	0	14	8	2	2	6	6	7	1	14	11	2	3	6	8	4	2	0
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	1	5	0	11	5	16	2	7	3	10	1	16	9	2	3	14	6	9	2	5
9	Farmyard Manure (14 tons), 3½ cwts. Superphosphate (3)	..		..		..		..		9	7	2	19	..		..		..		..	

FIFTH SEASON, 1880. Seed dibbled, April 22–23 (Plot 9, April 24th). Crop taken up, Nov. 2–11.

1	Farmyard Manure (14 tons)	18	11	2	14	26	8	3	5	25	4	5	10	27	3	6	1	27	5	4	1
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1) ..	17	8	2	0	27	16	3	14	25	15	5	10	26	0	5	12	27	9	4	3
3	Without Manure (1846, and since)	4	10	0	18	14	0	2	13	9	17	2	11	11	4	3	0	12	6	2	9
4	{3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia .. .. ..}	5	17	0	19	23	6	3	3	19	14	2	18	30	11	5	12	24	4	3	6
5	3½ cwts. Superphosphate	5	3	0	16	18	6	2	4	9	18	2	13	12	9	2	18	14	8	2	13
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash	4	15	0	14	21	10	2	11	18	12	3	4	27	4	5	11	21	8	2	7
7	3½ cwts. Superphos., 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (2)	7	0	0	19	21	10	2	6	19	6	2	19	26	0	5	6	23	2	2	11
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	4	0	0	17	11	14	3	5	5	19	2	17	12	4	3	1	12	1	2	15
9	Farmyard Manure (14 tons), 3½ cwts. Superphosphate (3)	..		..		..		..		20	19	4	0	..		..		..		..	

AVERAGE OF 5 SEASONS, 1876, '77, '78, '79, and 1880.

1	Farmyard Manure (14 tons)	14	12	2	15	20	17	4	3	23	0	5	5	24	19	6	6	21	1	3	18
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1) ..	15	1	2	12	22	18	4	8	22	14	5	4	24	2	6	2	22	3	4	0
3	Without Manure (1846, and since)	4	6	1	2	13	6	3	7	8	3	2	19	11	16	4	3	11	4	2	18
4	{3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia .. .. ..}	5	14	1	4	19	8	3	17	15	11	2	15	24	8	5	1	18	18	3	2
5	3½ cwts. Superphosphate	5	1	1	2	16	9	3	9	9	14	3	1	12	10	4	2	12	8	3	2
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash	4	10	1	0	17	6	3	6	14	0	2	16	21	1	5	5	16	5	2	16
7	3½ cwts. Superphos., 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (2)	6	0	1	6	17	13	3	9	14	13	3	2	20	16	5	9	16	18	3	4
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	3	9	1	1	11	0	4	1	7	1	3	5	12	0	4	13	10	2	3	5
9	Farmyard Manure (14 tons), 3½ cwts. Superphosphate (3)	..		..		..		..		17	3	4	15	..		..		..		..	

(1) "Superphosphate of Lime"—in all cases made from 200 lbs. Bone-ash, 150 lbs. Sulphuric acid, sp. gr. 1·7 (and water). (2) "Ammonium-salts"—in each case equal parts Sulphate and Muriate of Ammonia of Commerce.
(3) Plot 9 sown on the flat instead of on ridges; plants ridged up afterwards; rows 22 inches apart, plants 10 inches apart in the rows.

EXPERIMENTS ON **MANGEL WURZEL**.—BARN FIELD—*continued*.—SUMMARY OF THE COMPOSITION OF THE MANGEL ROOTS, in each of the first 5 Seasons, 1876–1880; also the average composition over the first 5 Seasons. For the composition in 1881 and succeeding years, see pp. 62–3, 66–7, 70–1, and 74–5.

An abstract of the analytical results obtained, illustrating the influence of different manures, and of different seasons, on the composition of Mangels, is given below. The dry matter, ash, and nitrogen, are of course determined in the roots themselves. The amounts of dry matter, ash, and nitrogen, have also, in many cases, been determined in the expressed juice. In many cases also, the amount of the nitrogen existing as albuminoids has been determined (by Church's method); and in some cases the amount as amides and as nitric acid. It may be observed that by far the larger proportion of both the mineral matter and the nitrogen of the roots is found in the juice; and of the nitrogen in the juice a variable proportion, ranging from less than one-fifth to not more than one-third of the total, is found to exist as albuminoids.

The sugar was determined in the expressed juice, and calculated into its percentage in the roots in accordance with the methods adopted at the time the experiments were made (1876–80), which were founded on the estimate of the percentage of juice in the roots, reckoned from the determined percentage of dry matter in the juice and in the roots. The results showed an average of about 96 per cent. of juice, and this figure was adopted in calculating the amount of sugar in the roots from that determined in the juice. In 1879, however, Scheibler published results obtained by determining the sugar in *Sugar-beet*, both directly in the roots by extraction with dilute alcohol, and also in the juice in the ordinary way. Whilst the old method indicated an average of about 95 per cent. of juice, the new one showed only about 90 per cent. Scheibler concluded that water equal to the difference (about 5 per cent.) existed in combination with the marc, and this he termed "colloid water," as distinguished from the water of the juice. In the Rothamsted "Memoranda" for 1881, attention was called to Scheibler's new results and conclusions, in regard to Sugar-beet, and it was pointed out that if they were confirmed the percentages of sugar annually recorded in the Tables of the Rothamsted results should be reduced by about $\frac{1}{15}$ or $\frac{1}{20}$. It was further pointed out, that supposing the same applied to Mangels, and that the amount of true juice in them averaged only 90 instead of 96 per cent., the percentage of sugar in their roots would also be from $\frac{1}{15}$ or $\frac{1}{20}$ less than given in the Table. Subsequently, further evidence, and especially results obtained by Maercker, by the extraction of the sugar in the roots by alcohol, left no doubt that the amount of juice in Sugar-beet averages more nearly 90 than 95 per cent. We are not aware of any published results of the determinations of sugar in Mangel-roots by extraction with alcohol; but until direct evidence on the point is available, it is assumed that the amount of juice in Mangels, like that in Sugar-beet, will probably average about 90 per cent.; and having in 1895 to reconsider the subject for a paper on "Root-crops," the previously annually recorded percentages of sugar in the experimentally grown Mangel-roots, were then corrected on the assumption that the amount of juice will on the average be only 90 per cent., and the results as so corrected are given in the Table below. It is obvious, however, that with roots varying so much in character of growth, size, and ripeness, the percentage of juice would not be the same in all. Nevertheless, it was considered that the results calculated on the assumption of 96 per cent. of juice, approximately and usefully represented the actual and relative amounts of sugar in the various roots; and now that only 90 per cent. of juice is assumed it may be supposed that the results will be actually nearer the truth than before, and relatively as near.

In interpreting the figures, it must be borne in mind, that, with forty different experiments each year, and, in each year four, five, or more times, as much produce on some Plots as on others, it would be impossible to sample each at its best, and all in the same condition of ripeness. Each year the seed was sown on all the Plots at the same time. The sample analysed was in each case a mixture of vertical sections of ten or fifteen roots, and all the samples were as a rule taken within a period of from one to two weeks; as far as practicable beginning with the ripest. It is obvious, however, that the smaller crops would be much riper than the larger ones; but, although the larger crops generally contain a lower percentage of sugar, they yield very much more sugar per acre.

Plots.	Abbreviated Description of Standard Manures. For details, see pp. 56–7.	Series 1. Standard Manures only.				Series 2. Standard Manures, and Cross-dressed with 550 lbs. Nitrate Soda.				Series 3. Standard Manures, and Cross-dressed with 400 lbs. Ammonium-salts.				Series 4. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake and 400 lbs. Am.-salts.				Series 5. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake.			
		Manures, per Acre, per Annum.																			
		First Season, 1876.																			
		Mean Per Cent. Total Dry Matter, Sugar, Mineral Matter (Crude Ash), and Nitrogen, in the Roots.																			
		Dry Matter.	Sugar.	Ash.	Nitrogen.	Dry Matter.	Sugar.	Ash.	Nitrogen.	Dry Matter.	Sugar.	Ash.	Nitrogen.	Dry Matter.	Sugar.	Ash.	Nitrogen.	Dry Matter.	Sugar.	Ash.	Nitrogen.
		Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.
1	Farmyard Manure	12·14	6·70	0·969		10·54	..	1·031		10·65	..	1·080		8·98	..	1·065		11·30	..	0·989	
2	Farmyard Manure, & Super. ..	12·41	6·74	0·943		9·35	4·55	1·020		9·64	5·36	1·018		8·92	..	1·034		10·51	..	1·005	
3	Unmanured (1846, & since) ..	15·14	..	0·828		11·94	..	0·903		12·16	..	0·904		11·60	..	0·811		12·42	..	0·751	
4	Super., & Pot., Sod., & Mag. ..	13·99	8·42	0·905		11·36	5·92	1·013		12·23	6·71	0·989		9·91	5·27	1·067		11·28	6·51	1·003	
5	Superphosphate	13·51	8·88	0·818		10·99	5·96	0·917		11·73	6·82	0·735		10·93	5·67	0·816		10·65	6·41	0·744	
6	Super., & Potash	13·67	8·19	0·928		11·23	7·19	0·929		11·02	6·95	0·993		10·56	5·07	1·036		11·55	6·84	0·911	
7	Super., Pot., & 36½ lb. Am.-slts.	13·63	..	0·882		11·61	..	0·922		10·62	..	0·969		10·66	..	1·015		11·58	..	0·936	
8	Unmanured (1853, & since) ..	13·06	..	0·900		11·23	..	0·945		11·43	..	0·905		10·20	..	0·856		11·61	..	0·757	
9	Farmyard Manure, & Super. ..	..	..	..	..	..	..	..	..	11·59	..	0·876	..	..	..	..	..	..	..	..	..
		Second Season, 1877.																			
1	Farmyard Manure	14·48	8·48	0·988		12·01	7·70	1·122		12·95	8·39	1·097		12·44	7·47	1·114		13·34	7·30	1·010	
2	Farmyard Manure, & Super. ..	13·85	9·39	0·961		12·91	7·70	1·107		13·24	7·35	1·089		11·78	7·20	1·126		14·08	7·97	1·000	
3	Unmanured (1846, & since) ..	16·58	10·49	0·827		14·06	8·21	1·072		17·11	9·52	0·888		14·44	9·19	0·834		16·41	9·58	0·819	
4	Super., & Pot., Sod., & Mag. ..	15·42	10·24	0·948		12·25	6·80	1·121		13·11	8·77	1·085		12·69	7·04	1·221		13·45	9·20	1·046	
5	Superphosphate	15·84	10·93	0·797		12·90	8·01	0·889		15·63	9·38	0·838		14·36	7·72	0·786		15·35	10·04	0·784	
6	Super., & Potash	16·15	10·60	0·891		12·53	8·53	1·135		15·05	8·86	1·095		14·27	8·34	1·061		14·10	9·32	0·978	
7	Super., Pot., & 36½ lb. Am.-slts.	15·88	..	0·943		12·74	..	1·034		13·96	..	1·098		12·58	..	1·136		13·83	..	1·036	
8	Unmanured (1853, & since) ..	16·23	..	0·933		14·01	..	1·023		14·95	..	0·932		14·51	..	0·811		14·87	..	0·807	
9	Farmyard Manure, & Super. ..	..	..	..	..	..	..	..	..	14·84	..	1·011	..	..	..	..	..	..	..	..	..

THIRD SEASON, 1878.

1	Farmyard Manure	12·26	6·87	0·995	0·170	11·47	5·97	1·036	0·218	11·17	5·88	1·013	0·206	10·83	5·30	1·046	0·241	11·98	6·47	0·985	0·186
2	Farmyard Manure, & Super. ..	11·51	6·53	0·981	0·182	10·05	4·89	1·072	0·216	11·00	5·70	1·034	0·206	10·50	5·57	0·987	0·217	10·66	5·76	0·948	0·175
3	Unmanured (1846, & since) ..	15·25	9·56	0·824	0·186	12·02	6·64	0 908	0·211	13·47	7·59	0·811	0·261	12·86	7·14	0·802	0·247	14·10	8·27	0·846	0 240
4	Super., & Pot., Sod., & Mag. ..	13·56	8·45	0·928	0·129	11·03	5·85	1·084	0·188	11·90	6·81	0·975	0·144	10·33	5·51	1·027	0·181	11·22	6·12	1·044	0·171
5	Superphosphate	13·91	8·60	0·810	0·144	11·61	6·47	0·873	0·188	13·00	7·63	0·845	0·187	12·69	7·20	0·739	0·244	13·87	8·12	0·786	0·211
6	Super., & Potash	14·23	8·55	0·989	0·173	11·04	5·84	0·986	0·193	13·55	8·13	0·988	0·184	12·09	6·53	1·016	0·235	12·18	6·90	0·940	0·197
7	Super., Pot., & 36½ lb. Am.-slts.	13·42	..	0·976	..	11·26	..	0·982	..	11·92	..	0·932	..	12·03	..	0·986	..	12·05	..	0·977	..
8	Unmanured (1853, & since) ..	14·50	..	0·903	..	11·10	..	0·937	..	12·81	..	0·869	..	11·93	..	0·879	..	12·52	..	0·863	..
9	Farmyard Manure, & Super. ..	..	..	..	..	..	..	..	..	10·77	..	0·939	..	..	..	..	..	..	..	..	..

FOURTH SEASON, 1879.

1	Farmyard Manure	14·91	9·02	1·007	0·175	13·18	7·47	1·010	0·196	13·86	8·13	1·025	0·193	13·34	7·51	1·025	0·186	14·62	8·61	1·022	0·177
2	Farmyard Manure, & Super. ..	14·78	8·90	1·012	0·185	13·43	7·58	1·016	0·184	13·14	7·57	1·051	0·181	13·54	7·80	1·064	0·186	14·40	8·67	0·995	0·219
3	Unmanured (1846, & since) ..	18·81	11·72	0·861	0·205	16·01	9·38	0·955	0·226	17·18	10·39	0·834	0·252	16·27	9·79	0·831	0·260	16·16	9·81	0·842	0·203
4	Super., & Pot., Sod., & Mag. ..	15·56	9·78	0·980	0·151	12·83	7·60	1·010	0·156	14·03	8·70	0·962	0·134	13·67	7·84	1·086	0·171	13·51	8·08	0·938	0·136
5	Superphosphate	16·53	10·58	0·848	0·159	12·60	7·34	0·951	0·180	15·61	9·77	0·814	0·202	14·84	8·68	0·810	0·220	15·57	9·75	0·840	0·182
6	Super., & Potash	16·34	10·29	1·008	0·156	13·75	8·21	0·972	0·180	14·50	9·00	0·998	0·162	13·49	7·94	1·038	0·214	14·42	8·77	0·949	0·157
7	Super., Pot., & 36½ lb. Am.-slts.	16·33	..	0·895	..	12·97	..	0·997	..	14·48	..	0·946	..	14·18	..	0·947	..	15·35	..	0·947	..
8	Unmanured (1853, & since) ..	18·46	..	0·903	..	13·78	..	0·963	..	15·44	..	0·812	..	14·13	..	0·853	..	15·58	..	0·852	..
9	Farmyard Manure, & Super. ..	..	..	..	..	..	..	..	..	14·52	..	0·930	..	..	..	..	..	..	..	..	..

FIFTH SEASON, 1880.

1	Farmyard Manure	12·65	7·79	0·841	0·126	10·72	5·63	0·942	0·186	11·23	6·39	0·871	0·172	11·26	6·35	0·877	0·212	12·08	6·72	0·877	0·176
2	Farmyard Manure, & Super. ..	12·87	7·56	0·850	0·136	10·44	5·52	0·986	0·188	11·68	6·59	0·891	0·189	10·47	5·94	0·948	0·220	11·66	6·69	0·855	0·171
3	Unmanured (1846, & since) ..	17·02	11·04	0·739	0·142	12·18	6·90	0·874	0·217	14·48	8·63	0·746	0·272	11·75	6·66	0·716	0·225	12·95	7·80	0·690	0·203
4	Super., & Pot., Sod., & Mag. ..	14·05	9·25	0·756	0·082	12·36	7·61	0·847	0·136	12·23	7·71	0·849	0·119	10·77	6·12	0·883	0·151	11·18	6·74	0·869	0·123
5	Superphosphate	13·72	8·85	0·709	0·100	11·50	6·47	0·819	0·173	12·84	7·94	0·709	0·158	10·72	6·20	0·679	0·192	12·27	7·35	0·676	0·165
6	Super., & Potash	14·04	8·99	0·761	0·097	11·86	7·00	0·807	0·153	12·40	7·46	0·878	0·123	12·16	7·00	0·837	0·188	13·17	8·14	0·745	0·151
7	Super., Pot., & 36½ lb. Am.-slts.	13·63	..	0·798	..	11·64	..	0·862	0·154	12·14	..	0·863	..	11·68	..	0·906	..	12·79	..	0·742	..
8	Unmanured (1853, & since) ..	14·26	..	0·776	..	12·61	..	0·863	..	14·08	..	0·772	..	11·29	..	0·693	..	12·91	..	0·672	..
9	Farmyard Manure, & Super. ..	..	..	..	..	..	..	..	..	11·32	..	0·801	..	..	..	..	..	..	..	..	..

AVERAGE OF 5(1) SEASONS, 1876, '77, '78, '79, and 1880.

1	Farmyard Manure	13·29	8·04	0·960	0·157	11·58	6·69	1·028	0·200	11·97	7·20	1·017	0·190	11·37	6·66	1·025	0·213	12·66	7·28	0·977	0·180
2	Farmyard Manure, & Super. ..	13·08	8·10	0·949	0·168	11·24	6·42	1·040	0·196	11·74	6·80	1·017	0·192	11·04	6.63	1·032	0·208	12·26	7·27	0·961	0·188
3	Unmanured (1846, & since) ..	16·56	10·70	0·816	0·178	13·24	7·78	0·942	0·218	14·88	9·03	0·837	0·262	13·38	8·20	0·799	0·244	14·41	8·87	0·790	0·215
4	Super., & Pot., Sod., & Mag. ..	14·52	9·23	0·903	0·121	11·97	6·76	1·015	0·160	12·70	7·74	0·972	0·132	11·47	6·36	1·057	0·168	12·13	7·33	0·980	0·143
5	Superphosphate	14·70	9·57	0·796	0·134	11·92	6·85	0·890	0·180	13·76	8·31	0·788	0·182	12·71	7·09	0·766	0·219	13·54	8·33	0·766	0·186
6	Super., & Potash	14·89	9·32	0·915	0·142	12·08	7·35	0·966	0·175	13·30	8·08	0·990	0·156	12·51	6·98	0·998	0·212	13·08	7·99	0·905	0·168
7	Super., Pot., & 36½ lb. Am.-slts.	14·58	..	0·899	..	12·04	..	0·959	..	12·62	..	0·962	..	12·23	..	0·998	..	13·12	..	0·928	..
8	Unmanured (1853, & since) ..	15·30	..	0·883	..	12·55	..	0·946	..	13·74	..	0·858	..	12·41	..	0·818	..	13·50	..	0·790	..
9	Farmyard Manure, & Super. ..	..	..	..	..	..	..	..	..	12·61	..	0·911	..	..	..	..	..	..	..	..	..

(1) For Plots 1, 2, and 3, the average percentages of *Sugar* are taken over the last four years only; and in all cases the average percentages of *Nitrogen* are taken over the last three years only.

EXPERIMENTS ON **MANGEL WURZEL.**—BARN FIELD (after SUGAR-BEET); commencing 1876—*continued.*

Below are given the particulars of the Manures and Produce of the Sixth, Seventh, Eighth, Ninth, and Tenth Seasons, 1881, 1882, 1883, 1884, and 1885. For the Manures and Produce of the 5 preceding Seasons, see pp. 56–7, and for those of succeeding seasons, see pp. 64–5, 68–9 and 72–3.

The arrangement of the Plots, and of the Manures, is precisely the same as for the five preceding years of Mangels, and also the same as previously for Sugar-beet (see pp. 52–3), excepting that Plot 9, which was unmanured for Sugar-beet, and also previously for Swedes, was brought in as a manured Plot. With this exception, the manures are also substantially the same as previously for Sugar-beet; in fact, precisely the same as for the Sugar-beet in 1872 and 1873. Seed, Yellow Globe; in 1881 and 1883, seed dibbled, in 1882 and 1884 drilled, on ridges, rows 26 inches apart; plants 11 inches apart in the rows (3). In 1885 the seed was drilled on the flat on all the plots; see note 5, below. Roots all carted off; Leaves weighed, spread on the respective Plots, and ploughed in.

(Area under experiment, about 8 acres.)

Plots.	Manures per Acre per Annum.	Series 1. Standard Manures only.	Series 2. Standard Manures, and Cross-dressed with 550 lbs. Nitrate Soda.	Series 3. Standard Manures, and Cross-dressed with 400 lbs. "Ammonium-salts."	Series 4. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake and 400 lbs. "Ammonium-salts."	Series 5. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake.
	Sixth Season, 1881. Seed dibbled, April 19. Crop taken up, October 31 to November 10.					
	Produce per Acre.	Roots. Tons. cwts. / Leaves. Tons. cwts.	Roots. Tons. cwts. / Leaves. Tons. cwts.	Roots. Tons. cwts. / Leaves. Tons. cwts.	Roots. Tons. cwts. / Leaves. Tons. cwts.	Roots. Tons. cwts. / Leaves. Tons. cwts.
1	Farmyard Manure (14 tons)	13 15 / 2 8	17 19 / 3 16	15 14 / 3 13	15 3 / 4 10	15 5 / 3 14
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	15 2 / 2 3	19 12 / 4 4	16 10 / 4 8	18 6 / 5 5	15 5 / 3 16
3	Without Manure (1846, and since)	4 8 / 0 13	11 6 / 2 12	3 15 / 1 14	6 18 / 2 12	7 19 / 2 16
4	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	6 3 / 0 16	16 18 / 3 5	12 17 / 2 10	21 13 / 5 6	17 8 / 3 1
5	3½ cwts. Superphosphate	5 11 / 0 13	15 13 / 2 10	7 3 / 2 18	10 9 / 3 17	10 17 / 3 4
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash	4 19 / 0 12	16 8 / 2 9	11 9 / 2 10	17 7 / 4 7	16 7 / 2 10
7	3½ cwts. Superphos., 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (2)	6 12 / 0 16	16 17 / 2 17	12 12 / 2 13	17 15 / 4 4	18 1 / 2 13
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	4 10 / 0 13	10 16 / 3 13	4 3 / 2 1	8 18 / 3 9	10 0 / 3 2
9	Farmyard Manure (14 tons), 3½ cwts. Superphosphate (3)	.. / ..	.. / ..	20 18 / 5 10	.. / ..	.. / ..
	Seventh Season, 1882. Drilling the seed commenced on April 23, but, owing to wet weather, it was not completed until May 9. Plot 9 was *dibbled* May 23. Crop taken up Nov. 8–21.					
1	Farmyard Manure (14 tons)	14 14 / 2 12	21 19 / 3 19	23 5 / 5 13	27 4 / 6 15	25 3 / 4 4
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	15 18 / 2 17	25 2 / 5 4	23 5 / 6 4	25 10 / 6 18	25 12 / 4 3
3	Without Manure (1846, and since)	4 12 / 0 19	14 5 / 2 15	6 3 / 3 8	12 0 / 4 8	13 1 / 3 1
4	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	4 19 / 1 0	18 3 / 3 8	17 13 / 2 13	28 6 / 5 3	21 10 / 2 18
5	3½ cwts. Superphosphate	4 14 / 1 1	15 10 / 3 15	9 8 / 3 18	11 12 / 5 6	13 14 / 3 4
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash	4 5 / 0 18	15 16 / 3 2	17 2 / 2 18	24 4 / 6 3	19 19 / 2 13
7	3½ cwts. Superphos., 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (2)	6 1 / 1 3	16 8 / 3 14	17 6 / 3 5	23 12 / 5 19	20 16 / 3 2
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	3 10 / 0 17	11 9 / 3 12	7 0 / 3 18	9 14 / 4 15	10 12 / 4 1
9	Farmyard Manure (14 tons), 3½ cwts. Superphosphate (3)	.. / ..	.. / ..	18 3 / 5 10	.. / ..	.. / ..

EIGHTH SEASON, 1883. Seed dibbled April 5. Crop taken up Nov. 2–10. (4)

1	Farmyard Manure (14 tons)	22	12	3	16	27	5	4	7	24	6	6	3	33	5	7	7	33	5	4	7
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	18	19	2	16	28	15	5	2	23	5	6	10	32	14	7	11	31	2	3	19
3	Without Manure (1846, and since)	4	18	1	1	18	14	4	2	8	6	4	0	13	3	4	18	13	13	2	19
4	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	5	15	1	1	23	15	3	16	19	18	3	2	33	12	5	15	23	10	3	2
5	3½ cwts. Superphosphate	5	3	0	18	21	12	3	10	10	15	3	9	14	12	5	3	16	4	3	5
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash	4	6	0	16	21	1	2	14	19	4	2	17	33	5	6	9	23	9	2	13
7	3½ cwts. Superphos., 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (2)	6	4	1	1	22	14	2	19	20	12	2	17	33	4	6	8	24	17	3	4
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	4	6	0	18	17	0	3	19	7	11	3	0	13	1	4	15	13	10	4	1
9	Farmyard Manure (14 tons), 3½ cwts. Superphosphate (3)	..		..		..		..		20	11	5	9	..		..		..		..	

NINTH SEASON, 1884. Seed drilled April 10–11. Plot 9 dibbled April 12. Crop taken up Oct. 29–31.

1	Farmyard Manure (14 tons)	15	19	2	0	26	14	3	12	22	3	4	13	25	2	4	3	26	17	3	0
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	16	8	2	0	26	13	4	3	22	14	4	14	23	3	4	8	25	14	3	6
3	Without Manure (1846, and since)	5	11	0	19	7	5	2	8	5	15	2	9	7	16	2	15	10	0	2	18
4	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	6	7	1	1	12	1	2	19	13	18	3	3	23	19	4	14	19	7	2	6
5	3½ cwts. Superphosphate	5	19	0	18	5	17	1	15	4	14	2	12	8	7	3	5	9	4	3	0
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash	5	9	0	15	4	19	1	7	9	15	3	1	21	13	4	19	17	15	2	7
7	3½ cwts. Superphos., 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (2)	7	9	1	1	3	3	0	15	8	0	2	2	19	18	4	6	19	6	2	12
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	4	15	0	16	1	8	0	13	3	2	1	7	7	8	2	12	7	4	2	9
9	Farmyard Manure (14 tons), 3½ cwts. Superphosphate (3)	..		..		..		..		14	8	3	8	..		..		..		..	

TENTH SEASON, 1885. Mineral Manures and Rape-cake sown April 13; seed drilled April 14 and 15; Nitrate Soda and Ammonium-salts not sown (see note 5 below). Crop taken up Oct. 26–Nov. 2.

1	Farmyard Manure (14 tons)	3	6	0	16	2	15	0	15	3	1	0	18	11	15	2	9	15	8	2	9
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	2	1	0	10	2	1	0	12	2	14	0	14	10	7	2	7	13	10	2	5
3	Without Manure (1846, and since)	0	1	0	1	0	1	0	1	0	1	0	1	2	5	1	8	3	3	1	10
4	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	0	6	0	2	0	6	0	3	0	19	0	6	14	15	1	18	13	1	1	7
5	3½ cwts. Superphosphate	0	3	0	2	0	4	0	2	0	12	0	8	2	19	1	19	3	12	1	11
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash	0	10	0	4	0	10	0	5	2	5	0	12	8	16	2	5	7	14	2	4
7	3½ cwts. Superphos., 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (2)	0	10	0	4	0	14	0	5	1	16	0	10	7	18	2	2	6	6	1	12
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	0	9	0	4	1	0	0	9	0	4	0	2	0	14	0	17	0	12	0	13
9	Farmyard Manure (14 tons), 3½ cwts. Superphosphate (3)	..		..		..		..		2	8	0	19	..		..		..		..	

AVERAGE OF 4 SEASONS, 1881, '82, '83 and 1884. (6)

1	Farmyard Manure (14 tons)	16	15	2	14	23	9	3	19	21	7	5	0	25	3	5	14	25	3	3	16
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	16	12	2	9	25	1	4	13	21	9	5	9	24	18	6	1	24	8	3	16
3	Without Manure (1846, and since)	4	17	0	18	12	18	2	19	6	0	2	18	9	19	3	13	11	3	2	19
4	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	5	16	1	0	17	14	3	7	16	2	2	17	26	18	5	4	20	9	2	17
5	3½ cwts. Superphosphate	5	7	0	17	14	13	2	18	8	0	3	4	11	5	4	8	12	10	3	3
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash	4	15	0	15	14	11	2	8	14	8	2	16	24	2	5	10	19	7	2	11
7	3½ cwts. Superphos., 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (2)	6	12	1	0	14	16	2	11	14	13	2	14	23	12	5	4	20	15	2	18
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	4	5	0	16	10	3	2	19	5	9	2	12	9	15	3	18	10	7	3	8
9	Farmyard Manure (14 tons), 3½ cwts. Superphosphate (3)	..		..		..		..		18	10	4	19	..		..		..		..	

(1) "Superphosphate of Lime"—in all cases made from 200 lbs. Bone ash, 150 lbs. Sulphuric acid, sp. gr. 1·7 (and water). (2) "Ammonium-salts"—in each case equal parts Sulphate and Muriate of Ammonia of Commerce.
(3) Plot 9 sown on the flat instead of on ridges; plants ridged up afterwards; rows 22 inches apart, plants 10 inches apart in the rows.
(4) Owing to dry weather much seed failed, especially on some Ammonia and Nitrate plots, and the blanks were filled up by transplanting.
(5) In order to lessen possible loss by drainage, or injury to the seed or young plants, it was decided to top-dress the Nitrate of Soda and Ammonium-salts after the plant was well up, and for greater convenience the seed was sown on the flat; but owing to unfavourable weather, and to the unsatisfactory condition of the land where these manures had been applied without any organic matter for so many years, the plant almost entirely failed, and the Nitrate and Ammonium-salts were therefore not sown at all. On Series 4 and 5, however, where Rape-cake is usually applied, and the soil was more open, the seed germinated, and the plants grew fairly well.
(6) Owing to the failure of the plant on many plots, and the irregularity of the crops in 1885, the produce of that year is not brought into the average.

EXPERIMENTS ON **MANGEL WURZEL.**—BARN FIELD—*continued.*—SUMMARY OF THE COMPOSITION OF THE MANGEL ROOTS, in the Sixth, Seventh, Eighth, Ninth, and Tenth Seasons, 1881, 1882, 1883, 1884, and 1885. For particulars of the composition in the first 5 Years, 1876–1880, see pp. 58–9, and for those in succeeding seasons see pp. 66–7, 70–1, and 74–5.

An abstract of the analytical results obtained, illustrating the influence of different manures, and of different seasons, on the composition of Mangels, is given below. The dry matter, ash, and nitrogen, are of course determined in the roots themselves. The amounts of dry matter, ash, and nitrogen, have also, in many cases, been determined in the expressed juice. In many cases also, the amount of the nitrogen existing as albuminoids has been determined (by Church's method); and in some cases the amount as amides and as nitric acid. It may be observed that by far the larger proportion of both the mineral matter and the nitrogen of the roots is found in the juice; and of the nitrogen in the juice a variable proportion, ranging from less than one-fifth to not more than one-third of the total, is found to exist as albuminoids. When sugar has been estimated, it has been determined in the expressed juice, and calculated into its percentage in the roots, as described in more detail in the letterpress above the Table on p. 58.

In interpreting the figures, it must be borne in mind, that, with forty different experiments each year, and, in each year four, five, or more, times, as much produce on some plots as on others, it would be impossible to sample each at its best, and all in the same condition of ripeness. Each year the seed was sown on all the plots at the same time. The sample analysed was in each case a mixture of vertical sections of ten or fifteen roots, and all the samples were as a rule taken within a period of from one to two weeks; as far as practicable beginning with the ripest. It is obvious, however, that the smaller crops would be much riper than the larger ones; but, although the larger crops generally contain a lower percentage of sugar, they yield very much more sugar per acre.

Plots.	Abbreviated Description of Standard Manures. For details, see pp. 60–1.	Manures, per Acre, per Annum. Series 1. Standard Manures only.				Series 2. Standard Manures, and Cross-dressed with 550 lbs. Nitrate Soda.				Series 3. Standard Manures, and Cross-dressed with 400 lbs. Ammonium-salts.				Series 4. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake and 400 lbs. Ammonium-salts.				Series 5. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake.			
		Mean Per Cent. Total Dry Matter, Mineral Matter (Crude Ash), and Nitrogen, in the Roots.																					
		Dry Matter.	Sugar.	Ash.	Nitrogen.	Dry Matter.	Sugar.	Ash.	Nitrogen.	Dry Matter.	Sugar.	Ash.	Nitrogen.	Dry Matter.	Sugar.	Ash.	Nitrogen.	Dry Matter.	Sugar.	Ash.	Nitrogen.
		Sixth Season, 1881.																					
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1	Farmyard Manure	12·98		0·946	0·207	12·26		1·014	0·257	12·38		0·984	0·243	12·86		0·983	0·257	11·80		0·945	0·217
2	Farmyard Manure, & Super. ..	12·35		0·883	0·171	11·91		0·946	0·217	11·83		0·995	0·237	13·32		0·963	0·280	12·07		0·929	0·234
3	Unmanured (1846, & since) ..	17·88		0·700	0·205	13·98		0·864	0·238	17·13		0·801	0·333	15·94		0·722	0·320	15·93		0·675	0·257
4	Super., & Pot., Sod., & Mag. ..	15·11		0·839	0·134	12·77		1·020	0·217	14·10		0·977	0·192	13·02		1·057	0·255	13·35		0·979	0·190
5	Superphosphate..	15·76		0·724	0·139	12·50		0·836	0·205	14·50		0·649	0·238	14·59		0·708	0·257	13·96		0·691	0·222
6	Super., & Potash	16·10		0·797	0·133	14·14		0·910	0·197	13·84		1·007	0·201	13·65		0·985	0·222	13·69		0·978	0·202
7	Super., Pot., & 36½ lb. Am.-slts.	15·11		0·870		12·42		0·945		13·54		1·033		13·33		0·982		13·44		0·888	
8	Unmanured (1853, & since) ..	15·77		0·788		12·40		0·876		15·28		0·766		14·07		0·671		14·78		0·704	
9	Farmyard Manure, & Super. ..	..		..	..	..		..	..	12·73		0·865	..	..		..	..	..		..	..
		Seventh Season, 1882.																					
1	Farmyard Manure	14·29		0·850	0·153	13·32		0·901	0·175	12·73		0·900	0·196	11·60		0·940	0·224	12·51		0·898	0·196
2	Farmyard Manure, & Super. ..	13·19		0·871	0·143	13·08		0·929	0·200	12·52		0·849	0·226	12·75		0·885	0·231	13·14		0·869	0·178
3	Unmanured (1846, & since) ..	17·08		0·746	0·153	14·78		0·817	0·192	15·43		0·745	0·282	14·37		0·675	0·293	15·67		0·677	0·250
4	Super., & Pot., Sod., & Mag. ..	15·41		0·820	0·144	12·45		0·883	0·146	14·26		0·882	0·144	12·81		0·885	0·166	13·32		0·811	0·140
5	Superphosphate..	15·05		0·720	0·127	12·58		0·781	0·161	14·69		0·656	0·243	12·96		0·701	0·273	14·98		0·665	0·214
6	Super., & Potash	15·40		0·794	0·135	13·87		0·830	0·164	14·59		0·862	0·163	12·97		0·873	0·216	14·58		0·836	0·156
7	Super., Pot., & 36½ lb. Am.-slts.	15·19				13·67				14·23				13·41		..		14·10		0·833	
8	Unmanured (1853, & since) ..	15·42		0·808		12·57		0·891		14·04		0·858		13·31		0·696		13·99		0·662	
9	Farmyard Manure, & Super. ..	..		..	..	..		..	..	12·89		0·896	..	..		..	..	..		..	..

Eighth Season, 1883.

1	Farmyard Manure	13·10		0·820		11·82		0·870		12·23		0·852		12·24		0·812		13·32		0·813	
2	Farmyard Manure, & Super. ..	13·30		0·841		11·40		0·882		11·30		0·843		12·62		0·727		13·72		0·764	
3	Unmanured (1846, & since) ..	17·24		0·707		13·53		0·720		14·56		0·714		12·33		0·668		14·58		0·585	
4	Super., & Pot., Sod., & Mag. ..	15·18		0·764	0.114	12·80		0·897	0·152	13·46		0·832	0·127	13·44		0·930	0·172	13·81		0·860	0·126
5	Superphosphate	15·17		0·686	0·124	12·16		0·821	0·172	13·01		0·691	0·211	13·14		0·636	0·234	15·04		0·614	0·185
6	Super., & Potash	14·74		0·813	0·129	13·52		0·804	0·150	14·06		0·820	0·147	12·83		0·846	0·163	13·98		0·844	0·149
7	Super., Pot., & 36½ lb. Am.-slts.	14·94				13·04				13·94				13·10				13·68			
8	Unmanured (1853, & since) ..	15·26		0·718		11·85		0·744		14·36		0·653		13·98		0·629		13·66		0·553	
9	Farmyard Manure, & Super. ..	..		..	..	..		..	..	12·74		..	..	..		..	..	..		..	..

Ninth Season, 1884.

1	Farmyard Manure	13·27		0·947		12·37		0·957		11·74		0·887		11·33		0·903		12·23		0·878	
2	Farmyard Manure, & Super. ..	13·72		0·892		10·69		1·018		12·18		0·908		11·28		0·893		12·44		0·891	
3	Unmanured (1846, & since) ..	16·41		0·748		13·89		0·973		16·30		0·734		14·61		0·722		15·58		0·716	
4	Super., & Pot., Sod., & Mag. ..	14·45		0·934	0·125	11·83		1·100	0·205	11·83		1·123	0·180	11·16		1·113	0·244	12·79		0·952	0·152
5	Superphosphate	14·99		0·754	0·125	11·84		1·055	0·318	14·67		0·843	0·255	13·64		0·776	0·262	14·70		0·746	0·279
6	Super., & Potash	15·83		0·818	0·111	12·63		1·059	0·239	13·64		1·020	0·203	13·93		0·971	0·203	13·89		0·963	0·184
7	Super., Pot., & 36½ lb. Am.-slts.	14·56				13·10				12·88		1·082		12·58				12·98			
8	Unmanured (1853, & since) ..	15·59		0·806		12·74		1·010		14·91		0·898		13·70		0·763		14·82		0·757	
9	Farmyard Manure, & Super. ..	..		..	..	..		..	..	13·27		..	..	..		..	..	..		..	..

Tenth Season, 1885.

1	Farmyard Manure	11·58		0·976		10·68		1·020		12·19		0·904		13·01		0·830		13·21		0·820	
2	Farmyard Manure, & Super. ..	11·41		1·015		11·44		0·983		12·17		0·942		12·92		0·868		11·99		0·880	
3	Unmanured (1846, & since) ..	14·21		1·160		13·97		1·016		15·06		0·963		16·57		0·820		16·84		0·820	
4	Super., & Pot., Sod., & Mag. ..	14·34		1·094	0·261	12·53		1·104	0·251	12·38		1·047	0·247	13·07		0·842	0·162	13·70		0·840	0·168
5	Superphosphate	13·44		1·028	0·283	12·72		1·062	0·300	(14·22)(2)		(0·729)	(0·281)	15·39		0·789	0·314	14·79		0·758	0·278
6	Super., & Potash	13·87		1·110	0·256	13·23		0·976	0·248	13·36		0·997	0·225	13·56		0·789	0·212	13·76		0·843	0·214
7	Super., Pot., & 36½ lb. Am.-slts.	13·87				13·20				(13·65)(2)		(1·112)		13·40				14·16			
8	Unmanured (1853, & since) ..	15·09		1·019		13·02		0·966		14·57		1·027		16·81		0·841		16·48		0·915	
9	Farmyard Manure, & Super. ..	..		..	..	..		..	..	13·66		..	..	..		..	..	..		..	..

Average of 4 (1) Seasons, 1881, '82, '83, and 1884. (3)

1	Farmyard Manure	13·41		0·891	0·180	12·44		0·936	0·216	12·27		0·906	0·220	12·01		0·910	0·240	12·47		0·884	0·207
2	Farmyard Manure, & Super. ..	13·14		0·872	0·157	11·77		0·944	0·208	11·96		0·899	0·232	12·49		0·867	0·256	12·84		0·863	0·206
3	Unmanured (1846, & since) ..	17·15		0·725	0·179	14·05		0·844	0·215	15·86		0·749	0·308	14·31		0·697	0·307	15·44		0·663	0·254
4	Super., & Pot., Sod., & Mag. ..	15·04		0·839	0·129	12·46		0·975	0·180	13·41		0·954	0·161	12·61		0·996	0·209	13·32		0·901	0·152
5	Superphosphate	15.24		0·721	0·129	12·27		0·873	0·214	14·22		0·710	0·237	13·58		0·705	0·259	14·67		0·679	0·225
6	Super., & Potash	15·52		0·806	0·127	13·54		0·901	0·188	14·03		0·927	0·179	13·35		0·919	0·201	14·04		0·905	0·173
7	Super., Pot., & 36½ lb. Am.-slts.	14·95				13·06				13·65				13·11				13·55			
8	Unmanured (1853, & since) ..	15·51		0·780		12·39		0·880		14·65		0·794		13·77		0·690		14·31		0·669	
9	Farmyard Manure, & Super. ..	..		..	..	..		..	..	12·91		..	..	..		..	..	..		..	..

(1) For plots 1, 2, and 3, the average percentages of nitrogen are for two years only, 1881 and 1882, as no determinations were made in these plots in 1883 and 1884.
(2) Owing to an accident, the determinations of dry matter were in these cases lost; the means of the percentages of dry matter in the four preceding years are therefore entered in parentheses, and are adopted in the calculation of the percentages of ash and nitrogen, which are also entered in parentheses.
(3) Owing to the failure of the plant on many plots, and the irregularity of the crops, in 1885, the composition of the produce for that year is not brought into the average.

EXPERIMENTS ON **MANGEL WURZEL.**—BARN FIELD (after SUGAR-BEET); commencing 1876—*continued.*

Below are given the particulars of the Manures and Produce, of the Eleventh, Twelfth, Thirteenth, Fourteenth, and Fifteenth seasons, 1886, 1887, 1888, 1889, and 1890. For the Manures and Produce of the 10 preceding seasons see pp. 56–7 and 60–1, and for those of succeeding seasons, pp. 68–9 and 72–3.

The arrangement of the plots, and of the Manures, is precisely the same as it was for the ten preceding years of Mangels (see pp. 56–7 and 60–1), and also the same as previously for Sugar-beet (see pp. 52–3); excepting that Plot 9, which was unmanured for Sugar-beet, and also previously for Swedes, was brought in as a manured plot for Mangels. With this exception, the Manures are also substantially the same as previously for Sugar-beet; in fact, precisely the same as for the Sugar-beet in 1872 and 1873. Seed, Yellow Globe; dibbled on ridges; rows 26 inches apart; plants 11 inches apart in the rows.(3) Roots all carted off; leaves weighed, spread on the respective plots, and ploughed in.

(Area under experiment, about 8 acres.)

PLOTS.	STANDARD MANURES.	MANURES PER ACRE PER ANNUM. SERIES 1. Standard Manures only.	SERIES 2. Standard Manures, and Cross-dressed with 550 lbs. Nitrate Soda.	SERIES 3. Standard Manures, and Cross-dressed with 400 lbs. "Ammonium-Salts." (4)	SERIES 4. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake and 400 lbs. "Ammonium-Salts." (4)	SERIES 5. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake.
	ELEVENTH SEASON, 1886. Seed dibbled May 7 and 8. Crop taken up, November 3–9.					
		PRODUCE PER ACRE.				
		Roots. Tons. cwts. / Leaves. Tons. cwts.	Roots. Tons. cwts. / Leaves. Tons. cwts.	Roots. Tons. cwts. / Leaves. Tons. cwts.	Roots. Tons. cwts. / Leaves. Tons. cwts.	Roots. Tons. cwts. / Leaves. Tons. cwts.
1	Farmyard Manure (14 tons)	16 6 / 2 19	23 8 / 4 4	19 19 / 5 8	21 0 / 5 8	21 4 / 4 4
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	15 5 / 2 17	22 7 / 4 11	19 4 / 5 11	19 3 / 5 12	19 1 / 4 5
3	Without Manure (1846, and since)	5 11 / 1 6	14 2 / 4 5	5 4 / 3 2	8 3 / 4 15	8 11 / 3 16
4	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	5 15 / 1 5	17 6 / 4 0	12 19 / 2 12	20 9 / 4 4	17 4 / 3 15
5	3½ cwts. Superphosphate	6 12 / 1 6	15 3 / 3 6	6 7 / 3 8	8 12 / 4 6	10 9 / 3 19
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash	5 15 / 1 1	14 4 / 2 19	13 0 / 2 15	20 4 / 5 4	15 4 / 3 3
7	3½ cwts. Superphos., 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (2)	6 17 / 1 7	15 3 / 3 5	14 16 / 3 4	19 16 / 5 3	16 13 / 4 0
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	4 17 / 1 3	10 19 / 3 9	6 2 / 3 5	8 1 / 4 3	7 11 / 3 15
9	Farmyard Manure (14 tons), 3½ cwts. Superphosphate (3)	.. / ..	.. / ..	14 2 / 4 18	.. / ..	.. / ..
	TWELFTH SEASON, 1887. Seed dibbled April 25–27. Plants failed on many plots, especially on the plots of Series 2 and 3. Crop taken up, October 25–27.					
1	Farmyard Manure (14 tons)	10 17 / 1 19	10 18 / 2 7	11 17 / 2 17	15 2 / 3 13	17 5 / 3 8
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	9 6 / 2 1	3 2 / 0 17	6 14 / 1 16	17 5 / 3 18	16 16 / 3 13
3	Without Manure (1846, and since)	1 5 / 0 16	0 2 / 0 1	0 2 / 0 2	5 5 / 3 5	5 15 / 3 0
4	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	1 15 / 0 16	0 11 / 0 6	0 14 / 0 6	13 2 / 3 3	11 9 / 2 11
5	3½ cwts. Superphosphate	2 3 / 0 18	0 3 / 0 3	0 2 / 0 2	3 15 / 2 6	4 13 / 2 9
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash	2 6 / 0 17	0 6 / 0 3	0 8 / 0 4	8 0 / 2 8	8 16 / 2 6
7	3½ cwts. Superphos., 500 lbs. Sulphate Potash, 41 lbs. Sulphate-Am.	2 5 / 0 17	0 9 / 0 5	0 13 / 0 6	8 10 / 2 9	9 9 / 2 8
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	1 4 / 0 15	0 1 / 0 1	0 2 / 0 2	3 1 / 1 14	3 13 / 1 18
9	Farmyard Manure (14 tons), 3½ cwts. Superphosphate (3)	.. / ..	.. / ..	8 10 / 3 12	.. / ..	.. / ..

THIRTEENTH SEASON, 1888. Seed dibbled April 16; Plot 9 April 25. Plants to a great extent failed on the dung plots, and the Series 4 and 5 plots; seed resown, June 13. Crop taken up, November 17–20.

1	Farmyard Manure (14 tons)	5	16	3	2	7	8	3	15	6	4	3	10	7	8	4	2	7	2	4	0
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate	6	12	3	15	19	14	4	17	11	4	4	7	7	11	4	8	8	2	4	3
3	Without Manure (1846, and since)	1	7	1	2	20	7	3	15	6	13	3	0	2	16	1	17	4	2	2	1
4	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	1	16	1	3	23	4	4	16	20	1	3	17	7	19	4	16	8	0	4	3
5	3½ cwts. Superphosphate	1	15	1	11	22	2	3	14	11	11	3	9	3	10	2	0	3	6	1	15
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash	1	8	1	0	20	12	3	8	17	12	3	8	8	9	3	11	5	1	3	0
7	3½ cwts. Superphos., 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (2)	2	10	1	7	21	10	3	10	17	18	3	1	9	18	4	0	6	12	3	9
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	1	10	0	13	15	19	3	13	4	12	2	6	5	14	2	15	2	19	1	8
9	Farmyard Manure (14 tons), 3½ cwts. Superphosphate (3)	..		..		..		..		12	11	4	6	..		..		..		..	

FOURTEENTH SEASON, 1889. Seed dibbled May 15 and 16; Plot 9 dibbled May 21 and 22. Crop taken up, November 8–12. (5)

1	Farmyard Manure (14 tons)	22	16	3	8	31	6	5	7	31	10	7	3	32	16	7	5	29	12	5	17
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate	27	0	3	19	33	19	5	16	31	10	6	15	33	5	8	3	29	18	5	15
3	Without Manure (1846, and since)	6	8	1	2	16	15	3	3	10	19	3	14	20	1	5	12	19	6	4	2
4	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	7	9	1	6	(22 | 12)	(3 | 14)	18	13	2	11	37	2	6	16	31	1	4	14
5	3½ cwts. Superphosphate	6	13	1	4	(17 | 15)	(3 | 2)	12	7	3	8	21	8	6	7	21	9	4	7
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash	5	18	1	2	(18 | 0)	(2 | 13)	17	11	2	12	30	13	7	2	26	4	4	8
7	3½ cwts. Superphos., 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (2)	6	9	1	5	(19 | 1)	(3 | 2)	17	17	2	17	30	16	7	3	25	11	4	18
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	4	12	1	4	12	7	3	18	9	12	3	17	17	3	6	4	16	6	5	4
9	Farmyard Manure (14 tons), 3½ cwts. Superphosphate (3)	..		..		..		..		19	1	6	2	..		..		..		..	

FIFTEENTH SEASON, 1890. Seed dibbled April 23 and 24. Crop taken up, October 17–23.

1	Farmyard Manure (14 tons)	22	19	3	3	31	17	4	15	30	18	6	9	30	17	6	4	32	13	5	7
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate	23	9	3	9	33	13	5	11	30	2	6	0	30	13	6	13	33	4	5	5
3	Without Manure (1846, and since)	6	5	1	0	16	16	3	3	8	19	3	1	15	15	2	14	15	19	2	18
4	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	7	1	1	4	27	1	4	4	21	16	3	7	33	5	5	14	29	0	4	2
5	3½ cwts. Superphosphate	6	9	1	1	21	18	3	8	10	4	3	4	15	5	4	7	17	13	3	2
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash	5	13	0	18	21	12	2	16	19	11	2	17	30	19	5	6	26	2	3	1
7	3½ cwts. Superphos., 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (2)	7	4	1	2	22	5	2	18	22	7	3	7	33	12	6	7	27	11	3	9
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	5	5	1	0	15	5	3	13	10	9	3	15	13	14	4	7	18	5	3	7
9	Farmyard Manure (14 tons), 3½ cwts. Superphosphate (3)	..		..		..		..		28	11	5	14	..		..		..		..	

AVERAGE OF 5 SEASONS, 1886, '87, '88, '89, and 1890.

1	Farmyard Manure (14 tons)	15	15	2	18	20	19	4	2	20	2	5	1	21	9	5	6	21	11	4	11
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate	16	7	3	4	22	11	4	6	19	15	4	18	21	11	5	15	21	8	4	12
3	Without Manure (1846, and since)	4	3	1	1	13	13	2	17	6	7	2	12	10	8	3	13	10	15	3	3
4	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	4	15	1	3	18	8	3	9	14	16	2	11	22	7	4	19	19	7	3	17
5	3½ cwts. Superphosphate	4	14	1	4	15	12	2	15	8	2	2	14	10	10	3	17	11	10	3	2
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash	4	4	1	0	15	4	2	9	13	13	2	7	19	13	4	14	16	6	3	3
7	3½ cwts. Superphos., 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (2)	5	1	1	4	15	16	2	12	14	14	2	11	20	10	5	1	17	3	3	13
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	3	10	0	19	10	18	2	19	6	3	2	13	9	10	3	17	9	15	3	2
9	Farmyard Manure (14 tons), 3½ cwts. Superphosphate (3)	..		..		..		..		16	11	4	19	..		..		..		..	

(1) "Superphosphate of Lime," 1886 and 1887, made from 200 lbs. Bone ash, 150 lbs. Sulphuric acid, sp. gr. 1·7 (and water); 1888, and since, made from high percentage mineral phosphates, and containing 37 per cent. or more, of soluble phosphate. (2) "Ammonium-salts" equal parts Sulphate and Muriate of Ammonia of Commerce.

(3) Plot 9 sown on the flat instead of on ridges; plants ridged up afterwards; rows 22 inches apart, plants 10 inches apart in the rows.

(4) 400 lbs. Ammonium-salts, consisting of equal parts of Sulphate and Muriate of Ammonia of Commerce; excepting that for the crop of 1887, 450 lbs. Sulphate Ammonia containing an equal amount of Nitrogen, were applied instead.

(5) Season 1889.—It will be seen that the produce of plots 4, 5, 6, and 7, of Series 2, is entered between parentheses thus ( ), the amounts being those actually obtained, but owing to a heavy rainfall in July, some of the soil, manure, and plants, were washed away. The produce of roots so lost, is estimated at about 1 ton per acre.

F

EXPERIMENTS ON MANGEL WURZEL.—BARN FIELD—*continued.*—SUMMARY OF THE COMPOSITION OF THE MANGEL ROOTS, in the Eleventh, Twelfth, Thirteenth, Fourteenth, and Fifteenth Seasons, 1886, 1887, 1888, 1889, and 1890. For particulars of the composition in the first 10 Years, 1876–1885, see pp. 58–9 and 62–3, and for those in succeeding seasons, see pp. 70–1, and 74–5.

An abstract of the analytical results obtained, illustrating the influence of different manures, and of different seasons, on the composition of Mangels, is given below. The dry matter, ash, and nitrogen, are of course determined in the roots themselves. The amounts of dry matter, ash, and nitrogen, have also, in many cases, been determined in the expressed juice. In many cases also, the amount of the nitrogen existing as albuminoids has been determined (by Church's method); and in some cases the amount as amides and as nitric acid. It may be observed that by far the larger proportion of both the mineral matter and the nitrogen of the roots is found in the juice; and of the nitrogen in the juice a variable proportion, ranging from less than one-fifth to not more than one-third of the total, is found to exist as albuminoids. When sugar has been estimated, it has been determined in the expressed juice, and calculated into its percentage in the roots, as described in more detail in the letterpress above the Table on p. 58.

In interpreting the figures, it must be borne in mind, that, with forty different experiments each year, and in each year four, five, or more, times, as much produce on some plots as on others, it would be impossible to sample each at its best, and all in the same condition of ripeness. Each year the seed was sown on all the plots at the same time. The sample analysed was in each case a mixture of vertical sections of ten or fifteen roots, and all the samples were as a rule taken within a period of from one to two weeks; as far as practicable beginning with the ripest. It is obvious, however, that the smaller crops would be much riper than the larger ones; but, although the larger crops generally contain a lower percentage of sugar, they yield very much more sugar per acre.

Plots.	Abbreviated Description of Standard Manures. For details, see pp. 64–5.	Manures, per Acre, per Annum. Series 1. Standard Manures only.				Series 2. Standard Manures, and Cross-dressed with 550 lbs. Nitrate Soda.				Series 3. Standard Manures, and Cross-dressed with 400 lbs. Ammonium-salts. (1)				Series 4. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake and 400 lbs. Ammonium-salts. (1)				Series 5. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake.			
		Mean Per Cent. Total Dry Matter, Mineral Matter (Crude Ash), and Nitrogen in the Roots.																					
		Dry Matter.	Sugar.	Ash.	Nitro-gen.	Dry Matter.	Sugar.	Ash.	Nitro-gen.	Dry Matter.	Sugar.	Ash.	Nitro-gen.	Dry Matter.	Sugar.	Ash.	Nitro-gen.	Dry Matter.	Sugar.	Ash.	Nitro-gen.
		Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.	Percent.
	Eleventh Season, 1886.																				
1	Farmyard Manure	13·75		0·851		12·28		0·950		12·85		0·888		11·92		0·854		12·69		0·845	
2	Farmyard Manure, & Super. ..	12·96		0·908		11·80		0·951		11·52		0·941		11·93		0·900		13·18		0·834	
3	Unmanured (1846, & since) ..	16·07		0·750		12·67		0·953		14·93		0·799		13·76		0·734		14·08		0·687	
4	Super., & Pot., Sod., & Mag. ..	14·72		0·878	0·135	12·02		0·966	0·168	13·77		0·909	0·154	13·00		0·947	0·176	12·50		0·885	0·150
5	Superphosphate	14·38		0·745	0·133	12·27		0·790	0·180	14·29		0·697	0·235	12·47		0·750	0·256	13·59		0·702	0·224
6	Super., & Potash	14·52		0·813	0·132	12·02		0·878	0·180	14·18		0·924	0·171	12·72		0·847	0·189	13·52		0·850	0·168
7	Super., Pot., & 36½ lb. Am.-slts.	14·45		0·847		12·74		0·920		13·82		0·886		12·77		0·997		14·52		0·888	
8	Unmanured (1853, & since) ..	15·44		0·81[illegible]		11·26		0·921		14·29		0·783		13·58		0·734		14·22		0·669	
9	Farmyard Manure, & Super. ..	..		..	..	..		..	..	11·95		0·930	..	..		..	..	..		..	..
	Twelfth Season, 1887.																				
1	Farmyard Manure	15·21		1·042		13·66		1·066		14·56		1·040		14·95		0·953		15·00		0·981	
2	Farmyard Manure, & Super. ..	14·47		1·044		15·39		1·118		14·82		1·051		15·48		0·944		14·79		0·943	
3	Unmanured (1846, & since) ..	18·94		1·119		17·03		1·078		20·26		1·087		17·41		0·917		17·14		0·822	
4	Super., & Pot., Sod., & Mag. ..	17·11		1·219	0·283	16·41		1·201	0·322	15·11		1·217	0·329	14·56		1·146	0·283	14·60		1·154	0·260
5	Superphosphate	16·81		0·946	0·245	15·60		1·056	0·359	19·00		0·952	0·399	17·44		0·868	0·370	17·34		0·810	0·314
6	Super., & Potash	16·92		1·093	0·236	17·89		1·286	0·350	15·69		1·230	0·286	15·50		1·102	0·315	14·77		1·093	0·263
7	Super., Pot., & 36½ lb. Am.-slts.	16·76		1·143		15·98		1·167		15·64		1·281		15·86		1·144		15·31		1·088	
8	Unmanured (1853, & since) ..	17·74		1·077		18·13		1·134		19·24		1·004		17·88		0·861		18·32		0·823	
9	Farmyard Manure, & Super. ..	..		..	..	..		..	..	15·28		0·982	..	..		..	..	..		..	..

Thirteenth Season, 1888.

1	Farmyard Manure	13·54		1·104		11·67		1·095		13·30		1·126		14·27		1·116		13·35		1·066	
2	Farmyard Manure, & Super. ..	13·29		1·114		12·56		1·062		13·77		0·950		13·11		1·110		13·59		1·091	
3	Unmanured (1846, & since) ..	15·62		0·849		13·87		0·907		16·25		0·782		14·49		0·823		14·93		0·830	
4	Super., & Pot., Sod., & Mag. ..	15·66		1·028	0·218	13·94		1·005	0·179	14·05		0·915	0·172	11·29		1·184	0·314	11·70		1·226	0·285
5	Superphosphate	15·72		0·833	0·254	13·61		0·885	0·205	14·43		0·705	0·231	13·77		0·830	0·279	14·96		0·900	0·267
6	Super., & Potash	15·28		1·006	0·277	13·81		0·904	0·198	14·78		0·848	0·142	14·32		1·010	0·269	14·66		0·978	0·271
7	Super., Pot., & 36½ lb. Am.-slts.	16·04		0·983		14·31		0·897		14·44		0·831		14·53		0·960		14·45		1·019	
8	Unmanured (1853, & since) ..	17·17		0·876		13·49		0·904		15·60		0·759		15·81		0·751		15·46		0·731	
9	Farmyard Manure, & Super. ..	..		..	..	..		..	..	15·55		0·878	..	..		..	..	..		..	..

Fourteenth Season, 1889.

1	Farmyard Manure	13·87		0·863		14·20		0·866		12·89		0·852		12·83		0·840		13·76		0·834	
2	Farmyard Manure, & Super. ..	14·51		0·786		12·93		0·954		13·27		0·840		13·07		0·876		14·16		0·835	
3	Unmanured (1846, & since) ..	16·12		0·719		14·52		0·772		16·50		0·640		14·17		0·679		15·39		0·599	
4	Super., & Pot., Sod., & Mag. ..	15·56		0·795	0·102	13·80		0·818	0·113	14·47		0·796	0·094	12·91		0·836	0·122	14·05		0·846	0·110
5	Superphosphate	15·04		0·666	0·090	13·31		0·739	0·123	14·97		0·584	0·133	12·70		0·667	0·200	14·60		0·641	0·161
6	Super., & Potash	15·40		0·762	0·084	13·51		0·824	0·118	14·72		0·778	0·082	13·94		0·809	0·171	13·81		0·808	0·145
7	Super., Pot., & 36½ lb. Am.-slts.	15·51		0·787		13·69		0·877		15·23		0·759		14·94		0·834		13·63		0·804	
8	Unmanured (1853, & since) ..	16·19		0·742		12·70		0·778		15·06		0·690		13·30		0·669		14·87		0·640	
9	Farmyard Manure, & Super. ..	..		..	..	..		..	..	13·64		0·860	..	..		..	..	..		..	..

Fifteenth Season, 1890.

1	Farmyard Manure	14·34		0·725		13·86		0·836		13·42		0·734		13·12		0·751		13·63		0·794	
2	Farmyard Manure, & Super. ..	14·27		0·794		13·29		0·831		13·81		0·789		14·58		0·833		13·65		0·763	
3	Unmanured (1846, & since) ..	16·12		0·635		14·47		0·679		15·39		0·596		13·06		0·624		14·96		0·523	
4	Super., & Pot., Sod., & Mag. ..	15·45		0·767	0·086	13·58		0·827	0·102	14·18		0·845	0·093	12·96		0·868	0·117	13·25		0·826	0·102
5	Superphosphate	15·28		0·632	0·084	13·95		0·695	0·113	14·31		0·570	0·157	13·27		0·641	0·200	13·94		0·534	0·154
6	Super., & Potash	15·44		0·752	0·094	13·99		0·781	0·106	14·79		0·779	0·112	13·87		0·755	0·115	13·77		0·702	0·108
7	Super., Pot., & 36½ lb. Am.-slts.	15·45		0·711		13·86		0·767		14·89		0·765		13·48		0·768		13·91		0·759	
8	Unmanured (1853, & since) ..	15·34		0·700		12·34		0·774		14·82		0·652		12·41		0·650		14·04		0·513	
9	Farmyard Manure, & Super. ..	..		..	..	..		..	..	14·09		0·729	..	..		..	..	..		..	..

Average of Five Seasons, 1886, '87, '88, '89, and 1890.

1	Farmyard Manure	14·14		0·917		13·13		0·963		13·41		0·928		13·42		0·903		13·69		0·904	
2	Farmyard Manure, & Super. ..	13·90		0·929		13·19		0·983		13·44		0·914		13·63		0·933		13·87		0·893	
3	Unmanured (1846, & since) ..	16·57		0·814		14·51		0·878		16·67		0·781		14·58		0·755		15·30		0·692	
4	Super., & Pot., Sod., & Mag. ..	15·70		0·937	0·165	13·95		0·963	0·177	14·32		0·936	0·168	12·94		0·996	0·202	13·22		0·987	0·181
5	Superphosphate	15·45		0·764	0·161	13·75		0·833	0·196	15·40		0·702	0·231	13·93		0·751	0·261	14·89		0·717	0·224
6	Super., & Potash	15·51		0·885	0·165	14·24		0·935	0·190	14·83		0·912	0·159	14·07		0·905	0·212	14·11		0·886	0·191
7	Super., Pot., & 36½ lb. Am.-slts.	15·64		0·894		14·12		0·926		14·80		0·904		14·32		0·941		14·36		0·912	
8	Unmanured (1853, & since) ..	16·38		0·841		13·58		0·902		15·79		0·778		14·60		0·733		15·38		0·675	
9	Farmyard Manure, & Super. ..	..		..	..	..		..	..	14·10		0·876	..	..		..	..	..		..	..

(1) 400 lbs. Ammonium-salts, consisting of equal parts of Sulphate and Muriate of Ammonia of Commerce; excepting that for the crop of 1887, 450 lbs. Sulphate Ammonia, containing an equal amount of Nitrogen, were applied instead.

EXPERIMENTS ON **MANGEL WURZEL.**—BARN FIELD (after SUGAR-BEET); commencing 1876—*continued.*

Below are given the particulars of the Manures and Produce, of the Sixteenth, Seventeenth, Eighteenth, Nineteenth, and Twentieth Seasons, 1891, 1892, 1893, 1894, and 1895. For the Manures and Produce of the 15 preceding seasons, see pp. 56–7, 60–1, and 64–5, and for those of succeeding seasons, see pp. 72–3.

The arrangement of the plots, and of the manures, is precisely the same as it was for the fifteen preceding years of Mangels (see pp. 56–7, 60–1, and 64–5), and also the same as previously for Sugar-beet (see pp. 52–3); excepting that Plot 9, which was unmanured for Sugar-beet, and also previously for Swedes, was brought in as a manured plot for Mangels. With this exception the manures are also substantially the same as previously for Sugar-beet; in fact, precisely the same as for the Sugar-beet in 1872 and 1873. Seed, Yellow Globe; dibbled on ridges; rows 26 inches apart; plants 11 inches apart in the rows.(2) Roots all carted off; leaves weighed, spread on the respective plots, and ploughed in.

In the spring of 1894 permanent division paths were laid out between plot and plot.

(Area under experiment, about 8 acres.)

Plots.	Standard Manures.	Manures per Acre per Annum. Series 1. Standard Manures only.	Series 2. Standard Manures, and Cross-dressed with 550 lbs. Nitrate Soda. (4)	Series 3. Standard Manures, and Cross-dressed with 400 lbs. "Ammonium-Salts." (4)	Series 4. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake and 400 lbs. "Ammonium-Salts." (4)	Series 5. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake.
	Sixteenth Season, 1891. Seed dibbled April 16 and 17. Crop taken up, November 2–7.					
		Produce per Acre.				
		Roots. / Leaves.	Roots. / Leaves.	Roots. / Leaves.	Roots. / Leaves.	Roots. / Leaves.
		Tons. cwts. / Tons. cwts.	Tons. cwts. / Tons. cwts.	Tons. cwts. / Tons. cwts.	Tons. cwts. / Tons. cwts.	Tons. cwts. / Tons. cwts.
1	Farmyard Manure (14 tons)	19 19 / 3 6	24 15 / 5 12	25 4 / 7 7	31 8 / 9 0	29 17 / 6 1
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	20 14 / 3 13	20 17 / 6 16	20 19 / 7 4	27 3 / 8 4	26 7 / 5 0
3	Without Manure (1846, and since)	5 0 / 1 1	10 18 / 4 10	4 13 / 3 10	8 8 / 4 11	11 13 / 3 1
4	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	5 6 / 1 6	13 15 / 5 13	13 12 / 4 7	30 1 / 7 2	25 4 / 4 3
5	3½ cwts. Superphosphate	4 18 / 1 3	12 8 / 5 5	6 8 / 3 11	12 4 / 4 8	13 2 / 3 0
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash	4 10 / 1 0	10 15 / 4 7	12 12 / 4 6	26 0 / 6 15	21 6 / 3 4
7	3½ cwts. Superphos., 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (2)	5 19 / 1 5	9 15 / 4 6	14 11 / 4 11	26 2 / 7 10	21 10 / 3 14
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	4 1 / 1 2	4 3 / 3 4	5 1 / 3 5	10 11 / 4 4	11 8 / 3 16
9	Farmyard Manure (14 tons), 3½ cwts. Superphosphate (3)	.. / ..	.. / ..	23 16 / 7 1	.. / ..	.. / ..
	Seventeenth Season, 1892. Seed dibbled April 7 and 8. Crop taken up, October 26 to November 14.					
1	Farmyard Manure (14 tons)	22 2 / 3 5	33 0 / 5 18	28 6 / 6 15	28 11 / 6 18	30 0 / 5 13
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	21 10 / 3 18	30 13 / 6 5	23 15 / 5 4	22 8 / 5 11	27 1 / 5 6
3	Without Manure (1846, and since)	4 18 / 1 0	16 12 / 4 4	6 0 / 3 4	9 8 / 3 5	11 12 / 3 2
4	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	5 9 / 1 1	21 15 / 4 16	18 3 / 3 11	27 3 / 7 8	25 13 / 4 12
5	3½ cwts. Superphosphate	5 1 / 0 19	19 10 / 4 2	8 12 / 3 14	9 10 / 3 14	11 10 / 3 2
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash	4 11 / 0 16	20 17 / 3 18	18 2 / 3 15	24 17 / 7 3	21 19 / 3 11
7	3½ cwts. Superphos., 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (2)	6 1 / 1 1	20 6 / 4 2	18 7 / 4 5	23 17 / 6 17	22 5 / 3 15
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	3 16 / 1 1	10 13 / 3 18	4 2 / 2 7	8 7 / 3 6	10 9 / 3 2
9	Farmyard Manure (14 tons), 3½ cwts. Superphosphate (3)	.. / ..	.. / ..	23 19 / 6 10	.. / ..	.. / ..

EIGHTEENTH SEASON, 1893. Seed dibbled April 13 and 14. Crop taken up, October 30 to November 4.

1	Farmyard Manure (14 tons)	15	13	3	12	18	10	6	1	13	13	4	10	16	14	5	3	20	7	5	12
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1) ..	14	5	3	10	17	14	5	18	11	5	4	6	13	16	4	16	18	8	5	9
3	Without Manure (1846, and since)	6	2	2	5	11	18	4	6	1	16	1	6	6	3	2	18	7	13	3	5
4	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	4	7	1	2	6	0	3	4	5	16	2	13	16	5	4	12	19	15	3	10
5	3½ cwts. Superphosphate	4	11	1	3	13	6	3	19	2	7	1	18	4	14	2	17	7	7	3	5
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash	3	12	0	19	6	15	2	16	8	4	2	15	16	11	4	7	15	17	3	3
7	3½ cwts. Superphos., 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (2)	4	14	1	2	7	5	3	6	7	10	2	19	14	0	4	0	16	2	3	11
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	3	12	1	2	5	3	2	10	1	7	1	1	4	18	2	17	7	5	3	0
9	Farmyard Manure (14 tons), 3½ cwts. Superphosphate (3)	..		..		..		..		16	4	4	18	..		..		..		..	

NINETEENTH SEASON, 1894. Seed dibbled April 6 and 7. Crop taken up, October 23 to November 9.

1	Farmyard Manure (14 tons)	25	15	3	7	38	11	6	13	29	17	7	4	31	13	7	5	31	10	7	3
2	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1) ..	26	11	4	4	39	8	7	6	30	14	7	16	30	19	7	11	32	1	7	2
3	Without Manure (1846, and since)	6	18	1	7	22	19	4	17	10	13	4	19	13	3	4	15	11	19	3	18
4	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	5	7	1	4	29	7	5	5	25	7	3	16	35	12	6	15	28	7	3	19
5	3½ cwts. Superphosphate	5	13	1	5	19	7	4	2	11	0	4	10	14	6	4	15	14	0	4	4
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash	5	3	1	1	21	16	3	14	23	10	3	11	31	4	7	6	25	1	3	14
7	3½ cwts. Superphos., 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (2)	7	7	1	6	23	10	3	17	25	0	4	2	30	3	7	11	26	12	4	5
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	4	19	1	4	14	5	5	7	9	18	4	19	13	9	4	19	13	15	4	8
9	Farmyard Manure (14 tons), 3½ cwts. Superphosphate (3)	..		..		..		..		26	0	6	19	..		..		..		..	

TWENTIETH SEASON, 1895. Seed dibbled April 17 and 18. Crop taken up, October 25–30.

1	Farmyard Manure (14 tons)	27	14	2	0	33	8	2	15	28	1	2	8	34	6	2	12	37	4	3	0
2	Farmyard Manure (14 tons), 3½ cwts. Super. (1) and 500 lbs. Sul. Pot.	25	18	2	1	20	7	2	10	26	9	2	13	37	1	3	1	37	6	3	0
3	Without Manure (1846, and since)	(8	18 (6)	0	18	1	11	0	17	1	11	0	13	12	3	1	13	12	9	1	13
4	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	5	1	0	16	0	5	0	11	1	0	1	2	34	6	3	5	31	13	2	14
5	3½ cwts. Superphosphate	7	16	0	17	(7) 0	3	0	2	0	5	0	6 (7)	10	18	1	13	13	1	1	17
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash	6	7	0	13	0	4	0	6	1	12	1	2	30	7	2	14	27	7	1	19
7	3½ cwts. Superphos., 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (2)	5	17	0	15	0	4	0	6	0	15	0	13	27	4	2	16	26	18	2	5
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	5	13	0	17	0	9	0	5	1	0	0	9	11	13	1	14	14	5	1	15
9	Farmyard Manure (14 tons), 3½ cwts. Superphosphate (3)	..		..		..		..		19	11	2	6	..		..		..		..	

AVERAGE OF 5 SEASONS, 1891, '92, '93, '94, and 1895.

1	Farmyard Manure (14 tons)	22	4	3	2	29	13	5	8	25	0	5	13	28	11	6	4	29	16	5	10
2	Farmyard Manure (14 tons), 3½ cwts. Super. (1) and 500 lbs. Sul. Pot. (5)	21	16	3	9	25	16	5	15	22	12	5	9	26	5	5	17	28	5	5	3
3	Without Manure (1846, and since)	6	7	1	6	12	16	3	15	4	19	2	14	9	17	4	4	11	1	3	0
4	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	5	2	1	2	14	4	3	18	12	16	3	2	28	13	5	16	26	3	3	15
5	3½ cwts. Superphosphate	5	12	1	1	(8) 12	18	3	10	5	14	2	16 (8)	10	7	3	9	11	16	3	2
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potash	4	17	0	18	12	1	3	0	12	16	3	2	25	16	5	13	22	6	3	3
7	3½ cwts. Superphos., 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (2)	6	0	1	2	12	4	3	4	13	5	3	6	24	5	5	15	22	13	3	10
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	4	8	1	1	6	18	3	1	4	6	2	8	9	15	3	8	11	9	3	4
9	Farmyard Manure (14 tons), 3½ cwts. Superphosphate (3)	..		..		..		..		21	18	5	11	..		..		..		..	

(1) "Superphosphate of Lime," made from high percentage mineral phosphates, and containing 37 per cent., or more, of soluble phosphate. (2) "Ammonium-salts" equal parts Sulphate and Muriate of Ammonia of Commerce.
(3) Plot 9 sown on the flat instead of on ridges; plants ridged up afterwards; rows 22 inches apart, plants 10 inches apart in the rows. (4) 1892, Series 2, one-half the Nitrate of Soda = 275 lbs. only, applied at the time of sowing the seed, the other half sown broadcast, July 10. Series 3 and Series 4, one-half the Ammonium-salts = 200 lbs. only, applied at the time of sowing the seed, the other half sown broadcast, July 10.
(5) Applied for the first time in 1895. (6) Owing to very heavy rains in November, 1894, flooding the lower parts of the Experimental Mangel Field, and washing soil from the Dung plots, especially on to Plot 3, Series 1, there is no doubt that this result is too high, and possibly also those given for Plots 5 and 6. (7) The plant failed on these plots owing to drought. (8) In the case of these plots the averages are given for the five years, though as the details show, there was failure of plant from drought, and scarcely any crop, in 1895.

EXPERIMENTS ON MANGEL WURZEL.—BARN FIELD—*continued.*—SUMMARY OF THE COMPOSITION OF THE MANGEL ROOTS IN THE SIXTEENTH, SEVENTEENTH, EIGHTEENTH, NINETEENTH, AND TWENTIETH SEASONS, 1891, 1892, 1893, 1894, AND 1895.

For particulars of the composition in the first 15 Years, 1876–1890, see pp. 58–9, 62–3, and 66–7, and for those in succeeding seasons, see pp. 74–5.

An abstract of the analytical results obtained, illustrating the influence of different manures, and of different seasons, on the composition of Mangels, is given below. The dry matter, ash, and nitrogen, are of course determined in the roots themselves. The amounts of dry matter, ash, and nitrogen, have also, in many cases, been determined in the expressed juice. In many cases also, the amount of the nitrogen existing as albuminoids has been determined (by Church's method); and in some cases the amount as amides and as nitric acid. It may be observed that by far the larger proportion of both the mineral matter and the nitrogen of the roots is found in the juice; and of the nitrogen in the juice a variable proportion, ranging from less than one-fifth to not more than one-third of the total, is found to exist as albuminoids. In former years when sugar has been estimated, it has been determined by polariscope in the expressed juice, and calculated into its percentage in the roots, as described in more detail in the letterpress above the Table on p. 58. In selected cases of the crops of the twentieth season, 1895, sugar was again determined; not, however, in the expressed juice as formerly, but in both an aqueous, and in an alcoholic extract of the pulp, and the results given in the Table are the means of the determinations in the aqueous, and in the alcoholic extracts, which agreed very closely, calculated into their percentage in the original root.

In interpreting the figures, it must be borne in mind, that, with forty different experiments each year, and in each year four, five, or more, times, as much produce on some plots as on others, it would be impossible to sample each at its best, and all in the same condition of ripeness. Each year the seed was sown on all the plots at the same time. The sample analysed was in each case a mixture of vertical sections of ten or fifteen roots, and all the samples were as a rule taken within a period of from one to two weeks; as far as practicable beginning with the ripest. It is obvious, however, that the smaller crops would be much riper than the larger ones; but, although the larger crops generally contain a lower percentage of sugar, they yield very much more sugar per acre.

Plots.	Abbreviated Description of Standard Manures. — For details, see pp. 68–9.	Manures, per Acre, per Annum. Series 1. Standard Manures only.	Series 2. Standard Manures, and Cross-dressed with 550 lbs. Nitrate Soda.	Series 3. Standard Manures, and Cross-dressed with 400 lbs. Ammonium-salts.	Series 4. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake and 400 lbs. Ammonium-salts.	Series 5. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake.
Sixteenth Season, 1891.						
		Mean Per Cent. Total Dry Matter (Sugar 1895), Mineral Matter (Crude Ash), and Nitrogen in the Roots.				
		Dry Matter. / Sugar. / Ash. / Nitrogen.	Dry Matter. / Sugar. / Ash. / Nitrogen.	Dry Matter. / Sugar. / Ash. / Nitrogen	Dry Matter. / Sugar. / Ash. / Nitrogen.	Dry Matter. / Sugar. / Ash. / Nitrogen.
		Per cent. / Per cent. / Per cent. / Per cent.	Per cent. / Per cent. / Per cent. / Per cent.	Per cent. / Per cent. / Per cent. / Per cent.	Per cent. / Per cent. / Per cent. / Per cent.	Per cent. / Per cent. / Per cent. / Per cent.
1	Farmyard Manure	13·32 / 0·792	12·99 / 0·845	13·04 / 0·768	11·97 / 0·823	13·24 / 0·807
2	Farmyard Manure, & Super. ..	13·80 / 0·801	12·41 / 0·919	12·39 / 0·936	11·95 / 0·775	13·52 / 0·807
3	Unmanured (1846, & since) ..	16·34 / 0·699	14·21 / 0·821	14·78 / 0·730	13·73 / 0·650	14·79 / 0·591
4	Super., & Pot., Sod., & Mag. ..	15·39 / 0·764 / 0·108	11·75 / 0·903 / 0·174	13·48 / 0·852 / 0·135	12·03 / 0·901 / 0·155	13·78 / 0·784 / 0·129
5	Superphosphate	14·73 / 0·615 / 0·095	12·51 / 0.852 / 0·185	13·51 / 0·649 / 0·167	13·31 / 0·615 / 0·146	14·53 / 0·560 / 0·242
6	Super., & Potash	14·96 / 0·754 / 0·106	12·55 / 0·902 / 0·174	14·31 / 0·806 / 0·142	13·52 / 0·787 / 0·176	13·97 / 0·705 / 0·110
7	Super., Pot., & 36½ lb. Am.-slts.	15·15 / 0·745	.. / ..	.. / ..	.. / ..	.. / ..
8	Unmanured (1853, & since) ..	.. / ..	.. / ..	.. / ..	.. / ..	.. / ..
9	Farmyard Manure, & Super. ..	.. /	.. /	.. /	.. /	.. / .. ..
Seventeenth Season, 1892.						
1	Farmyard Manure	14·07 / 0·774	13·25 / 0·831	12·49 / 0·886	13·13 / 0·778	14·19 / 0·821
2	Farmyard Manure, & Super. ..	13·53 / 0·753	12·78 / 0·855	12·77 / 0·815	12·94 / 0·872	13·25 / 0·829
3	Unmanured (1846, & since) ..	15·80 / 0·666	13·25 / 0·841	14·70 / 0·678	12·89 / 0·708	14·48 / 0·658
4	Super., & Pot., Sod., & Mag. ..	15·22 / 0·793 / 0·124	13·99 / 0·904 / 0·158	14·06 / 0·843 / 0·137	11·26 / 0·997 / 0·206	13·03 / 0·854 / 0·148
5	Superphosphate	15·03 / 0·625 / 0·122	12·13 / 0·741 / 0·182	14·31 / 0·639 / 0·185	13·48 / 0·633 / 0·251	13·43 / 0·620 / 0·214
6	Super., & Potash	14·70 / 0·757 / 0·120	13·78 / 0·866 / 0·161	14·35 / 0·819 / 0·126	13·35 / 0·905 / 0·206	13·85 / 0·784 / 0·172
7	Super., Pot., & 36½ lb. Am.-slts.	14·94 / 0·779	.. / ..	.. / ..	.. / ..	.. / ..
8	Unmanured (1853, & since) ..	.. / ..	.. / ..	.. / ..	.. / ..	.. / ..
9	Farmyard Manure, & Super. ..	.. /	.. /	.. /	.. /	.. / .. ..

Eighteenth Season, 1893.

1	Farmyard Manure	12·88		0·871		11·50		1·004		12·18		0·952		11·64		0·865		12·82		0·914	
2	Farmyard Manure, & Super. ..	12·41		0·949		11·08		1·073		12·20		0·936		12·75		0·911		12·73		0·886	
3	Unmanured (1846, & since) ..	14·88		0·685		11·20		0·935		14·03		0·679		13·74		0·756		13·97		0·649	
4	Super., & Pot., Sod., & Mag. ..	14·04		0·899	0·184	11·45		1·128	0·266	11·53		1·135	0·265	11·12		1·186	0·287	11·91		1·032	0·201
5	Superphosphate	15·10		0·647	0·134	12·07		0·769	0·218	12·74		0·743	0·276	13·42		0·766	0·316	12·82		0·667	0·237
6	Super., & Potash	14·90		0·787	0·168	11·87		1·003	0·240	12·36		1·122	0·256	12·59		1·046	0·269	14·02		0·903	0·236
7	Super., Pot., & 36½ lb. Am.-slts.	14·78		0·877		..		..		..		..		..		..		..		..	
8	Unmanured (1853, & since) ..	..		..		..		..		..		..		..		..		..		..	
9	Farmyard Manure, & Super. ..	..		..		..		..		..		..		..		..		..		..	

Nineteenth Season, 1894.

1	Farmyard Manure	13·46		0·809		11·73		0·870		12·42		0·765		11·47		0·843		12·56		0·779	
2	Farmyard Manure, & Super. ..	13·62		0·756		11·21		0·942		12·21		0·788		11·47		0·839		12·10		0·768	
3	Unmanured (1846, & since) ..	15·82		0·607		12·00		0·745		13·75		0·586		13·23		0·575		13·93		0·589	
4	Super., & Pot., Sod., & Mag. ..	15·28		0·781	0·092	13·03		0·939	0·146	13·37		0·918	0·140	12.30		0·946	0·177	13·10		0·878	0·134
5	Superphosphate	15·62		0·581	0·113	12·61		0·770	0·157	13·20		0·595	0·208	12·69		0·631	0·230	13·65		0·602	0·205
6	Super., & Potash	15·64		0·691	0·093	12·97		0·881	0·144	14·04		0·851	0·147	12·43		0·858	0·201	13·54		0·769	0·139
7	Super., Pot., & 36½ lb. Am.-slts.	15·40		0·724		..		..		..		..		..		..		..		..	
8	Unmanured (1853, & since) ..	..		..		..		..		..		..		..		..		..		..	
9	Farmyard Manure, & Super. ..	..		..		..		..		..		..		..		..		..		..	

Twentieth Season, 1895.

1	Farmyard Manure	11·68	7·16	0·834		10·21	5·81	0·906		9·69	5·28	0·811		10·01	5·24	0·828		10·76	6·27	0·767	
2	Farmyard Manure, Super., & Pot.	10·85	6·16	0·902		8·82	3·83	0·996		9·88	5·36	0·831		10·02	4·98	0·853		10·48	6·22	0·807	
3	Unmanured (1846, & since) ..	12·18	7·62	0·738										10·86	5·88	0·691		11·60	6·29	0·700	
4	Super., & Pot., Sod., & Mag. ..	11·66	6·98	0·970	0·117	(1)							(1)	9·66	4·87	0·981	0·144	10·49	5·43	0·928	0·112
5	Superphosphate	13·76	9·00	0·666	0·097									10·10	5·22	0·675	0·212	11·71	6·80	0·693	0·207
6	Super., & Potash	13·69	8·85	0·791	0·096									10·93	6·14	0·873	0·184	11·23	6·90	0·835	0·142
7	Super., Pot., & 36½ lb. Am.-slts.	13·18	..	0·841				..		..		..		..	..	..		..	..	..	
8	Unmanured (1853, & since) ..	..	..	..		..		..		..		..		..	..	..		..	..	..	
9	Farmyard Manure, & Super. ..	..	..	..		..		..		..		..		..	..	..		..	..	..	

Average of Five Seasons, 1891, '92, '93, '94, and 1895.

1	Farmyard Manure	13·08		0·816		11·94		0·891		11·96		0·836		11·64		0·827		12·71		0·818	
2	Farmyard Manure, Super., & Pot.	12·84		0·832		11·26		0·957		11·89		0·861		11·83		0·850		12·42		0·819	
3	Unmanured (1846, & since) ..	15·00		0·679		12·67		0·836		14·32		0·668		12·89		0·676		13·75		0·637	
4	Super., & Pot., Sod., & Mag. ..	14·32		0·841	0·125	12·56		0·969	0·186	13·11		0·937	0·169	11·27		1·002	0·194	12·46		0·895	0·145
5	Superphosphate	14·85		0·627	0·112	(2) 12·33		0·783	0·186	13·44		0·657	0·209	(2) 12·60		0·664	0·231	13·23		0·628	0·221
6	Super., & Potash	14·78		0·756	0·117	12·79		0 913	0·180	13·77		0·900	0·168	12·56		0·894	0·207	13·32		0·799	0·160
7	Super., Pot., & 36½ lb. Am.-slts.	14·69		0·793		..		..		..		..		..		..		..		..	
8	Unmanured (1853, & since) ..	..		..		..		..		..		..		..		..		..		..	
9	Farmyard Manure, & Super. ..	..		..		..		..		..		..		..		..		..		..	

(1) The plant failed on these plots, owing to drought, and hence no particulars of composition are given.
(2) In the case of these plots the averages are for only four years, owing to the failure of the plant from drought in 1895.

EXPERIMENTS ON **MANGEL WURZEL.**—BARN FIELD (after SUGAR-BEET); commencing 1876—*continued.*

Below are given the particulars of the Manures for the Twenty-first, Twenty-second, and Twenty-third Seasons, 1896, 1897, and 1898; and of the Produce of the Twenty-first and Twenty-second Seasons, 1896 and 1897. For the Manures and Produce of the 20 preceding seasons, see pp. 56–7, 60–1, 64–5, and 68–9.

The arrangement of the plots, and of the manures, is substantially the same as it was for the 20 preceding years of Mangels (see pp. 56–7, 60–1, 64–5, and 68–9), and also practically the same as previously for Sugar-beet (see pp. 52–3); excepting that Plot 9, which was unmanured for Sugar-beet, and also previously for Swedes, was brought in as a manured plot for Mangels. In 1896 and since, however, Basic Slag was substituted for Superphosphate of Lime. Seed, Yellow Globe; dibbled or drilled on ridges; rows 26 inches apart; plants 11 inches apart in the rows (2). Roots all carted off; leaves weighed, spread on the respective plots, and ploughed in.

In the spring of 1894 permanent division paths were laid out between plot and plot.

(Area under experiment, about 8 acres.)

Plots.	Standard Manures.	Manures per Acre per Annum. Series 1. Standard Manures only.	Series 2. Standard Manures, and Cross-dressed with 550 lbs. Nitrate Soda.	Series 3. Standard Manures, and Cross-dressed with 400 lbs. "Ammonium-Salts."	Series 4. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake and 400 lbs. "Ammonium-Salts."	Series 5. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake.
	Twenty-first Season, 1896. Seed drilled May 6 and 7; Plot 9, dibbled May 8. Crop taken up, November 3–10.					
		Produce per Acre.				
		Roots. / Leaves.	Roots. / Leaves.	Roots. / Leaves.	Roots. / Leaves.	Roots. / Leaves.
		Tons. cwts. / Tons. cwts.	Tons. cwts. / Tons. cwts.	Tons. cwts. / Tons. cwts.	Tons. cwts. / Tons. cwts.	Tons. cwts. / Tons. cwts.
1	Farmyard Manure (14 tons)	18 11 / 4 0	27 18 / 6 2	19 3 / 4 17	19 13 / 5 4	19 3 / 4 10
2	Farmyard Manure (14 tons), 450 lbs. Basic Slag, and 500 lbs. Sul. Pot.	21 7 / 4 3	31 0 / 7 0	24 4 / 6 0	23 18 / 6 5	22 5 / 4 17
3	Without Manure (1846, and since)	(7 12[3]) / 1 14	20 11 / 5 18	6 3 / 2 19	6 17 / 2 13	6 11 / 2 6
4	400 lbs. Basic Slag, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	7 2 / 1 9	22 1 / 5 15	16 19 / 3 0	23 12 / 3 14	20 13 / 2 16
5	400 lbs. Basic Slag	5 9 / 1 8	19 1 / 4 11	5 2 / 2 9	5 6 / 2 8	4 19 / 2 1
6	400 lbs. Basic Slag, 500 lbs. Sulphate Potash	5 8 / 1 3	19 5 / 4 8	15 17 / 3 8	20 17 / 4 19	18 9 / 3 7
7	400 lbs. Basic Slag, 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (1)	6 8 / 1 9	17 19 / 4 10	16 13 / 3 11	21 13 / 4 18	18 2 / 3 13
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	3 12 / 1 4	11 9 / 4 8	5 0 / 2 15	6 19 / 2 14	6 1 / 2 6
9	Farmyard Manure (14 tons), 450 lbs. Basic Slag (2)	.. / ..	.. / ..	17 19 / 4 19	.. / ..	.. / ..
	Twenty-second Season, 1897. Seed drilled May 4 and 5; Plot 9, dibbled May 5 and 6. Crop taken up, October 11–23.					
1	Farmyard Manure (14 tons)	15 16 / 4 4	25 6 / 8 7	19 5 / 7 9	20 4 / 8 7	20 6 / 7 10
2	Farmyard Manure (14 tons), 400 lbs. Basic Slag, and 500 lbs. Sul. Pot.	17 5 / 4 0	27 1 / 8 13	23 3 / 7 10	25 4 / 8 14	22 6 / 7 7
3	Without Manure (1846, and since)	(5 8[3]) / 1 12	17 4 / 7 11	7 8 / 5 1	8 17 / 5 9	8 13 / 4 18
4	400 lbs. Basic Slag, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	4 5 / 1 6	17 8 / 7 12	11 14 / 4 13	24 13 / 7 5	20 6 / 4 13
5	400 lbs. Basic Slag	4 0 / 1 9	16 3 / 6 16	8 7 / 4 17	7 18 / 4 19	6 15 / 4 9
6	400 lbs. Basic Slag, 500 lbs. Sulphate Potash	3 2 / 1 3	14 4 / 6 12	11 4 / 4 14	18 16 / 6 18	16 2 / 4 1
7	400 lbs. Basic Slag, 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (1)	3 17 / 1 12	14 4 / 7 0	10 17 / 4 15	19 7 / 6 15	16 11 / 4 13
8	Unmanured, 1853, and since; previously part Unman., part Superphos.	1 13 / 1 2	7 10 / 5 4	3 12 / 3 1	5 16 / 4 10	6 6 / 4 7
9	Farmyard Manure (14 tons), 400 lbs. Basic Slag (2)	.. / ..	.. / ..	13 14 / 5 17	.. / ..	.. / ..

TWENTY-THIRD SEASON, 1898. Seed drilled April 13; Plot 9, dibbled April 14; Crop taken up,

1	Farmyard Manure (14 tons) .. ..
2	Farmyard Manure (14 tons), 400 lbs. Basic Slag, and 500 lbs. Sul. Pot.
3	Without Manure (1846, and since) .. ..
4	400 lbs. Basic Slag, 500 lbs. Sulphate Potash, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia .. .. ..
5	400 lbs. Basic Slag .. ..
6	400 lbs. Basic Slag, 500 lbs. Sulphate Potash .. ..
7	400 lbs. Basic Slag, 500 lbs. Sulphate Potash, 36½ lbs. Am.-salts (1)
8	Unmanured, 1853, and since; previously part Unman., part Superphos.
9	Farmyard Manure (14 tons), 400 lbs. Basic Slag (2) .. ..

EXPERIMENTS ON SUGAR BEET IN 1898 (VILMORIN'S WHITE GREEN TOP BRABANT).

Plots 1–8. On ridges; rows 26 inches apart; plants 8 inches apart in the rows. Seed sown April 19–20. Crops taken up
Plot 9. On the flat; rows 15 inches apart; plants 8 inches apart in the rows. Seed sown May 12–13. Crops taken up
Manures, Produce, and Composition—see below. For arrangement of plots, see Plan, p. 48.

PLOTS.	MANURES PER ACRE. ABBREVIATED DESCRIPTION OF "STANDARD MANURES." For details of Plots 1–8, see Manures for Mangels above.	SERIES 1. Standard Manures only.	SERIES 2. Standard Manures and 2 cwt. Sulphate Ammonia.	SERIES 3. Standard Manures and 272 lb. Nitrate of Soda.
PRODUCE PER ACRE—ROOTS AND LEAVES.				
		Roots. Tons. cwt. / Leaves. Tons. cwt.	Roots. Tons. cwt. / Leaves. Tons. cwt.	Roots. Tons. cwt. / Leaves. Tons. cwt.
1	Farmyard Manure			
2	Farmyard Manure, Slag, & Pot. ..			
3	Unmanured (1846, & since)			
4	Basic Slag, & Pot., Sod., & Mag. ..			
5	Basic Slag			
6	Basic Slag, & Potash			
7	Slag, Pot., & 36½ lb. Am.-salts ..			
8	Unmanured (1853, & since)			
9	1876–97, Dung & Phosphate, 1898, 400 lb. Slag, & 500 lb. Sul. Pot.			

PERCENTAGE COMPOSITION OF THE ROOTS.

		Dry Matter. Per cent.	Sugar. Per cent.	Ash. Per cent.	Nitrogen. Per cent.	Dry Matter. Per cent.	Sugar. Per cent.	Ash. Per cent.	Nitrogen. Per cent.	Dry Matter. Per cent.	Sugar. Per cent.	Ash. Per cent.	Nitrogen. Per cent.
1	Farmyard Manure												
2	Farmyard Manure, Slag, & Pot. ..												
3	Unmanured (1846, & since)												
4	Basic Slag, & Pot., Sod., & Mag. ..												
5	Basic Slag												
6	Basic Slag, & Potash												
7	Slag, Pot., & 36½ lb. Am.-salts ..												
8	Unmanured (1853, & since)												
9	1876–97, Dung & Phosphate, 1898, 400 lb. Slag, & 500 lb. Sul. Pot.												

EXPERIMENTS ON MANGEL WURZEL.—BARN FIELD—*continued.*—SUMMARY OF THE COMPOSITION OF THE MANGEL ROOTS IN THE TWENTY-FIRST, AND TWENTY-SECOND SEASONS, 1896, AND 1897.

For particulars of the composition in the first 20 Years, 1876–1895, see pp. 58–9, 62–3, 66–7, and 70–1.

An abstract of the analytical results obtained, illustrating the influence of different manures, and of different seasons, on the composition of Mangels, is given below. The dry matter, ash, and nitrogen, are of course determined in the roots themselves. The amounts of dry matter, ash, and nitrogen, have also, in many cases, been determined in the expressed juice. In many cases also, the amount of the nitrogen existing as albuminoids has been determined (by Church's method); and in some the amount as amides and as nitric acid. It may be observed that by far the larger proportion of both the mineral matter and the nitrogen of the roots is found in the juice; and of the nitrogen in the juice a variable proportion, ranging from less than one-fifth to not more than one-third of the total, is found to exist as albuminoids. In former years when sugar has been estimated, it has been determined by polariscope in the expressed juice, and calculated into its percentage in the roots, as described in more detail in the letterpress above the Table on p. 58. In selected cases of the crops of the twentieth and twenty-second seasons, 1895 and 1897, sugar was again determined; not, however, in the expressed juice as formerly, but in both an aqueous, and in an alcoholic extract of the pulp, and the results given in the Table are the means of the determinations in the aqueous, and in the alcoholic extracts, which agreed very closely, calculated into their percentage in the original root.

In interpreting the figures, it must be borne in mind, that, with forty different experiments each year, and in each year four, five, or more, times, as much produce on some plots as on others, it would be impossible to sample each at its best, and all in the same condition of ripeness. Each year the seed was sown on all the plots at the same time. The sample analysed was in each case a mixture of vertical sections of ten or fifteen roots, and all the samples were as a rule taken within a period of from one to two weeks; as far as practicable beginning with the ripest. It is obvious, however, that the smaller crops would be much riper than the larger ones; but, although the larger crops generally contain a lower percentage of sugar, they yield very much more sugar per acre.

Plots.	Abbreviated Description of Standard Manures. — For details, see pp. 72–3.	Manures, per Acre, per Annum. Series 1. Standard Manures only.				Series 2. Standard Manures, and Cross-dressed with 550 lbs. Nitrate Soda.				Series 3. Standard Manures, and Cross-dressed with 400 lbs. Ammonium-salts.				Series 4. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake and 400 lbs. Ammonium-salts.				Series 5. Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake.			
		Mean Per Cent. Total Dry Matter, Sugar, Mineral Matter (Crude Ash), and Nitrogen in the Roots.																					
		Dry Matter.	Sugar.	Ash.	Nitro-gen.	Dry Matter.	Sugar.	Ash.	Nitro-gen.	Dry Matter.	Sugar.	Ash.	Nitro-gen.	Dry Matter.	Sugar.	Ash.	Nitro-gen.	Dry Matter.	Sugar.	Ash.	Nitro-gen.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
	Twenty-first Season, 1896.																				
1	Farmyard Manure	10·73		0.915		8·69		1·029		9·61		0·908		9·56		0·901		10·36		0·944	
2	Farmyard Manure, Slag, & Pot.	10·81		0·899		9·03		1·033		10·66		1·026		10·46		1·033		10·10		1·012	
3	Unmanured (1846, & since) ..	14·02		0·760		10·70		0·892		13·63		0·789		12·29		0·731		11·77		0·755	
4	Basic Slag, & Pot., Sod., & Mag.	12·42		0·905	0·119	9·52		1·066	0·169	11·02		1·005	0·160	9·38		1·056	0·200	10·15		0 986	0·165
5	Basic Slag	13·63		0·684	0·122	9·29		0·797	0·185	12·84		0·780	0·289	11·77		0·803	0·285	12·30		0·755	0·260
6	Basic Slag, & Potash	13·32		0·837	0·124	10·22		0·940	0·182	11·40		0·938	0·186	10·78		1·018	0·237	10·36		0·919	0·200
7	Slag, Pot., & 36½ lb. Am.-slts.	13·73		0·876		..		..		..	..	..		..		..		..		..	
8	Unmanured (1853, & since) ..	..		..		..		..		..	..	..		..		..		..		..	
9	Farmyard Manure, & Basic Slag	..		..		..		..		..	..	..		..		..		..		..	
	Twenty-second Season, 1897.																				
1	Farmyard Manure	14·91		0·834	0·187	13·79	8·87	0·886	0·222	12·98		0·819	0·227	13·64		0·821	0·259	13·29	8·19	0·850	0·256
2	Farmyard Manure, Slag, & Pot.	14·80		0·873	0·185	12·99	8·03	0·934	0·217	13·47		0·953	0·229	12·92		0·967	0·249	13·85	8·52	0·812	0·229
3	Unmanured (1846, & since) ..	16·65		0·670		14·32		0·793		15·48		0·589		14·26		0·634		14·54		0·609	
4	Basic Slag, & Pot., Sod., & Mag.	15·89	10·11	0·865	0·147	13·76	8·53	0·976	0·201	14·86	9·23	0·996	0·196	13·32	8·10	0·944	0·212	13·46	8·32	0·901	0·188
5	Basic Slag	15·91	10·08	0·671	0·142	14·23	9·03	0·826	0·214	14·76	8·88	0·606	0·254	14·03	8·10	0·608	0·299	14·51	8·77	0·629	0·264
6	Basic Slag, & Potash	15·23	9·56	0·785	0·132	13·17	8·05	0·952	0·191	14·94	9·12	0·958	0·179	13·47	8·22	0·947	0·227	14·72	9·37	0·834	0·206
7	Slag, Pot., & 36½ lb. Am.-slts.	15·95		0·856		..		..		..		..		..		..		13·82		0·838	
8	Unmanured (1853, & since) ..	..		..		..		..		..		..		..		..		..		..	
9	Farmyard Manure, & Basic Slag	..		..		..		..		13·61		0·795		..		..		..		..	

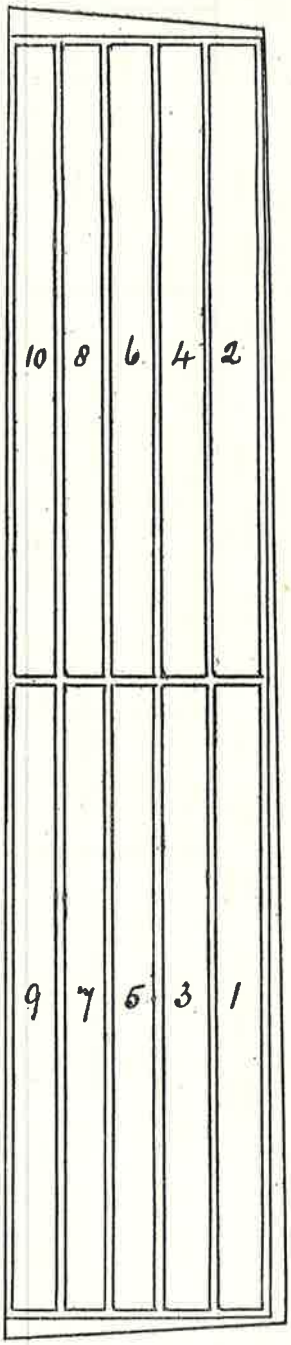
TWENTY-THIRD SEASON, 1898.

1	Farmyard Manure .. ..
2	Farmyard Manure, Slag, & Pot.
3	Unmanured (1846, & since) ..
4	Basic Slag, & Pot., Sod., & Mag.
5	Basic Slag .. ..
6	Basic Slag, & Potash .. ..
7	Slag, Pot., & 36½ lb. Am.-slts.
8	Unmanured (1853, & since) ..
9	Farmyard Manure, & Basic Slag

PLAN OF THE PLOTS IN HOOS FIELD,
ON WHICH EXPERIMENTS HAVE BEEN MADE ON POTATOES,
WITHOUT MANURE, AND WITH VARIOUS MANURES.

23 years, 1876–98.

[For brief summary of results and conclusions, see opposite page.]



Total area of ploughed land about $2\frac{1}{10}$ acre.
Area of each plot $\frac{1}{6}$ acre.
The double lines indicate division paths between plot and plot.

[For details of the manuring and produce, see pp. 78–97.]

RESULTS OF EXPERIMENTS MADE IN HOOS FIELD, ON THE GROWTH OF POTATOES.

These experiments were commenced in 1876, so that 1898 is the 23rd year of their continuance. The descriptions grown were "Rock," 4 years, "Champion," 11 years, "Sutton's Abundance," 5 years, "Bruce," 1 year, and "White Beauty of Hebron," 1897, and 1898. The question was not as to the comparative merits of different descriptions, and different sorts were selected on the supposition that in growing the crop year after year change was desirable, especially with a view to the avoidance or lessening of disease. The special object was to ascertain the manurial requirements of the crop, and the comparative characters and composition of the produce.

The crop was grown continuously without manure, with various artificial manures, and also with farmyard manure, both alone and with some artificial manures. There were 10 differently manured plots, and under each of the 10 conditions the crop more or less declined over the later compared with the earlier years. The average produce per acre of total tubers over the 20 years was—without manure, only 1 ton, 11½ cwt.; with ammonium-salts alone, 1 ton, 18½ cwt.; with nitrate of soda alone, 2 tons, 8 cwt.; with superphosphate alone, 3 tons, 2¼ cwt.; with mixed mineral manure, including potash, 3 tons, 6¾ cwt. Thus, purely nitrogenous manures yielded less than purely mineral manures, indicating that there was a deficiency of ash-constituents rather than of available nitrogen within the soil. With the mixed mineral manure and ammonium-salts together, the average produce of total tubers was nearly 6 tons, and with the mixed mineral manure and nitrate of soda rather over 6 tons per acre. The better result by the nitrate of soda is doubtless due to its nitrogen being more immediately available, and more rapidly distributed within the soil, and so inducing a more extended development of feeding root. The average produce by the mineral and nitrogenous manures together, over 20 years of continuous growth, was very nearly that of the estimated average produce of Great Britain under ordinary cultivation, and much more than that of Ireland. It was also more than the average of any other country in Europe, much more than many of them, and about 3 times as much as that of the United States.

The plots receiving farmyard manure containing about 200 lb. of nitrogen, gave less produce than the mixture of mineral manure and ammonium-salts, or nitrate of soda, supplying only 86 lb. of nitrogen. In fact, only a small proportion of the nitrogen of farmyard manure is rapidly available, that due to undigested matter being more slowly available, and that in the litter remaining a long time inactive. Farmyard manure is, however, often applied in very large quantities for potatoes, the process being to a great extent one of forcing, and there remains a great amount of unexhausted manure-residue within the soil.

The percentage of nitrogen in potato tubers is much increased by the application of nitrogenous manures, but the less so the riper the crop. Without manure there is a comparatively low percentage of mineral matter and a medium percentage of nitrogen. With mineral manure alone there is the highest percentage of mineral matter, and the lowest of nitrogen. With purely nitrogenous manures there is the lowest percentage of mineral matter, and the highest of nitrogen. Lastly, with mineral and nitrogenous manures together, there are intermediate percentages, both of mineral matter and of nitrogen, in the tubers. More than 80 per cent. of the total nitrogen of the tubers exists in the juice. A comparatively small but variable proportion of the nitrogen of the tubers exists as albuminoids in the solid portion; perhaps on the average only about 15 per cent.; whilst from 40 to 50 per cent. of the total nitrogen may exist as soluble albuminoids in the juice, so that about or nearly two-thirds of the total nitrogen may exist as albuminoids, by far the larger proportion being, however, in the juice. The non-albuminoid nitrogenous matter exists chiefly as amides.

The characteristic effect of nitrogenous manures, provided there be a sufficient available supply of ash-constituents, and especially of potash, is to increase the amount of the non-nitrogenous substance—starch, in the tubers. Thus, the produce of starch per acre was about 1100 lb. without manure, nearly 2000 lb. with purely mineral manure, and with nitrogenous and mineral manures together about 3400 lb., or about 1½ ton. In other words, the increased produce of starch by the use of the mineral and nitrogenous manures together was more than 1 ton per acre. That is, there was a great increase in the production of the *non*-nitrogenous constituent—*starch*, by the use of nitrogen in manure, just as there is an increase in the produce of the non-nitrogenous constituent—sugar, by the use of nitrogenous manures to root crops. The increased production of non-nitrogenous substances by nitrogenous manures, is equally striking in cereal crops; the result in their case being an increased production of starch in the grain, and of cellulose in the straw. Indeed, it is for the production of the non-nitrogenous substances—starch, sugar, and cellulose—that our direct nitrogenous manures are chiefly used.

It is well known that season has much to do with the development of the potato disease; and there was on the average much more disease in the wetter seasons. As regards the influence of manure, the proportion of diseased tubers was the least where there was no supply of nitrogen; that is, where there was the least luxuriance, the most restricted growth, and where the ripening was early developed. On the other hand, with liberal supply of nitrogen, and luxuriant growth, there was the greatest proportion of diseased tubers; these being the conditions in which the juice is relatively rich in nitrogenous and mineral matters. Indeed, when the unsuitable weather comes, those tubers suffer the most which have the richest juice, that is, the least fixity of composition. It was found that there was always a higher, and sometimes a much higher, percentage of nitrogen in the dry substance of the diseased than in that of the sound tubers, indicating a loss of non-nitrogenous constituents. In many cases the still white, and also the separated discoloured portion of the diseased tubers, were analysed. Whilst the juice of the white portion contained approximately the normal amount of nitrogen, that of the discoloured portion contained very much less. On the other hand, the washed "Marc" of the white portion contained very little nitrogen, whilst that of the discoloured portion contained very much more. The distribution of the mineral matter to a great extent followed that of the nitrogen. The juice had obviously suffered exhaustion of much of both its nitrogen and its mineral matter in the development of the fungus. Further, there was more sugar (partly cane and partly glucose) in the diseased potatoes, which probably contributed to the development of the fungus. Apparently the first material change in the development of the disease is the destruction of starch and the formation of sugar. There is also a considerable loss of organic, and chiefly *non*-nitrogenous substance, due in part to the decomposition of the produced sugar, but probably in part to the evolution of carbonic acid, as a coincident of the growth of the fungus at the expense of ready-formed organic substance, this being a characteristic of the growth of such non-chlorophyllous plants. Thus the results adduced as to the course of the disease are quite consistent with the fact that it develops the more in tubers grown by highly nitrogenous manures, and having a highly nitrogenous juice.

A full available supply of ash-constituents is essential for the successful growth of the potato, but these being provided, the amount of produce is largely dependent on the available supply of nitrogen. In ordinary practice, farmyard manure is mainly relied upon. It is used in very large quantities, and it is sometimes supplemented by liberal dressings of artificial manures, both mineral and nitrogenous. The potato removes, however, a less proportion of the nitrogen supplied than any other farm crop.

For particulars of the manuring and produce, and to some extent of the composition of the differently grown tubers, see pages 78–97.

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EXPERIMENTS ON POTATOES.—HOOS FIELD; commencing 1876.

Below are given the particulars of the Manures and Produce of each of the first 5 Seasons, 1876–1880; also the *average* Produce of those first 5 Seasons. For continuation, 1881 and since, see pp. 82–3, 86–7, 90–1, and 94–5.

The Land had been under experiments with Wheat, differently manured, from 1856 to 1874; and was fallowed in 1875.

Plots 1, 2, 3, and 4 had been unmanured for the Wheat. Plots 5 and 6 had received the same quantity of Ammonium-salts alone every year for the Wheat, as Plot 5 now receives for potatoes: Plot 6 now receiving the same amount of nitrogen, but as Nitrate of Soda, instead of Ammonium-salts. Plots 7 and 8 received the same amount of complex mineral manure, and Ammonium-salts, for the Wheat, as Plot 7 now receives for potatoes; and Plot 8 now receives the same complex mineral manures, and the same amount of nitrogen, but as Nitrate of Soda instead of Ammonium-salts. Plots 9 and 10 received the same complex mineral manures alone for the Wheat as Plot 10 now receives for potatoes; Plot 9 now receives superphosphate only. (3) Description of Potatoes, in 1876, 1877, 1878, and 1879, the "Rock" (White); and in those years the rows were 25 inches apart; with 12 inches from plant to plant in the rows. In 1880, the description was the "Champion" (White); and the rows were 25 inches apart, with 14 inches from plant to plant in the rows.

(Area under experiment, 2 acres.)

Plots.	Manures per Acre per Annum.	Produce per Acre. Tubers. Good.	Small.	Diseased.	Total.	Tops.
	First Season, 1876. Potatoes planted, June 10–13; Crop taken up, Oct. 30–31.	Tons. cwts.	Tons. cwts.	Tons. cwts.	Tons. cwts.	
1	Unmanured	3 6¼	0 5¼	0 5¾	3 17¼	Withered, not weighed, each lot spread on its own Plot and ploughed in.
2	Farmyard Manure (14 tons)	3 18¼	0 4	0 3⅛	4 5¼	
3	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	4 14¾	0 6¾	0 5¼	5 6¾	
4	Farmyard Manure (14 tons), 3½ cwts. Superphosphate, and 550 lbs. Nitrate of Soda	5 9¼	0 5¾	0 19½	6 14½	
5	400 lbs. Ammonium-salts (2)	2 5¼	0 6¾	0 6	2 18	
6	550 lbs. Nitrate of Soda	3 2	0 5¾	0 9⅞	3 17⅝	
(3) 7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	6 12½	0 9½	1 0	8 2	
(3) 8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	6 17¾	0 10	1 8⅛	8 15⅞	
(3) 9	3½ cwts. Superphosphate	4 18¾	0 8½	0 13¾	6 1	
(3) 10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	5 3¾	0 6¾	0 13⅛	6 3⅝	
	Second Season, 1877. Potatoes planted, April 27–28; Crop taken up, Oct. 8–10.					
1	Unmanured	2 11¼	0 6¾	0 2½	3 0½	Withered, not weighed, each lot spread on its own Plot, but high wind (Oct. 14th) blew all off, before ploughing.
2	Farmyard Manure (14 tons)	5 0¾	0 11¼	0 6	5 18	
3	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	4 13½	0 7¼	0 4	5 4¾	
4	Farmyard Manure (14 tons), 3½ cwts. Superphosphate, and 550 lbs. Nitrate of Soda	6 18¾	0 7	0 17⅓	8 3½	
5	400 lbs. Ammonium-salts (2)	3 9¾	0 7¼	0 4	4 1	
6	550 lbs. Nitrate of Soda	4 14¾	0 6¾	0 5¾	5 7¼	
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	6 12	0 11¼	0 14¼	7 17½	
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	7 8¼	0 8¾	0 16¾	8 13¾	
9	3½ cwts. Superphosphate	2 12¾	0 11¾	0 1½	3 6	
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	3 6¾	0 7½	0 1¼	3 15½	

THIRD SEASON, 1878. Potatoes planted, April 29. Crop taken up, Sept. 18-21; Tops weighed, and spread on the Plots.

1	Unmanured	2	6¾	0	8¾	0	2	2	17½	0	3¾	
2	Farmyard Manure (14 tons)	4	11	0	12¼	0	8½	5	11¾	0	6¾	
3	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	5	18¼	0	14½	0	13¼	7	6	0	11	
4	Farmyard Manure (14 tons), 3½ cwts. Superphosphate, and 550 lbs. Nitrate of Soda	6	11¾	0	11¼	1	6¼	8	9¼	1	6	
5	400 lbs. Ammonium-salts (2)	2	16¼	0	8½	0	5¾	3	10½	0	7	
6	550 lbs. Nitrate of Soda	3	16¾	0	7	0	9½	4	13¼	0	11	
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	7	6¾	0	9½	1	1	8	17¼	0	13¾	
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	7	11½	0	9	1	3¾	9	4¼	1	0½	
9	3½ cwts. Superphosphate	3	5¾	0	9½	0	3½	3	18¾	0	4¾	
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	3	8	0	9	0	4¾	4	1¾	0	4¾	

FOURTH SEASON, 1879. Potatoes planted, May 2; Crop taken up, Oct. 13-16.

1	Unmanured	0	11½	0	4	0	0¾	0	16¼	Withered, not weighed, each lot spread on its own Plot and ploughed in.		
2	Farmyard Manure (14 tons)	1	13½	0	4½	0	10½	2	8½			
3	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	1	14	0	6	0	10¼	2	10¼			
4	Farmyard Manure (14 tons), 3½ cwts. Superphosphate, and 550 lbs. Nitrate of Soda	2	16	0	5¾	0	12¾	3	14½			
5	400 lbs. Ammonium-salts (2)	0	17½	0	4	0	1½	1	3			
6	550 lbs. Nitrate of Soda	0	14½	0	4½	0	2	1	0¾			
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	2	4½	0	5	0	6	2	15½			
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1	18¼	0	4½	0	6¼	2	9			
9	3½ cwts. Superphosphate	0	17¼	0	3½	0	1¼	1	2			
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	0	16¾	0	3	0	1¾	1	1½			

FIFTH SEASON, 1880. Potatoes planted, April 13; Crop taken up, Plots 5 and 6, Sept. 9th; other Plots, Sept. 28-30.

1	Unmanured	0	14½	0	6¼	0	0½	1	1¼	Withered, not weighed, each lot spread on its own Plot and ploughed in.		
2	Farmyard Manure (14 tons)	4	13½	0	6	0	5	5	4¼			
3	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	5	6¾	0	5¼	0	10¾	6	2¾			
4	Farmyard Manure (14 tons), 3½ cwts. Superphosphate, and 550 lbs. Nitrate of Soda	5	4	0	5¼	1	1½	6	10¼			
5	400 lbs. Ammonium-salts (2)	0	8½	0	9¼	0	0	0	17¾			
6	550 lbs. Nitrate of Soda	0	11¼	0	10	0	0	1	1¼			
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	5	15½	0	5½	0	13	6	14			
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	6	3½	0	6¾	1	1	7	11¼			
9	3½ cwts. Superphosphate	3	9	0	6¾	0	3¼	3	19			
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	3	7¼	0	6	0	3¼	3	16½			

AVERAGE OF 5 SEASONS, 1876, '77, '78, '79, and 1880.

1	Unmanured	1	18	0	6¼	0	2¼	2	6½	In each year the Tops were spread on the respective Plots. For particulars see above.		
2	Farmyard Manure (14 tons)	3	19⅜	0	7⅝	0	6⅛	4	13⅝			
3	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	4	9½	0	8	0	8¾	5	6¼			
4	Farmyard Manure (14 tons), 3½ cwts. Superphosphate, and 550 lbs. Nitrate of Soda	5	8	0	7	0	19¼	6	14¼			
5	400 lbs. Ammonium-salts (2)	1	19½	0	7⅛	0	3½	2	10½			
6	550 lbs. Nitrate of Soda	2	11⅞	0	6⅞	0	5¼	3	4			
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	5	14¼	0	8¼	0	14¾	6	17¼			
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	5	19⅞	0	7⅞	0	19⅛	7	6⅝			
9	3½ cwts. Superphosphate	3	0¾	0	8	0	4⅝	3	13⅝			
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	3	4½	0	6½	0	4⅞	3	15⅞			

(1) "Superphosphate of Lime"—in all cases made from 200 lbs. Bone-ash, 150 lbs. Sulphuric acid, sp. gr. 1·7 (and water).
(2) "Ammonium-salts"—in each case equal parts Sulphate and Muriate Ammonia of Commerce.
(3) The complex mineral manure having been sown in October 1874, but the Wheat not put in, and therefore no crop taken in 1875, no mineral manures are sown afresh on Plots 7, 8, 9, and 10, for the first crop of potatoes, 1876.

EXPERIMENTS ON POTATOES.—HOOS FIELD—*continued.*—SUMMARY OF THE COMPOSITION OF THE "GOOD" TUBERS, in each of the first 5 Seasons, 1876–1880; also the average composition over those first 5 Seasons. For the composition in 1881 and since, see pp. 84–5, 88–9, 92–3, and 96–7.

An abstract of the analytical results obtained, illustrating the influence of different manures, and of different seasons, on the composition of Potatoes, is given below. The specific gravity of the tubers is also given. In the tubers the dry matter, nitrogen, and ash have been determined; and in some cases complete analyses of the ash have been made. Besides the results obtained relating to the composition of the tubers themselves, the dry matter, the sugar, the nitrogen, and the ash, in the expressed juice have in many cases been determined; in some cases the amount of the nitrogen existing as albuminoids has been determined; and in some, complete analyses of the ash of the juice have been made. It may be remarked, that by far the larger proportion of both the mineral matter, and the nitrogen, is found to exist in the juice; and of the nitrogen in the juice, as a rule, not much more than half exists as albuminoids. In the majority of cases, the small potatoes have been submitted to the same methods of analysis as the good potatoes. And in a large number of cases, similar methods of examination have been applied to the still white, and also to the separated discoloured portions of the diseased potatoes. With regard to these latter results, it may be observed, that whilst the juice of the white portion of the diseased potatoes contained approximately the normal amount of nitrogen, that of the discoloured portion contained very much less. On the other hand, the washed, or exhausted "marc" of the white portion, contained very little nitrogen, whilst that of the discoloured portion contained very much more. The distribution of the mineral matter was much in the same order as that of the nitrogen. It was obvious that the juice had suffered exhaustion of much of both its nitrogen and its mineral matter, in the development of the fungus. There was an increased amount of sugar found in the diseased potatoes, the result of diseased action, and it probably also contributed to the development of the fungus.

The results given in the Table relate to the "good" potatoes only. In interpreting the figures it must be borne in mind that in each year, the seed was planted on all the plots at the same time, and that all the crops were taken up at the same time; and as there was several times as much produce in some cases as in others, it is obvious that the crops would not each be at its best, and all in the same condition of maturity, when taken up. Then, again, the analyses were not performed immediately after taking up the crops, but some time afterwards, in weighed samples which had been kept in a cool place for some weeks or months; and in the following only preliminary statement of results, no correction is made for any change from the original weight of the samples, the results being calculated upon the fresh weights as finally taken for analysis.

Plots.	Manures per Acre, per Annum. (For Produce, see pp. 78–9.)	Specific Gravity of the Tubers.	Composition of the "Good" Tubers.				
			Dry Matter.	Mineral Matter (Ash).		Nitrogen.	
				In Fresh Tubers.	In Dry Matter.	In Fresh Tubers.	In Dry Matter.
	First Season, 1876.						
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1	Unmanured	1·097	23·9	0·84	3·53	0·269	1·13
2	Farmyard Manure (14 tons)	1·091	23·4	0·96	4·11	0·223	0·95
3	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	1·097	23·5	1·00	4·27	0·191	0·81
4	Farmyard Manure (14 tons), 3½ cwts. Superphosphate, and 550 lbs. Nitrate of Soda	1·085	21·2	0·83	3·92	0·295	1·39
5	400 lbs. Ammonium-salts (2)	1·087	22·1	0·81	3·67	0·332	1·50
6	550 lbs. Nitrate of Soda	1·091	22·0	0·79	3·59	0·327	1·49
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·090	20·9	0·98	4·71	0·266	1·27
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·088	21·9	0·98	4·46	0·292	1·33
9	3½ cwts. Superphosphate	1·103	23·5	1·10	4·72	0·199	0·84
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·102	22·9	1·06	4·64	0·171	0·74
	Second Season, 1877.						
1	Unmanured	1·119	33·0	1·05	3·17	0·302	0·91
2	Farmyard Manure (14 tons)	1·109	26·5	1·06	4·00	0·212	0·80
3	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	1·103	26·0	1·11	4·26	0·207	0·80
4	Farmyard Manure (14 tons), 3½ cwts. Superphosphate, and 550 lbs. Nitrate of Soda	1·112	27·2	1·06	3·90	0·301	1·11
5	400 lbs. Ammonium-salts (2)	1·107	22·0	0·67	3·07	0·281	1·28
6	550 lbs. Nitrate of Soda	1·116	25·9	0·74	2·85	0·301	1·16
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·103	28·4	1·23	4·33	0·270	0·95
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·112	27·3	1·16	4·26	0·268	0·98
9	3½ cwts. Superphosphate	1·109	26·5	1·18	4·44	0·203	0·76
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·109	26·8	1·21	4·52	0·208	0·78

Third Season, 1878.

1	Unmanured	1·107	26·0	0·85	3·26	0·228	0·88
2	Farmyard Manure (14 tons)	1·100	24·4	1·02	4·20	0·209	0·86
3	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	1·090	23·8	1·03	4·35	0·205	0·86
4	Farmyard Manure (14 tons), 3½ cwts. Superphosphate, and 550 lbs. Nitrate of Soda	1·078	21·9	0·97	4·45	0·269	1·23
5	400 lbs. Ammonium-salts (2)	1·099	24·9	0·78	3·12	0·310	1·25
6	550 lbs. Nitrate of Soda	1·105	25·5	0·67	2·64	0·326	1·28
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·093	23·6	1·08	4·57	0·223	0·95
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·097	24·4	1·08	4·41	0·228	0·94
9	3½ cwts. Superphosphate	1·097	24·1	1·14	4·74	0·165	0·68
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·098	23·7	1·16	4·90	0·167	0·71

Fourth Season, 1879.

1	Unmanured	1·103	24·3	0·96	3·95	0·242	1·00
2	Farmyard Manure (14 tons)	1·103	23·7	0·99	4·16	0·220	0.93
3	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	1·099	24·0	1·02	4·26	0·218	0·91
4	Farmyard Manure (14 tons), 3½ cwts. Superphosphate, and 550 lbs. Nitrate of Soda	1·102	24·6	0·91	3·69	0·254	1·04
5	400 lbs. Ammonium-salts (2)	1·103	24·6	0·76	3·06	0·270	1·10
6	550 lbs. Nitrate of Soda	1·104	25·0	0·76	3·05	0·300	1·20
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·098	23·1	0·95	4·13	0·241	1·05
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·102	23·9	1·04	4·36	0·272	1·14
9	3½ cwts. Superphosphate	1·099	23·6	1·10	4·65	0·219	0·93
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·099	23·5	1·15	4·89	0·211	0·90

Fifth Season, 1880.

1	Unmanured	1·123	28·8	0·77	2·66	0·382	1·33
2	Farmyard Manure (14 tons)	1·114	27·6	0·98	3·56	0·287	1·04
3	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	1·117	27·8	0·98	3·52	0·275	0·99
4	Farmyard Manure (14 tons), 3½ cwts. Superphosphate, and 550 lbs. Nitrate of Soda	1·102	25·2	0·88	3·48	0·357	1·41
5	400 lbs. Ammonium-salts (2)	1·114	28·5	0·84	2·95	0·430	1·51
6	550 lbs. Nitrate of Soda	1·117	28·8	0·88	3·06	0·415	1·44
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·097	25·9	0·97	3·73	0·327	1·26
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·118	26·7	0·96	3·59	0·318	1·19
9	3½ cwts. Superphosphate	1·114	27·2	1·03	3·81	0·247	0·91
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·116	27·3	1·06	3·86	0·236	0·87

Average of 5 Seasons, 1876 '77, '78, '79, and 1880.

1	Unmanured	1·110	27·2	0·89	3·31	0·285	1·05
2	Farmyard Manure (14 tons)	1·103	25·1	1·00	4·01	0·231	0·92
3	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	1·101	25·0	1·03	4·13	0·220	0·88
4	Farmyard Manure (14 tons), 3½ cwts. Superphosphate, and 550 lbs. Nitrate of Soda	1·096	24·0	0·93	3·89	0·296	1·24
5	400 lbs. Ammonium-salts (2)	1·102	24·4	0·77	3·17	0·326	1·33
6	550 lbs. Nitrate of Soda	1·107	25·4	0·77	3·04	0·335	1·32
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·096	24·4	1·04	4·29	0·266	1·10
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·103	24·8	1·04	4·22	0·276	1·12
9	3½ cwts. Superphosphate	1·104	25·0	1·11	4·47	0·207	0·83
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·105	24·8	1·13	4·56	0·199	0·80

(1) "Superphosphate of Lime"—in all cases made from 200 lbs. Bone-ash, 150 lbs. Sulphuric acid, sp. gr. 1·7 (and water).
(2) "Ammonium-salts"—in each case equal parts Sulphate and Muriate Ammonia of Commerce.

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EXPERIMENTS ON POTATOES.—HOOS FIELD—*continued.*

Below are given the particulars of the Manures and Produce of the Sixth, Seventh, Eighth, Ninth, and Tenth Seasons, 1881, 1882, 1883, 1884, and 1885. For the Manures and Produce of the 5 preceding years, see pp. 78–9, and of succeeding years, 1886 and since, see pp. 86–7, 90–1, and 94–5.

The Land had been under experiments with Wheat, differently manured, from 1856 to 1874; and was fallowed in 1875.

Plots 1, 2, 3, and 4 had been unmanured for the Wheat. Plots 5 and 6 had received the same quantity of Ammonium-salts alone every year for the Wheat, as Plot 5 now receives for potatoes: Plot 6 now receiving the same amount of nitrogen, but as Nitrate of Soda, instead of Ammonium-salts. Plots 7 and 8 received the same amount of complex mineral manure, and Ammonium-salts, for the Wheat, as Plot 7 now receives for potatoes; and Plot 8 now receives the same complex mineral manures, and the same amount of nitrogen, but as Nitrate of Soda instead of Ammonium-salts. Plots 9 and 10 received the same complex mineral manures alone for the Wheat as Plot 10 now receives for potatoes; Plot 9 now receives superphosphate only. Description of Potatoes, in 1876, 1877, 1878, and 1879, the "Rock" (White); and in those years the rows were 25 inches apart, with 12 inches from plant to plant in the rows. In 1881, 1882, 1883, 1884, and 1885, the description was the "Champion" (White); and the rows were 25 inches apart, with 14 inches from plant to plant in the rows.

(Area under experiment, 2 acres.)

Plots.	Manures per Acre per Annum.	Produce per Acre. Tubers. Good.	Tubers. Small.	Tubers. Diseased.	Tubers. Total.	Tops.
	Sixth Season, 1881. Potatoes planted, March 31; Crop taken up, October 5, 6 and 7.	Tons. cwts.	Tons. cwts.	Tons. cwts.	Tons. cwts.	
1	Unmanured, in 1876, and each year since	1 17¼	0 3¼	0 0¼	2 0¾	Withered, not weighed, each lot spread on its own Plot and ploughed in.
2	Farmyard Manure (14 tons)	7 14½	0 3¾	0 1¾	8 0	
3	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	6 14¼	0 4	0 1¼	6 19½	
4	Farmyard Manure (14 tons), 3½ cwts. Superphosphate, and 550 lbs. Nitrate of Soda	8 6¾	0 5¼	0 9½	9 1½	
5	400 lbs. Ammonium-salts (2)	2 6	0 4½	0 0	2 10½	
6	550 lbs. Nitrate of Soda	2 19¾	0 3¼	0 0¾	3 3¾	
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	10 10½	0 3½	0 1⅝	10 16	
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	9 12½	0 4	0 3⅓	10 0	
9	3½ cwts. Superphosphate	5 7¾	0 3¼	0 0½	5 11½	
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	5 14¾	0 2¾	0 1	5 18½	
	Seventh Season, 1882. Potatoes planted, March 21. Crop taken up, September 25–27.					
1	Unmanured, in 1876, and each year since	1 15¼	0 3½	0 0¼	1 19	Withered, not weighed, each lot spread on its own Plot and ploughed in.
2	Unmanured in 1882. Previously Farmyard Manure (14 tons)	3 15¾	0 2¼	0 2	4 0	
3	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	5 8	0 4¼	0 3½	5 15¾	
4	Farmyard Manure (14 tons), 3½ cwts. Superphosphate. In 1881, and previously, 550 lbs. Nitrate of Soda also	4 7¼	0 3¾	0 1¼	4 12¼	
5	400 lbs. Ammonium-salts (2)	1 18¼	0 3¾	0 0¼	2 2¼	
6	550 lbs. Nitrate of Soda	1 18½	0 3	0 0¼	2 1¾	
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	7 15½	0 3½	0 11¾	8 10¾	
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	6 16½	0 3½	0 2¾	7 2¾	
9	3½ cwts. Superphosphate	4 12	0 2¼	0 1½	4 15¾	
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	4 7½	0 2¼	0 0¼	4 10	

EIGHTH SEASON, 1883. Potatoes planted, March 22. Crop taken up October 22–25.

1	Unmanured, in 1876, and each year since	2	4¼	0	6½	0	1¼	2	12	Withered, not weighed, each lot spread on its own Plot and ploughed in.
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	4	5¼	1	0½	0	4	5	9¾	
3	Farmyard Manure (14 tons) alone 1883; previously 3½ cwts. Superphosphate also (1)	5	6½	0	9½	0	4¾	6	0¾	
4	Farmyard Manure (14 tons) alone 1883. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	4	0¾	0	11¼	0	1¾	4	13¾	
5	400 lbs. Ammonium-salts (2)	2	13¼	0	8½	0	2¾	3	4½	
6	550 lbs. Nitrate of Soda	2	13½	0	7¾	0	1¼	3	2½	
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	7	16¾	0	14	0	8¼	8	19	
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	7	9½	0	9¾	0	3½	8	2¾	
9	3½ cwts. Superphosphate	4	8½	0	7¾	0	3¼	4	19½	
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	4	9½	0	7½	0	1¾	4	18¾	

NINTH SEASON, 1884. Potatoes planted, March 21. Crop taken up, September 24–26.

1	Unmanured, in 1876, and each year since	2	0¼	0	4¾	0	1	2	6	Withered, not weighed, each lot spread on its own Plot and ploughed in.
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	2	5¼	0	4¼	0	2	2	11½	
3	Farmyard Manure (14 tons), alone 1883–4, previously 3½ cwts. Superphosphate also (1)	3	10¾	0	5¾	0	2¼	3	18¾	
4	Farmyard Manure (14 tons) alone 1883–4. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	3	12½	0	6¼	0	2½	4	1¼	
5	400 lbs. Ammonium-salts (2)	2	0½	0	7½	0	0¾	2	8¾	
6	550 lbs. Nitrate of Soda	1	16¼	0	3¼	0	0½	2	0	
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	4	19¼	0	10½	0	2¼	5	12	
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	4	10¼	0	7	0	2½	4	19¾	
9	3½ cwts. Superphosphate	3	13¼	0	5	0	1¼	3	19½	
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	3	13	0	5	0	1¾	3	19¾	

TENTH SEASON, 1885. Potatoes planted, March 17 and 18. Crop taken up, September 24–26.

1	Unmanured in 1876, and each year since	0	16¾	0	4¼	0	0	1	1	Withered, not weighed, each lot spread on its own Plot and ploughed in.
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1	13	0	3⅝	0	1	1	17⅜	
3	Farmyard Manure (14 tons) alone 1883 and since; previously 3½ cwts. Superphosphate also (1)	2	6⅝	0	5⅛	0	0⅝	2	12⅜	
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	2	11	0	4⅛	0	0⅝	2	15¾	
5	400 lbs. Ammonium-salts (2)	1	6½	0	5½	0	0	1	12	
6	550 lbs. Nitrate of Soda	1	7¼	0	5	0	0¼	1	12½	
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	4	2	0	6½	0	1⅜	4	9⅞	
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	3	16½	0	4⅞	0	1⅛	4	2½	
9	3½ cwts. Superphosphate	2	1⅛	0	3¼	0	0⅛	2	5¼	
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	2	0	0	2¾	0	0½	2	3¼	

AVERAGE OF 5 SEASONS, 1881, '82, '83, '84, and 1885.

1	Unmanured in 1876, and each year since	1	14⅜	0	4⅜	0	0⅜	1	19¾	Withered, not weighed, each lot spread on its own Plot and ploughed in.
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	3	18⅜	0	6⅜	0	2⅛	4	7⅜	
3	Farmyard Manure (14 tons) alone 1883 and since; previously 3½ cwts. Superphosphate also (1)	4	13⅛	0	5¾	0	2½	5	1⅜	
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	4	11⅝	0	6⅛	0	3⅛	5	0⅞	
5	400 lbs. Ammonium-salts (2)	2	0⅞	0	6	0	0¾	2	7⅝	
6	550 lbs. Nitrate of Soda	2	3	0	4½	0	0⅝	2	8⅛	
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	7	0⅞	0	7⅜	0	5	7	13½	
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	6	9	0	5⅞	0	2⅝	6	17½	
9	3½ cwts. Superphosphate	4	0½	0	4¼	0	1½	4	6¼	
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	4	0⅞	0	4⅛	0	1	4	6	

(1) "Superphosphate of Lime"—in all cases made from 200 lbs. Bone-ash, 150 lbs. Sulphuric acid, sp. gr. 1·7 (and water).
(2) "Ammonium-salts"—in each case equal parts Sulphate and Muriate Ammonia of Commerce.

EXPERIMENTS ON POTATOES.—HOOS FIELD—*continued.*—SUMMARY OF THE COMPOSITION OF THE "GOOD" TUBERS, in the Sixth, Seventh, Eighth, Ninth, and Tenth Seasons, 1881, 1882, 1883, 1884, and 1885. For the particulars of the composition in the first 5 years, 1876–1880, see pp. 80–1, and for those in succeeding years, 1886 and since, see pp. 88–9, 92–3, and 96–7.

An abstract of the analytical results obtained, illustrating the influence of different manures, and of different seasons, on the composition of Potatoes, is given below. The specific gravity of the tubers is also given. In the tubers the dry matter, nitrogen, and ash have been determined; and in some cases complete analyses of the ash have been made. Besides the results obtained relating to the composition of the tubers themselves, the dry matter, the sugar, the nitrogen, and the ash, in the expressed juice have in many cases been determined; in some cases the amount of the nitrogen existing as albuminoids has been determined; and in some, complete analyses of the ash of the juice have been made. It may be remarked, that by far the larger proportion of both the mineral matter, and the nitrogen, is found to exist in the juice; and of the nitrogen in the juice, as a rule, not much more than half exists as albuminoids. In many cases, the small potatoes have been submitted to the same methods of analysis as the good potatoes. And in some cases, similar methods of examination have been applied to the still white, and also to the separated discoloured portions of the diseased potatoes. With regard to these latter results, it may be observed, that whilst the juice of the white portion of the diseased potatoes contained approximately the normal amount of nitrogen, that of the discoloured portion contained very much less. On the other hand, the washed, or exhausted "marc" of the white portion, contained very little nitrogen, whilst that of the discoloured portion contained very much more. The distribution of the mineral matter was much in the same order as that of the nitrogen. It was obvious that the juice had suffered exhaustion of much of both its nitrogen and its mineral matter, in the development of the fungus. There was an increased amount of sugar found in the diseased potatoes, the result of diseased action, and it probably also contributed to the development of the fungus.

The results given in the Table relate to the "good" potatoes only. In interpreting the figures it must be borne in mind that in each year, the seed was planted on all the plots at the same time, and that all the crops were taken up at the same time; and as there was several times as much produce in some cases as in others, it is obvious that the crops would not each be at its best, and all in the same condition of maturity when taken up. Then, again, the analyses were not performed immediately after taking up the crops, but sometime afterwards, in weighed samples which had been kept in a cool place for some weeks or months; and in the following only preliminary statement of results, no correction is made for any change from the original weight of the samples, the results being calculated upon the fresh weights as finally taken for analysis.

Plots.	Manures per Acre, per Annum. (For Produce, see pp. 82–3.)	Specific Gravity of the Tubers.	Composition of the "Good" Tubers.				
			Dry Matter.	Mineral Matter (Ash).		Nitrogen.	
				In Fresh Tubers.	In Dry Matter.	In Fresh Tubers.	In Dry Matter.
	Sixth Season, 1881.		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1	Unmanured, in 1876, and each year since	1·125	30·5	0·86	2·82	0·389	1·28
2	Farmyard Manure (14 tons)	1·116	29·1	0·99	3·41	0·294	1·01
3	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	1·113	28·1	1·07	3·81	0·295	1·05
4	Farmyard Manure (14 tons), 3½ cwts. Superphosphate, and 550 lbs. Nitrate of Soda	1·107	26·0	0·91	3·51	0·359	1·39
5	400 lbs. Ammonium-salts (2)	1·115	27·9	0·84	3·03	0·375	1·35
6	550 lbs. Nitrate of Soda	1·114	28·0	0·76	2·70	0·379	1·36
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·110	26·7	1·06	3·97	0·306	1·15
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·107	25·3	0·98	3·89	0·341	1·35
9	3½ cwts. Superphosphate	1·123	29·0	1·14	3·92	0·242	0·83
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·122	28·3	1·17	4·13	0·225	0·80
	Seventh Season, 1882.						
1	Unmanured, in 1876, and each year since	1·127	29·5	0·83	2·82	0·296	1·00
2	Unmanured in 1882. Previously Farmyard Manure (14 tons)	1·131	30·3	0·91	3·01	0·260	0·86
3	Farmyard Manure (14 tons), and 3½ cwts. Superphosphate (1)	1·122	28·7	0·97	3·39	0·261	0·91
4	Farmyard Manure (14 tons), 3½ cwts. Superphosphate. In 1881, and previously, 550 lbs. Nitrate of Soda also	1·116	26·6	0·93	3·48	0·313	1·18
5	400 lbs. Ammonium-salts (2)	1·119	27·9	0·77	2·78	0·372	1·34
6	550 lbs. Nitrate of Soda	1·119	27·9	0·79	2·82	0·408	1·46
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·120	27·5	0·96	3·49	0·305	1·11
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·123	28·2	0·98	3·46	0·336	1·19
9	3½ cwts. Superphosphate	1·128	29·3	1·03	3·53	0·209	0·71
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·125	29·1	1·08	3·71	0·229	0·79

Eighth Season, 1883.

1	Unmanured, in 1876, and each year since	1·123	28·5	0·79	2·78	0·312	1·10
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1·128	28·3	0·88	3·10	0·276	0·97
3	Farmyard Manure (14 tons) alone 1883; previously 3½ cwts. Superphosphate also (1)	1·117	26·6	0·95	3·56	0·289	1·09
4	Farmyard Manure (14 tons) alone 1883. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	1·109	26·2	0·93	3·53	0·320	1·22
5	400 lbs. Ammonium-salts (2)	1·117	26·8	0·75	2·81	0·368	1·37
6	550 lbs. Nitrate of Soda	1·118	26 8	0·71	2·64	0·393	1·47
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·113	26·2	0·96	3·67	0·282	1·08
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·111	26·2	0·97	3·86	0·359	1·37
9	3½ cwts. Superphosphate	1·123	27·2	1·02	3·76	0·208	0·77
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·122	27·2	1·05	3·86	0·197	0·73

Ninth Season, 1884.

1	Unmanured, in 1876, and each year since	1·117	27·0	0·75	2·78	0·360	1·33
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1·115	26·9	0·80	2·99	0·361	1·34
3	Farmyard Manure (14 tons) alone 1883–4; previously 3½ cwts. Superphosphate also (1)	1·102	24·6	0·91	3·69	0·390	1·59
4	Farmyard Manure (14 tons) alone 1883–4. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	1·099	23·8	0·92	3·88	0·382	1·61
5	400 lbs. Ammonium-salts (2)	1·107	25·8	0·67	2·58	0·456	1·77
6	550 lbs. Nitrate of Soda	1·105	25·2	0·66	2·61	0·443	1·76
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·099	24·3	0·95	3·89	0·387	1·59
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·098	23·8	0·89	3·72	0·440	1·85
9	3½ cwts. Superphosphate	1·117	26·6	1·01	3·78	0·260	0·98
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·118	26·8	1·07	3·98	0·238	0·88

Tenth Season, 1885.

1	Unmanured, in 1876, and each year since	1·123	28·7	0·82	2·85	0·390	1·36
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1·124	27·9	0·83	2·99	0·388	1·39
3	Farmyard Manure (14 tons) alone 1883 and since; previously 3½ cwts. Superphosphate also (1)	1·114	26·5	0·96	3·63	0·394	1·49
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	1·113	26·9	0·97	3·61	0·418	1·56
5	400 lbs. Ammonium-salts (2)	1·115	27·5	0·83	3·01	0·474	1·73
6	550 lbs. Nitrate of Soda	1·119	27·4	0·74	2·70	0·482	1·76
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda. 100 lbs. Sulph. Mag.	1·111	26·6	0·96	3·59	0·408	1·53
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·116	27·7	0·93	3·37	0·408	1·47
9	3½ cwts. Superphosphate	1·127	28·6	1·02	3·56	0·340	1·19
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·119	27·6	1·10	3·97	0·299	1·08

Average of 5 Seasons, 1881, '82, '83, '84, and 1885.

1	Unmanured in 1876, and each year since	1·123	28·8	0·81	2·81	0·349	1·21
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1·123	28·5	0·88	3·10	0·316	1·11
3	Farmyard Manure (14 tons) alone 1883 and since; previously 3½ cwts. Superphosphate also (1)	1·114	26·9	0·97	3·62	0·326	1·23
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	1·109	25·9	0·93	3·60	0·358	1·39
5	400 lbs. Ammonium-salts (2)	1·115	27·2	0 77	2·84	0·409	1·51
6	550 lbs. Nitrate of Soda	1·115	27·1	0·73	2·69	0·421	1·56
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·111	26·3	0·98	3·72	0·338	1·29
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·111	26·2	0·95	3·66	0·377	1·45
9	3½ cwts. Superphosphate	1·124	28·1	1·04	3·71	0·252	0·90
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·121	27·8	1·09	3·93	0·238	0·86

(1) "Superphosphate of Lime"—in all cases made from 200 lbs. Bone-ash, 150 lbs. Sulphuric acid, sp. gr. 1·7 (and water).
(2) "Ammonium-salts"—in each case equal parts Sulphate and Muriate Ammonia of Commerce.

EXPERIMENTS ON POTATOES.—HOOS FIELD—*continued.*

Below are given the particulars of the Manures and Produce, of the Eleventh, Twelfth, Thirteenth, Fourteenth, and Fifteenth Seasons, 1886, 1887, 1888, 1889, and 1890. For the Manures, description of Potatoes grown, and the Produce, in the 10 preceding years, see pp. 78–9, and 82–3, and in succeeding years, pp. 90–1, and 94–5.

The arrangement of the plots is precisely the same as for the 10 preceding potato crops. The manures are the same as for the crops of 1883, 1884 and 1885, excepting that for the crop of 1887 Sulphate Ammonia was applied instead of equal parts of Sulphate and Muriate Ammonia, as in former years and since (see foot-note No. 2). Description of Potato, "The Champion" (White). Rows 25 inches apart; 14 inches from plant to plant in the rows.

(Area under experiment, 2 acres.)

Plots.	Manures per Acre per Annum.	Produce per Acre. Tubers. Good.	Small.	Diseased.	Total.	Tops.
	Eleventh Season, 1886. Potatoes planted, April 10. Crop taken up, September 30, and October 1 and 2.	Tons. cwts.	Tons. cwts.	Tons. cwts.	Tons. cwts.	
1	Unmanured in 1876, and each year since	0 13¾	0 4	0 0¼	0 18	Withered, not weighed, each lot spread on its own Plot and ploughed in.
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1 17	0 3	0 1	2 1	
3	Farmyard Manure (14 tons) alone 1883 and since; previously 3½ cwts. Superphosphate also (1)	2 15	0 3¼	0 1	2 19¼	
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	2 12¼	0 3	0 1½	2 16¾	
5	400 lbs. Ammonium-salts (2)	1 2½	0 4½	0 1	1 8	
6	550 lbs. Nitrate of Soda	1 2½	0 3¾	0 0¼	1 6½	
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	3 10	0 3¼	0 1	3 14¼	
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	3 6¼	0 3½	0 0½	3 10¼	
9	3½ cwts. Superphosphate	1 17¾	0 2½	0 0¾	2 1	
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	2 2½	0 2¾	0 0½	2 5¾	
	Twelfth Season, 1887. Potatoes planted, March 24. Crop taken up, October 17–19.					
1	Unmanured in 1876, and each year since	1 3¾	0 3	0 0½	1 7¼	Withered, not weighed, each lot spread on its own Plot and ploughed in.
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	2 2¼	0 3¼	0 0½	2 6	
3	Farmyard Manure (14 tons) alone 1883 and since; previously 3½ cwts. Superphosphate also (1)	3 18	0 4¾	0 1	4 3¾	
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	4 14	0 4¾	0 3	5 1¾	
5	450 lbs. Sulphate Ammonia (3)	1 9¾	0 3½	0 0¼	1 13½	
6	550 lbs. Nitrate of Soda	1 18¼	0 3¼	0 0½	2 2	
7	450 lbs. Sulph. Ammonia, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	4 1¼	0 4¾	0 0¾	4 6¾	
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	4 18	0 4¼	0 2	5 4¼	
9	3½ cwts. Superphosphate	1 16½	0 4	0 1	2 1½	
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	2 3¾	0 3¾	0 1½	2 9	

	THIRTEENTH SEASON, 1888. Potatoes planted, April 17. Crop taken up, October 11–17.									
1	Unmanured in 1876, and each year since	0	12¾	0	2¼	0	0¼	0	15½	Withered, not weighed, each lot spread on its own Plot and ploughed in.
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1	10¾	0	2¼	0	1	1	14	
3	Farmyard Manure (14 tons) alone 1883 and since; previously 3½ cwts. Superphosphate also (1)	2	3	0	2¼	0	6	2	11¼	
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	2	3½	0	1¾	0	6	2	11¼	
5	400 lbs. Ammonium-salts (2)	0	19¾	0	2	0	0½	1	2¼	
6	550 lbs. Nitrate of Soda	1	7	0	2½	0	1¼	1	10¾	
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	2	8½	0	1½	0	8½	2	18½	
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	3	2¾	0	1¾	0	13¼	3	17¾	
9	3½ cwts. Superphosphate	1	11½	0	1½	0	0¾	1	13¾	
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia ..	1	12¾	0	1½	0	1¼	1	15½	
	FOURTEENTH SEASON, 1889. Potatoes planted, March 28 and 29. Crop taken up, September 16–18.									
1	Unmanured in 1876, and each year since	0	13¾	0	2¼	0	0½	0	16½	Withered, not weighed, each lot spread on its own Plot and ploughed in.
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1	9¾	0	2½	0	0¾	1	13	
3	Farmyard Manure (14 tons) alone 1883 and since; previously 3½ cwts. Superphosphate also (1)	1	9½	0	3	0	7¼	1	19¾	
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	2	10¾	0	3	0	5	2	18¾	
5	400 lbs. Ammonium-salts (2)	1	1¼	0	2½	0	0¾	1	4½	
6	550 lbs. Nitrate of Soda	1	7	0	2½	0	2½	1	12	
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	3	2¾	0	2¾	0	3½	3	9	
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	3	6¾	0	2	0	2½	3	11¼	
9	3½ cwts. Superphosphate	1	15½	0	2	0	1	1	18½	
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia ..	2	2¾	0	1¾	0	1	2	5½	
	FIFTEENTH SEASON, 1890. Potatoes planted, April 3. Crop taken up, September 9–11.									
1	Unmanured in 1876, and each year since	0	18¾	0	6	0	0¼	1	5	Withered, not weighed, each lot spread on its own Plot and ploughed in.
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	2	4	0	7	0	1¼	2	12¼	
3	Farmyard Manure (14 tons) alone 1883 and since; previously 3½ cwts. Superphosphate also (1)	6	1	0	8¼	0	6	6	15¼	
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	6	2½	0	8¾	0	5¾	6	17	
5	400 lbs. Ammonium-salts (2)	1	9¼	0	10¾	0	0¾	2	0½	
6	550 lbs. Nitrate of Soda	2	2	0	6¾	0	0¾	2	9½	
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	5	13¾	0	6¾	0	7¼	6	7¾	
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	5	14	0	6¼	0	3½	6	3¾	
9	3½ cwts. Superphosphate	2	6	0	5¾	0	0¾	2	12⅛	
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia ..	2	16¼	0	6¼	0	0½	3	3	
	AVERAGE OF 5 SEASONS, 1886, '87, '88, '89, and 1890.									
1	Unmanured in 1876, and each year since	0	16½	0	3½	0	0¼	1	0¼	Withered, not weighed, each lot spread on its own Plot and ploughed in.
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1	16¾	0	3¾	0	0¾	2	1¼	
3	Farmyard Manure (14 tons) alone 1883 and since; previously 3½ cwts. Superphosphate also (1)	3	5¼	0	4¼	0	4¼	3	13¾	
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	3	12½	0	4¼	0	4¼	4	1	
5	400 lbs. Ammonium-salts (2)	1	4½	0	4¾	0	0½	1	9¾	
6	550 lbs. Nitrate of Soda	1	11¼	0	3¾	0	1	1	16	
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	3	15¼	0	3¾	0	4¼	4	3¼	
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	4	1½	0	3¾	0	4¼	4	9⅛	
9	3½ cwts. Superphosphate	1	17½	0	3	0	0¾	2	1¼	
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia ..	2	3½	0	3¼	0	1	2	7¾	

(1) "Superphosphate of Lime," 1886 and 1887, made from 200 lbs. Bone-ash, 150 lbs. Sulphuric acid, sp. gr. 1·7 (and water); 1888, and since, made from high percentage mineral phosphates, and Containing 37 per cent., or more, of soluble phosphate.
(2) "Ammonium-salts"—in each case equal parts Sulphate and Muriate Ammonia of Commerce.
(3) 450 lbs. Sulphate Ammonia is estimated to contain the same amount of Nitrogen as the 200 lbs. Sulphate and 200 lbs. Muriate of Ammonia applied in former years, and since.

EXPERIMENTS ON POTATOES.—HOOS FIELD—*continued.*—SUMMARY OF THE COMPOSITION OF THE "GOOD" TUBERS, in the Eleventh, Twelfth, Thirteenth, Fourteenth, and Fifteenth Seasons, 1886, 1887, 1888, 1889, and 1890. For particulars of the composition in the first 10 years, 1876–1885, see pp. 80–1, and 84–5, and for those in succeeding years, 1891 and since, see pp. 92–3, and 96–7.

An abstract of the analytical results obtained, illustrating the influence of different manures, and of different seasons, on the composition of Potatoes, is given below. The specific gravity of the tubers is also given. In the tubers the dry matter, nitrogen, and ash have been determined; and in some cases complete analyses of the ash have been made. Besides the results obtained relating to the composition of the tubers themselves, the dry matter, the sugar, the nitrogen, and the ash, in the expressed juice have in many cases been determined; in some cases the amount of the nitrogen existing as albuminoids has been determined; and in some, complete analyses of the ash of the juice have been made. It may be remarked, that by far the larger proportion of both the mineral matter, and the nitrogen, is found to exist in the juice; and of the nitrogen in the juice, as a rule, not much more than half exists as albuminoids. In many cases, the small potatoes have been submitted to the same methods of analysis as the good potatoes. And in some cases, similar methods of examination have been applied to the still white, and also to the separated discoloured portions of the diseased potatoes. With regard to these latter results, it may be observed, that whilst the juice of the white portion of the diseased potatoes contained approximately the normal amount of nitrogen, that of the discoloured portion contained very much less. On the other hand, the washed, or exhausted "marc" of the white portion, contained very little nitrogen, whilst that of the discoloured portion contained very much more. The distribution of the mineral matter was much in the same order as that of the nitrogen. It was obvious that the juice had suffered exhaustion of much of both its nitrogen and its mineral matter, in the development of the fungus. There was an increased amount of sugar found in the diseased potatoes, the result of diseased action, and it probably also contributed to the development of the fungus.

The results given in the Table relate to the "good" potatoes only. In interpreting the figures it must be borne in mind that in each year, the seed was planted on all the plots at the same time, and that all the crops were taken up at the same time; and as there was several times as much produce in some cases as in others, it is obvious that the crops would not each be at its best, and all in the same condition of maturity when taken up. Then, again, the analyses were not performed immediately after taking up the crops, but sometime afterwards, in weighed samples which had been kept in a cool place for some weeks or months: and in the following only preliminary statement of results, no correction is made for any change from the original weight of the samples, the results being calculated upon the fresh weights as finally taken for analysis.

Plots.	Manures per Acre, per Annum. (For Produce, see pp. 86–7.)	Specific Gravity of the Tubers.	Composition of the "Good" Tubers.				
			Dry Matter.	Mineral Matter (Ash).		Nitrogen.	
				In Fresh Tubers.	In Dry Matter.	In Fresh Tubers.	In Dry Matter.
	Eleventh Season, 1886.						
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1	Unmanured in 1876, and each year since	1·125	28·9	0·77	2·68	0·403	1·39
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1·125	29·1	0·87	3·00	0·420	1·44
3	Farmyard Manure (14 tons) alone 1883 and since; previously 3½ cwts. Superphosphate also (1)	1·112	26·7	0·98	3·69	0·385	1·44
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	1·115	26·7	0·93	3·47	0·423	1·59
5	400 lbs. Ammonium-salts (2)	1·118	28·7	0·75	2·62	0·468	1·63
6	550 lbs. Nitrate of Soda	1·119	28·6	0·77	2·68	0·468	1·64
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·111	27·4	1·01	3·67	0·401	1·46
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·116	28·2	0·98	3·48	0·395	1·40
9	3½ cwts. Superphosphate	1·123	28·4	0·97	3·41	0·328	1·16
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·122	28·5	1·08	3·79	0·299	1·05
	Twelfth Season, 1887.						
1	Unmanured in 1876, and each year since	1·121	28·0	0·83	2·97	0·434	1·55
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1·121	28·2	0·87	3·07	0·424	1·50
3	Farmyard Manure (14 tons) alone 1883 and since; previously 3½ cwts. Superphosphate also (1)	1·106	25·1	1·00	3·98	0·396	1·58
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881 and previously, 550 lbs. Nitrate of Soda also	1·107	25·2	0·97	3·85	0·374	1·48
5	450 lbs. Sulphate Ammonia (3)	1·115	27·3	0·78	2·85	0·475	1.74
6	550 lbs. Nitrate of Soda	1·115	27·4	0·77	2·80	0·460	1·68
7	450 lbs. Sulph. Ammonia, 3½ cwts. Superphos., (lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·106	26·3	1·12	4·23	0·409	1·55
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 bs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·108	25·5	0·99	3·90	0·431	1·69
9	3½ cwts. Superphosphate	1·118	27·6	1·08	3·92	0·370	1·34
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·111	26·3	1·12	4·27	0·353	1·35

Thirteenth Season, 1888.

1	Unmanured in 1876, and each year since	1·114	27·6	0·84	3·02	0·360	1·30
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1·119	27·9	0·85	3·04	0·345	1·24
3	Farmyard Manure (14 tons) alone 1883 and since; previously 3½ cwts. Superphosphate also (1)	1·105	25·3	1·03	4·09	0·390	1·54
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	1·104	25·4	1·04	4·10	0·362	1·43
5	400 lbs. Ammonium-salts (2)	1·110	26·8	0·78	2·92	0·440	1·64
6	550 lbs. Nitrate of Soda	1·114	26·6	0·83	3·13	0·431	1·63
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·106	25·5	1·00	3·90	0·340	1·33
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·109	25·6	0·97	3·79	0·332	1·29
9	3½ cwts. Superphosphate	1·116	27·0	1·09	4·02	0·321	1·19
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·112	26·8	1·11	4·14	0·313	1·17

Fourteenth Season, 1889.

1	Unmanured in 1876, and each year since	1·119	28·4	0·81	2·84	0·423	1·49
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1·119	27·9	0·82	2·94	0·394	1·41
3	Farmyard Manure (14 tons) alone 1883 and since; previously 3½ cwts. Superphosphate also (1)	1·109	26·0	1·05	4·05	0·391	1·50
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	1·114	26·5	1·05	3·98	0·387	1·46
5	400 lbs. Ammonium-salts (2)	1·120	28·1	0·84	3·00	0·392	1·40
6	550 lbs. Nitrate of Soda	1·121	27·7	0·76	2·74	0 405	1·46
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·112	26·1	0·99	3·78	0·364	1·40
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·114	26·5	0·99	3·74	0·382	1·44
9	3½ cwts. Superphosphate	1·118	27·5	1·05	3·83	0·360	1·31
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·115	26·9	1·10	4·08	0·303	1·13

Fifteenth Season, 1890.

1	Unmanured in 1876, and each year since	1·125	28·9	0·81	2·80	0·381	1·32
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1·125	30·0	0·82	2·75	0·380	1·27
3	Farmyard Manure (14 tons) alone 1883 and since; previously 3½ cwts. Superphosphate also (1)	1·117	26·8	1·00	3·75	0·293	1·09
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	1·116	27·5	1·06	3·84	0·284	1·03
5	400 lbs. Ammonium-salts (2)	1·118	28·5	0·81	2·84	0·405	1·42
6	550 lbs. Nitrate of Soda	1·119	28·4	0·82	2·88	0·430	1·51
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·100	25·6	0·97	3·78	0·369	1·44
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·115	27·3	0·98	3·59	0·348	1·27
9	3½ cwts. Superphosphate	1·122	28·7	1·01	3·53	0·298	1·04
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·121	28·2	1·13	4·00	0·245	0·87

Average of 5 Seasons, 1886, '87, 88', '89, and 1890.

1	Unmanured in 1876, and each year since	1·121	28·4	0·81	2·86	0·400	1·41
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1·122	28·6	0·85	2·96	0·393	1·37
3	Farmyard Manure (14 tons) alone 1883 and since; previously 3½ cwts. Superphosphate also (1)	1·110	26·0	1·01	3·91	0·371	1·43
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	1·111	26·3	1·01	3·85	0·366	1·40
5	400 lbs. Ammonium-salts (2)	1·116	27·9	0·79	2·85	0·436	1·57
6	550 lbs. Nitrate of Soda	1·118	27·8	0·79	2·85	0·439	1·58
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·107	26·2	1·01	3·87	0·377	1·44
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·112	26·6	0·98	3·70	0·378	1·42
9	3½ cwts. Superphosphate	1·119	27·8	1·04	3·74	0·335	1·20
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·116	27·3	1·11	4·06	0·303	1·11

(1) "Superphosphate of Lime," 1886 and 1887, made from 200 lbs. Bone-ash, 150 lbs. Sulphuric acid, sp. gr. 1·7 (and water); 1888, and since, made from high percentage mineral phosphates, and containing 37 per cent., or more, of soluble phosphate.

(2) "Ammonium-salts"—in each case equal parts Sulphate and Muriate Ammonia of Commerce.

(2) 450 lbs. Sulphate Ammonia is estimated to contain the same amount of Nitrogen as the 200 lbs. Sulphate and 200 lbs. Muriate of Ammonia applied in former years, and since.

EXPERIMENTS ON POTATOES.—HOOS FIELD—*continued.*

Below are given the particulars of the Manures and Produce, for the Sixteenth, Seventeenth, Eighteenth, Nineteenth, and Twentieth Seasons, 1891, 1892, 1893, 1894, and 1895. For the Manures, description of Potatoes grown, and the Produce, of the 15 preceding years, see pp. 78–9, 82–3, and 86–7, and of the succeeding years, pp. 94–5.

The arrangement of the plots is precisely the same as for the 15 preceding potato crops. The manures are the same as for the crops of 1883, and since. Description of Potato, "Sutton's Abundance" (White). Rows 25 inches apart; 14 inches from plant to plant in the rows.

In the spring of 1894 permanent division paths were laid out between plot and plot.

(Area under experiment, 2 acres.)

PLOTS.	MANURES PER ACRE PER ANNUM.	PRODUCE PER ACRE.				
		Tubers.				Tops.
		Good.	Small.	Diseased.	TOTAL.	
	SIXTEENTH SEASON, 1891. Potatoes planted, April 1. Crop taken up, September 28–30.					
1	Unmanured in 1876, and each year since	Tons. cwts. 0 13	Tons. cwts. 0 0$\frac{7}{8}$	Tons. cwts. 0 0$\frac{1}{8}$	Tons. cwts. 0 14	Withered, not weighed, each lot spread on its own Plot and ploughed in.
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1 14$\frac{1}{4}$	0 1	0 1	1 16$\frac{1}{4}$	
3	Farmyard Manure (14 tons) alone 1883 and since; previously 3½ cwts. Superphosphate also (1)	5 16$\frac{1}{4}$	0 1	0 10$\frac{3}{4}$	6 8	
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	5 11$\frac{3}{4}$	0 1$\frac{1}{4}$	0 13	6 6	
5	400 lbs. Ammonium-salts (2)	1 2$\frac{1}{4}$	0 1	0 0$\frac{1}{2}$	1 3$\frac{3}{4}$	
6	550 lbs. Nitrate of Soda	2 3	0 1$\frac{1}{4}$	0 1$\frac{1}{4}$	2 5$\frac{1}{2}$	
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	4 17$\frac{3}{4}$	0 1$\frac{1}{4}$	0 3	5 2	
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	5 3$\frac{1}{2}$	0 1$\frac{1}{4}$	0 4$\frac{1}{2}$	5 9$\frac{1}{4}$	
9	3½ cwts. Superphosphate	2 10$\frac{1}{4}$	0 1	0 0$\frac{3}{4}$	2 12	
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	2 12$\frac{1}{4}$	0 1$\frac{1}{4}$	0 1$\frac{1}{4}$	2 14$\frac{3}{4}$	
	SEVENTEENTH SEASON, 1892. Potatoes planted, April 4 and 5. Crop taken up, September 29, October 7 and 8.					
1	Unmanured in 1876, and each year since	0 15$\frac{3}{4}$	0 2$\frac{3}{4}$	0 0$\frac{1}{4}$	0 18$\frac{3}{4}$	Withered, not weighed, each lot spread on its own Plot and ploughed in.
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1 18$\frac{1}{2}$	0 2$\frac{3}{4}$	0 8$\frac{1}{4}$	2 9$\frac{1}{2}$	
3	Farmyard Manure (14 tons) alone 1883 and since; previously 3½ cwts. Superphosphate also (1)	4 11	0 2	0 9$\frac{1}{4}$	5 2$\frac{1}{4}$	
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	5 0$\frac{3}{4}$	0 2	0 6$\frac{3}{4}$	5 9$\frac{1}{2}$	
5	400 lbs. Ammonium-salts (2)	1 3	0 2$\frac{1}{2}$	0 0$\frac{3}{4}$	1 6$\frac{1}{4}$	
6	550 lbs. Nitrate of Soda	1 19	0 2$\frac{1}{4}$	0 0$\frac{3}{4}$	2 2	
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	5 3$\frac{3}{4}$	0 2$\frac{3}{4}$	0 5$\frac{1}{2}$	5 12	
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	6 15$\frac{1}{4}$	0 2	0 5$\frac{1}{2}$	7 2$\frac{3}{4}$	
9	3½ cwts. Superphosphate	2 13$\frac{3}{4}$	0 2$\frac{1}{2}$	0 0$\frac{3}{4}$	2 17	
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	3 12$\frac{1}{2}$	0 2	0 3	3 17$\frac{1}{2}$	

	Eighteenth Season, 1893. Potatoes planted, March 28. Crop taken up, September 12–14.									
1	Unmanured in 1876, and each year since	0	18½	0	1½	0	1	1	1	Withered, not weighed, each lot spread on its own Plot and ploughed in.
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1	8¼	0	1¾	0	2¾	1	12¾	
3	Farmyard Manure (14 tons) alone 1883 and since; previously 3½ cwts. Superphosphate also (1)	5	16	0	2¼	0	8½	6	6¾	
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	6	2	0	2	0	9	6	13	
5	400 lbs. Ammonium-salts (2)	1	2½	0	1¾	0	1½	1	5¾	
6	550 lbs. Nitrate of Soda	1	12¼	0	1½	0	3	1	16¾	
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	4	4	0	2	0	3	4	9	
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	4	7½	0	1¾	0	4¼	4	13½	
9	3½ cwts. Superphosphate	1	19	0	2	0	3½	2	4½	
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	2	4¾	0	1¾	0	3	2	9½	
	Nineteenth Season, 1894. Potatoes planted, April 9. Crop taken up, September 21–28.									
1	Unmanured in 1876, and each year since	0	18¼	0	1½	0	4¼	1	4	Withered, not weighed, each lot spread on its own Plot and ploughed in.
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1	12¾	0	1½	0	4½	1	18¼	
3	Farmyard Manure (14 tons) alone 1883 and since; previously 3½ cwts. Superphosphate also (1)	6	3¾	0	1½	2	6	8	11¼	
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	6	6¾	0	2	2	0	8	8¾	
5	400 lbs. Ammonium-salts (2)	1	8½	0	1½	0	4¼	1	14¼	
6	550 lbs. Nitrate of Soda	2	16¼	0	1	0	5¾	3	3	
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	5	3¼	0	1½	1	10¾	6	15½	
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	5	7½	0	1	1	0½	6	9	
9	3½ cwts. Superphosphate	2	4¼	0	1¼	0	4½	2	10	
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	2	4¼	0	1¼	0	5¾	2	11¼	
	Twentieth Season, 1895. Potatoes planted, April 6. Crop taken up, September 10–12.									
1	Unmanured in 1876, and each year since	0	16¾	0	2¾	0	0¼	0	19¾	Withered, not weighed, each lot spread on its own Plot and ploughed in.
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1	5	0	3½	0	1½	1	10	
3	Farmyard Manure (14 tons) alone 1883 and since; previously 3½ cwts. Superphosphate also (1)	4	9¼	0	4	0	14¼	5	7½	
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	5	5	0	4½	1	1¼	6	10¾	
5	400 lbs. Ammonium-salts (2)	1	1¾	0	3	0	0¾	1	5½	
6	550 lbs. Nitrate of Soda	1	4½	0	3¾	0	2½	1	10¾	
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	3	6¼	0	2¾	0	5	3	14	
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	3	16	0	3¼	0	10½	4	9¾	
9	3½ cwts. Superphosphate	1	11½	0	2¾	0	1¾	1	16	
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	2	7½	0	3¼	0	2	2	12¾	
	Average of 5 Seasons, 1891, '92, '93, '94, and 1895.									
1	Unmanured in 1876, and each year since	0	16½	0	2	0	1⅝	0	19⅝	Withered, not weighed, each lot spread on its own Plot and ploughed in.
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1	11⅝	0	2⅛	0	3⅝	1	17⅜	
3	Farmyard Manure (14 tons) alone 1883 and since; previously 3½ cwts. Superphosphate also (1)	5	7¼	0	2⅛	0	17¾	6	7⅛	
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	5	13¼	0	2⅜	0	18	6	13⅝	
5	400 lbs. Ammonium-salts (2)	1	3⅝	0	2	0	1½	1	7⅛	
6	550 lbs. Nitrate of Soda	1	19	0	2	0	2⅝	2	3⅝	
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	4	11	0	2	0	9½	5	2½	
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	5	2	0	1⅞	0	9⅛	5	13	
9	3½ cwts. Superphosphate	2	3¾	0	2	0	2¼	2	8	
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	2	12¼	0	1⅞	0	3	2	17⅛	

(1) "Superphosphate of Lime," made from high percentage mineral phosphates, and containing 37 per cent., or more, of soluble phosphate.
(2) "Ammonium-salts"—in each case equal parts Sulphate and Muriate Ammonia of Commerce.

EXPERIMENTS ON POTATOES.—HOOS FIELD—*continued.*—SUMMARY OF THE COMPOSITION OF THE "GOOD" TUBERS in the Sixteenth, Seventeenth, Eighteenth, Nineteenth, and Twentieth Seasons, 1891, 1892, 1893, 1894, and 1895. For particulars of the composition in the first 15 years, 1876–1890, see pp. 80–1, 84–5, and 88–9, and for those in succeeding seasons, see pp. 96–7.

An abstract of the analytical results obtained, illustrating the influence of different manures, and of different seasons, on the composition of Potatoes, is given below. The specific gravity of the tubers is also given. In the tubers the dry matter, nitrogen, and ash have been determined; and in some cases complete analyses of the ash have been made. Besides the results obtained relating to the composition of the tubers themselves, the dry matter, the sugar, the nitrogen, and the ash, in the expressed juice have in many cases been determined; in some cases the amount of the nitrogen existing as albuminoids has been determined; and in some, complete analyses of the ash of the juice have been made. It may be remarked, that by far the larger proportion of both the mineral matter, and the nitrogen, is found to exist in the juice; and of the nitrogen in the juice, as a rule, not much more than half exists as albuminoids. In many cases, the small potatoes have been submitted to the same methods of analysis as the good potatoes. And in some cases, similar methods of examination have been applied to the still white, and also to the separated discoloured portions of the diseased potatoes. With regard to these latter results, it may be observed, that whilst the juice of the white portion of the diseased potatoes contained approximately the normal amount of nitrogen, that of the discoloured portion contained very much less. On the other hand, the washed or exhausted "marc" of the white portion, contained very little nitrogen, whilst that of the discoloured portion contained very much more. The distribution of the mineral matter was much in the same order as that of the nitrogen. It was obvious that the juice had suffered exhaustion of much of both its nitrogen and its mineral matter, in the development of the fungus. There was an increased amount of sugar found in the diseased potatoes, the result of diseased action, and it probably also contributed to the development of the fungus.

The results given in the Table relate to the "good" potatoes only. In interpreting the figures it must be borne in mind that in each year, the seed was planted on all the plots at the same time, and that all the crops were taken up at the same time; and as there was several times as much produce in some cases as in others, it is obvious that the crops would not each be at its best, and all in the same condition of maturity when taken up. Then, again, the analyses were not performed immediately after taking up the crops, but some time afterwards, in weighed samples which had been kept in a cool place for some weeks or months; and in the following only preliminary statement of results, no correction is made for any change from the original weight of the samples, the results being calculated upon the fresh weights as finally taken for analysis.

Plots.	Manures per Acre, per Annum. (For Produce, see pp. 90–1.)	Specific Gravity of the Tubers.	Composition of the "Good" Tubers.				
			Dry Matter.	Mineral Matter (Ash).		Nitrogen.	
				In Fresh Tubers.	In Dry Matter.	In Fresh Tubers.	In Dry Matter.
	Sixteenth Season, 1891.		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1	Unmanured in 1876, and each year since	1·107	25·5	0·79	3·11	0·379	1·49
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1·111	26·6	0·80	3·02	0·356	1·34
3	Farmyard Manure (14 tons) alone 1883 and since: previously 3½ cwts. Superphosphate also (1)	1·097	22·6	1·01	4·46	0·311	1·38
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	1·099	23·4	0·95	4·08	0·286	1·22
5	400 lbs. Ammonium-salts (2)	1·095	25·7	0·80	3·10	0·434	1·69
6	550 lbs. Nitrate of Soda	1·102	24·5	0·73	2·96	0·417	1·70
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·092	22·7	0·95	4·15	0·365	1·61
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·095	23·0	0·93	4·05	0·345	1·50
9	3½ cwts. Superphosphate	1·110	26·2	0·99	3·78	0·300	1·15
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·100	25·4	1·14	4·48	0·252	0·99
	Seventeenth Season, 1892.						
1	Unmanured in 1876, and each year since	1·104	25·9	0·83	3·22	0·385	1·48
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1·108	26·5	0·75	2·83	0·361	1·36
3	Farmyard Manure (14 tons) alone 1883 and since: previously 3½ cwts. Superphospate also (1)	1·101	23·8	1·05	4·37	0·279	1·17
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	1·100	23·5	1·05	4·47	0·352	1·49
5	400 lbs. Ammonium-salts (2)	1·103	25·2	0·84	3·33	0·419	1·66
6	550 lbs. Nitrate of Soda	1·101	25·0	0·71	2.84	0·437	1·75
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·096	23·2	0·93	4·02	0·346	1·49
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·097	23·0	0·96	4·17	0·363	1·58
9	3½ cwts. Superphosphate	1·111	26·6	0·95	3·58	0·301	1·13
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·110	25·6	1·09	4·26	0·253	0·98

Eighteenth Season, 1893.

1	Unmanured in 1876, and each year since	1·117	28·0	0·81	2·91	0·396	1·41
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1·116	27·9	0·80	2·86	0·394	1·41
3	Farmyard Manure (14 tons) alone 1883 and since: previously 3½ cwts. Superphosphate also (1)	1·097	23·7	1·09	4·59	0·358	1·51
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	1·096	23·5	1·05	4·48	0·366	1·56
5	400 lbs. Ammonium-salts (2)	1·115	28·3	0·81	2·88	0·438	1·55
6	550 lbs. Nitrate of Soda	1·108	26·8	0·80	2·99	0·443	1·65
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·104	25·7	1·07	4·18	0·360	1·40
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·099	24·6	1·10	4·47	0·403	1·63
9	3½ cwts. Superphosphate	1·115	28·1	1·02	3·62	0·338	1·20
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·110	26·9	1·19	4·42	0·304	1·13

Nineteenth Season, 1894.

1	Unmanured in 1876, and each year since	1·110	26·3	0·82	3·13	0·343	1·31
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1·115	27·2	0·79	2·90	0·342	1·26
3	Farmyard Manure (14 tons) alone 1883 and since: previously 3½ cwts. Superphosphate also (1)	1·100	24·2	1·08	4·46	0·279	1·15
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	1·101	24·8	1·07	4·33	0·290	1·17
5	400 lbs. Ammonium-salts (2)	1·109	27·0	0·74	2·75	0·433	1·60
6	550 lbs. Nitrate of Soda	1·106	25·9	0·75	2·91	0·437	1·68
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·103	24·9	0·99	3·98	0·338	1·35
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·100	24·1	0·96	3·99	0·331	1·37
9	3½ cwts. Superphosphate	1·113	27·0	0·99	3·66	0·263	0·98
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·108	25·3	1·13	4·49	0·247	0·98

Twentieth Season, 1895.

1	Unmanured in 1876, and each year since	1·121	29·0	0·87	3·00	0·375	1·30
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1·124	29·4	0·89	3·01	0·387	1·32
3	Farmyard Manure (14 tons) alone 1883 and since: previously 3½ cwts. Superphosphate also (1)	1·099	23·9	1·08	4·53	0·344	1·44
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	1·101	23·3	1·05	4·50	0·336	1·44
5	400 lbs. Ammonium-salts (2)	1·126	28·9	0·86	2·97	0·424	1·46
6	550 lbs. Nitrate of Soda	1·113	27·2	0·81	2·98	0·435	1·60
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·106	25·1	1·07	4·27	0·366	1·45
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·104	24·3	1·06	4·36	0·380	1·56
9	3½ cwts. Superphosphate	1·117	28·1	1·08	3·85	0·333	1·19
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·111	26 0	1·19	4·60	0·286	1·10

Average of 5 Seasons, 1891, '92, '93, '94, and 1895.

1	Unmanured in 1876, and each year since	1·112	26·9	0·83	3·07	0·376	1·40
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1·115	27·5	0·80	2·92	0·368	1·34
3	Farmyard Manure (14 tons) alone 1883 and since: previously 3½ cwts. Superphosphate also (1)	1·099	23·6	1·06	4·48	0·314	1·33
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	1·099	23·7	1·04	4·37	0·326	1·38
5	400 lbs. Ammonium-salts (2)	1·110	27·0	0·81	3·01	0·430	1·59
6	550 lbs. Nitrate of Soda	1·106	25·9	0·76	2·94	0·434	1·68
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos, 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·100	24·3	1·00	4·12	0·355	1·46
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·099	23·8	1·00	4·21	0·364	1·53
9	3½ cwts. Superphosphate	1·113	27·2	1·01	3·70	0·307	1·13
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·108	25·8	1·15	4·45	0·268	1·04

(1) "Superphosphate of Lime," made from high percentage mineral phosphates, and containing 37 per cent., or more, of soluble phosphate.
(2) "Ammonium-salts"—in each case equal parts Sulphate and Muriate Ammonia of Commerce.

EXPERIMENTS ON **POTATOES**.—HOOS FIELD—*continued*.

Below are given the particulars of the Manures for the Twenty-first, Twenty-second, and Twenty-third Seasons, 1896, 1897, and 1898; and of the produce of the Twenty-first and Twenty-second Seasons, 1896 and 1897. For the Manures, description of Potatoes grown, and the Produce, of the 20 preceding years, see pp. 78–9, 82–3, 86–7, and 90–1.

The arrangement of the plots is precisely the same as for the 20 preceding potato crops. The manures are the same as for the crops of 1883, and since; excepting that for the crops of 1897, and since, Basic Slag has been used instead of Superphosphate. Description of Potato, in 1896, "Bruce" (White); in 1897, and in 1898, "Beauty of Hebron" (White). Rows 25 inches apart; 14 inches from plant to plant in the rows.

In the spring of 1894 permanent division paths were laid out between plot and plot.

(Area under experiment, 2 acres.)

Plots.	Manures per Acre per Annum.	Produce per Acre. Tubers. Good.	Small.	Diseased.	Total.	Tops.
	Twenty-first Season, 1896. Potatoes planted, April 10. Crop taken up, October 23–30.					
1	Unmanured in 1876, and each year since	Tons. cwts. 1 $1\frac{1}{4}$	Tons. cwts. 0 $2\frac{3}{4}$	Tons. cwts. 0 $0\frac{3}{4}$	Tons. cwts. 1 $4\frac{3}{4}$	Withered, not weighed, each lot spread on its own Plot and ploughed in.
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1 $11\frac{3}{4}$	0 $2\frac{1}{4}$	0 $1\frac{1}{2}$	1 $15\frac{1}{2}$	
3	Farmyard Manure (14 tons) alone 1883 and since; previously $3\frac{1}{2}$ cwts. Superphosphate also (1)	5 $6\frac{1}{3}$	0 $1\frac{5}{8}$	1 $12\frac{1}{4}$	7 0	
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, $3\frac{1}{2}$ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	4 $11\frac{3}{4}$	0 $2\frac{1}{4}$	1 $14\frac{1}{2}$	6 $8\frac{1}{2}$	
5	400 lbs. Ammonium-salts (2)	1 $17\frac{1}{3}$	0 $1\frac{5}{8}$	0 $2\frac{1}{2}$	2 $1\frac{1}{4}$	
6	550 lbs. Nitrate of Soda	2 $1\frac{1}{8}$	0 $1\frac{3}{4}$	0 $3\frac{1}{8}$	2 6	
7	400 lbs. Ammonium-salts, $3\frac{1}{2}$ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	5 $6\frac{1}{2}$	0 2	0 $15\frac{5}{8}$	6 $4\frac{1}{8}$	
8	550 lbs. Nitrate of Soda, $3\frac{1}{2}$ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	5 $6\frac{1}{3}$	0 $1\frac{7}{8}$	0 $14\frac{7}{8}$	6 $3\frac{1}{4}$	
9	$3\frac{1}{2}$ cwts. Superphosphate	2 $10\frac{1}{3}$	0 $1\frac{3}{4}$	0 $3\frac{1}{8}$	2 15	
10	$3\frac{1}{2}$ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	2 $14\frac{1}{3}$	0 $1\frac{1}{2}$	0 $3\frac{1}{2}$	2 $19\frac{1}{8}$	
	Twenty-second Season, 1897. Potatoes planted, April 8. Crop taken up, September 13–15.					
1	Unmanured in 1876, and each year since	0 $8\frac{3}{4}$	0 3	..	0 $11\frac{3}{4}$	Withered, not weighed, each lot spread on its own Plot and ploughed in.
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1 $2\frac{1}{3}$	0 $3\frac{5}{8}$	0 $0\frac{1}{4}$	1 6	
3	Farmyard Manure (14 tons) alone 1883 and since; previously $3\frac{1}{2}$ cwts. Superphosphate also (1)	3 $15\frac{1}{3}$	0 $3\frac{3}{8}$	0 $0\frac{1}{2}$	3 19	
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, $3\frac{1}{2}$ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	3 15	0 $3\frac{5}{8}$	0 $0\frac{3}{4}$	3 $19\frac{3}{8}$	
5	400 lbs. Ammonium-salts (2)	0 $11\frac{5}{8}$	0 $4\frac{3}{8}$	0 $0\frac{1}{8}$	0 $16\frac{1}{8}$	
6	550 lbs. Nitrate of Soda	0 $19\frac{1}{2}$	0 4	0 $0\frac{1}{4}$	1 $3\frac{3}{4}$	
7	400 lbs. Ammonium-salts. 400 lbs. Basic Slag, 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	3 $2\frac{3}{4}$	0 $4\frac{1}{4}$	0 $0\frac{1}{4}$	3 $7\frac{1}{4}$	
8	550 lbs. Nitrate of Soda, 400 lbs. Basic Slag, 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	3 $11\frac{1}{4}$	0 $5\frac{1}{4}$	0 $0\frac{1}{4}$	3 $16\frac{3}{4}$	
9	400 lbs. Basic Slag	1 $8\frac{1}{2}$	0 $4\frac{1}{4}$	0 $0\frac{1}{2}$	1 $13\frac{1}{4}$	
10	400 lbs. Basic Slag, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1 $11\frac{1}{2}$	0 $4\frac{1}{4}$	0 $0\frac{1}{4}$	1 16	

TWENTY-THIRD SEASON, 1898. Potatoes planted, March 21 and 22. Crop taken up,

Plot	Manuring
1	Unmanured in 1876, and each year since .. ..
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons) .. .. ..
3	Farmyard Manure (14 tons) alone 1883 and since; previously 3½ cwts. Superphosphate also (1) .. ..
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also .. .. ..
5	400 lbs. Ammonium-salts (2) .. .. ..
6	550 lbs. Nitrate of Soda .. .. ..
7	400 lbs. Ammonium-salts, 400 lbs. Basic Slag, 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.
8	550 lbs. Nitrate of Soda, 400 lbs. Basic Slag, 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.
9	400 lbs. Basic Slag .. .. ..
10	400 lbs. Basic Slag, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia .. ..

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(1) "Superphosphate of Lime," made from high percentage mineral phosphates, and containing 37 per cent., or more, of soluble phosphate.
(2) "Ammonium-salts"—in each case equal parts Sulphate and Muriate Ammonia of Commerce.

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EXPERIMENTS ON POTATOES.—HOOS FIELD—*continued.*—SUMMARY OF THE COMPOSITION OF THE "GOOD" TUBERS in the Twenty-first, and Twenty-second Seasons, 1896 and 1897. For particulars of the composition in the first 20 years, 1876–1895, see pp. 80–1, 84–5, 88–9, and 92–3.

An abstract of the analytical results obtained, illustrating the influence of different manures, and of different seasons, on the composition of Potatoes, is given below. The specific gravity of the tubers is also given. In the tubers the dry matter, nitrogen, and ash have been determined; and in some cases complete analyses of the ash have been made. Besides the results obtained relating to the composition of the tubers themselves, the dry matter, the sugar, the nitrogen, and the ash, in the expressed juice have in many cases been determined; in some cases the amount of the nitrogen existing as albuminoids has been determined; and in some, complete analyses of the ash of the juice have been made. It may be remarked, that by far the larger proportion of both the mineral matter, and the nitrogen, is found to exist in the juice; and of the nitrogen in the juice, as a rule, not much more than half exists as albuminoids. In many cases, the small potatoes have been submitted to the same methods of analysis as the good potatoes. And in some cases, similar methods of examination have been applied to the still white, and also to the separated discoloured portions of the diseased potatoes. With regard to these latter results, it may be observed, that whilst the juice of the white portion of the diseased potatoes contained approximately the normal amount of nitrogen, that of the discoloured portion contained very much less. On the other hand, the washed or exhausted "marc" of the white portion, contained very little nitrogen, whilst that of the discoloured portion contained very much more. The distribution of the mineral matter was much in the same order as that of the nitrogen. It was obvious that the juice had suffered exhaustion of much of both its nitrogen and its mineral matter, in the development of the fungus. There was an increased amount of sugar found in the diseased potatoes, the result of diseased action, and it probably also contributed to the development of the fungus.

The results given in the Table relate to the "good" potatoes only. In interpreting the figures it must be borne in mind that in each year, the seed was planted on all the plots at the same time, and that all the crops were taken up at the same time; and as there was several times as much produce in some cases as in others, it is obvious that the crops would not each be at its best, and all in the same condition of maturity when taken up. Then, again, the analyses were not performed immediately after taking up the crops, but some time afterwards, in weighed samples which had been kept in a cool place for some weeks or months; and in the following only preliminary statement of results, no correction is made for any change from the original weight of the samples, the results being calculated upon the fresh weights as finally taken for analysis.

Plots.	Manures per Acre, per Annum. (For Produce, see pp. 94–5.)	Specific Gravity of the Tubers.	Composition of the "Good" Tubers.				
			Dry Matter.	Mineral Matter (Ash).		Nitrogen.	
				In Fresh Tubers.	In Dry Matter.	In Fresh Tubers.	In Dry Matter.
	Twenty-first Season, 1896.						
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1	Unmanured in 1876, and each year since	1·109	25·7	0·76	2·98	0·380	1·48
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1·109	25·5	0·76	2·96	0·376	1·47
3	Farmyard Manure (14 tons) alone 1883 and since: previously 3½ cwts. Superphosphate also (1)	1·096	22·0	0·99	4·49	0·339	1·54
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	1·090	21·6	0·98	4·53	0·322	1·49
5	400 lbs. Ammonium-salts (2)	1·102	24·8	0·74	2·99	0·405	1·63
6	550 lbs. Nitrate of Soda	1·085	23·2	0·78	3·36	0 416	1·79
7	400 lbs. Ammonium-salts, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·092	22·0	0·99	4·51	0·372	1·69
8	550 lbs. Nitrate of Soda, 3½ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·095	21·5	0·96	4·46	0·356	1·65
9	3½ cwts. Superphosphate	1·109	25·8	0·91	3·53	0·356	1·38
10	3½ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·107	23·3	1·08	4·62	0·312	1·34
	Twenty-second Season, 1897.						
1	Unmanured in 1876, and each year since	1·100	23·7	0·74	3·13	0·344	1·45
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)	1·109	25·7	0·76	2·95	0·381	1·48
3	Farmyard Manure (14 tons) alone 1883 and since: previously 3½ cwts. Superphosphate also (1)	1·101	23·4	0·97	4·14	0·369	1·58
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also	1·098	23·5	1·00	4·26	0·385	1·64
5	400 lbs. Ammonium-salts (2)	1·102	24·6	0·75	3·05	0·451	1·83
6	550 lbs. Nitrate of Soda	1·103	24·5	0·73	2·96	0·475	1·94
7	400 lbs. Ammonium-salts, 400 lbs. Basic Slag, 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·094	23·0	0·96	4·19	0·423	1·84
8	550 lbs. Nitrate of Soda, 400 lbs. Basic Slag, 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.	1·098	23·0	0·95	4·12	0·441	1·91
9	400 lbs. Basic Slag	1·112	26·5	0·89	3·37	0·325	1·23
10	400 lbs. Basic Slag, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia	1·108	25·2	1·06	4·21	0·294	1·17

TWENTY-THIRD SEASON, 1898.

1	Unmanured in 1876, and each year since						
2	Unmanured in 1882, and since. Previously Farmyard Manure (14 tons)						
3	Farmyard Manure (14 tons) alone 1883 and since: previously 3½ cwts. Superphosphate also (1)						
4	Farmyard Manure (14 tons) alone 1883 and since. In 1882, and previously, 3½ cwts. Superphosphate, and in 1881, and previously, 550 lbs. Nitrate of Soda also						
5	400 lbs. Ammonium-salts (2)						
6	550 lbs. Nitrate of Soda						
7	400 lbs. Ammonium-salts, 400 lbs. Basic Slag, 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.						
8	550 lbs. Nitrate of Soda, 400 lbs. Basic Slag, 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag.						
9	400 lbs. Basic Slag						
10	400 lbs. Basic Slag, 300 lbs. Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia						
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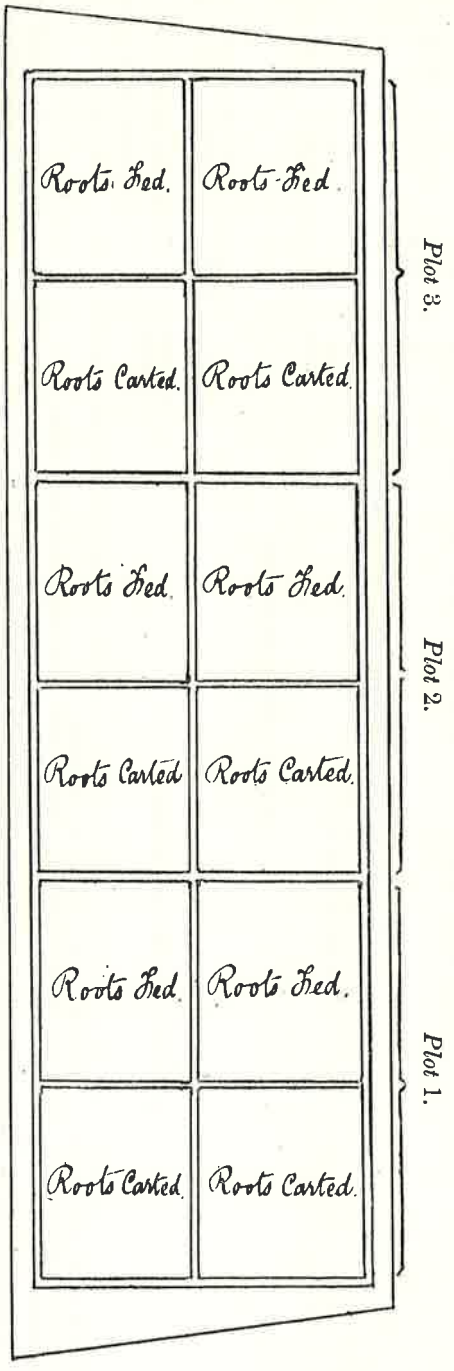
(1) "Superphosphate of Lime," made from high percentage mineral phosphates, and containing 37 per cent., or more, of soluble phosphate.
(2) "Ammonium-salts,"—in each case equal parts Sulphate and Muriate Ammonia of Commerce.

H

PLAN OF THE PLOTS IN AGDELL FIELD, ON WHICH EXPERIMENTS HAVE BEEN MADE ON FOUR-COURSE ROTATION.

51 years, commencing 1848.

[For brief summary of results and conclusions, see opposite page.]



Total area of ploughed land about 3 acres.
Area of each of the 12 divisions ¼ acre.

The 4 lower divisions, Unmanured continuously (Plot 1).
The 4 middle divisions, Mineral Manure, for the Roots, each Course (Plot 2).
The 4 upper divisions, Mineral and Nitrogenous Manure, for the Roots, each Course (Plot 3).
The 6 left-hand divisions, Clover (or Beans), 3rd year each Course.
The 6 right-hand divisions, Fallow, 3rd year each Course.
The double lines indicate division paths between plot and plot.

[For details of the manuring and produce, see pp. 100–109.]

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RESULTS OF EXPERIMENTS MADE IN AGDELL FIELD, ON THE ROTATION OF CROPS.

The experiments were commenced in 1848; so that 1898 is the 51st year of their continuance, and the third year of the 13th Course. In the experiments in other fields, some of the most important crops of rotation have been grown, each separately, for many years in succession—without manure, with farmyard manure, and with various artificial manures. But besides such experiments, others have been made on the growth of the crops in an actual course of rotation, without manure, and with different manures. The results with the individual crops throw much light on the characteristic requirements of each particular crop; whilst those on the growth of the crops in rotation serve to confirm and control those with the individual crops.

The rotation selected for investigation was the well known and typical four-course rotation of—1. Turnips; 2. Barley; 3. Leguminous Crops (or Fallow); 4. Wheat; that is, an alternation of Root-crops and of Leguminous Crops with cereals; which is the basis of most of the various rotations adopted in different parts of our own country, and also in many other countries. One portion of the land was left entirely without manure each course; another received mineral manure only, for the turnips of each course; and a third mixed mineral and nitrogenous manures, also only for the turnips of each course.

1. *The Swedish Turnips commencing each Course.*—When various root-crops were grown year after year on the same land without manure, they soon reverted to the uncultivated condition; and the experiments on rotation show that the Swedish turnips grown once in four years in unmanured rotation, came down to only about 1 ton per acre. The results further show, that mineral manures alone applied for the root-crops gave considerable increase, but that mineral and nitrogenous manures together gave more still. Without manure, the average produce of roots was less over the last 3 than over the preceding 8 courses; but with mineral manure alone (including potash in the last 3 courses) it was higher, and with mineral and nitrogenous manures together much higher, over the last 3 courses; the result being, however, largely due to more favourable seasons. Indeed, in 1888 and 1892, the years of root-crop in the 11th and 12th courses, although the produce without manure was less, that by each of the two descriptions of manure was considerably more than the average of the preceding courses; that is, both the reversion to the uncultivated condition without manure, and the increased growth with suitable manures, were very marked. In fact, without manure the produce of roots was as restricted in rotation as in continuous growth; with purely mineral manure it was greater in rotation than in continuous growth, the exhaustion of the available nitrogen of the soil being less under rotation; and with the mixed mineral and nitrogenous manure much more produce was obtained under rotation than with continuous growth. Lastly, the results conclusively show how artificial a product is the cultivated root-crop, and how dependent it is for its successful growth on an abundant supply of available food—nitrogenous as well as mineral—within the soil.

2. *The Barley Crops.*—Barley, without manure, succeeded the differently manured Swedish turnip crops of each course. Although the average produce of the root-crops was greater over the last 3 (10th, 11th, and 12th) than over the preceding 8 courses, the succeeding barley crops were much less over the last 3 courses. This was the case, not only where the root-crops had been carted off, but also where they had not been so removed. As, however, the produce of barley in the 3 years in question (1885, 1889, 1893) was also less than the average in Hoos Field where the crop is grown year after year, the result is doubtless mainly due to the seasons. Then, the average produce of barley over the 8 courses was actually less after the carted off roots grown by mineral manure (superphosphate) than after those grown without manure. The explanation is—that as there was practically no produce of roots without manure the unmanured plot was practically fallow for the barley; whilst with the mineral manure fair crops of roots were grown and removed, leaving the surface soil the more exhausted of its available nitrogen and other constituents. In the later years, however, after such long continued exhaustion, the unmanured plot has yielded less barley after the removal of the roots than the mineral manured plot. On the other hand, where the roots were not removed from the land, the mineral manured plot has generally yielded more barley than the unmanured. Further, under all conditions of treatment, the plots with mixed mineral and nitrogenous manure have yielded more barley than those with the mineral manure alone. In fact, the effects of the manurial and other treatment of the first crop of the course are clearly manifested in the produce of the second crop. Lastly, both without manure, and with the mineral manure alone, there was more produce of barley in rotation than in continuous growth, but with mixed mineral and nitrogenous manure there was more produce when the crop was grown continuously, the supply of nitrogen in that case being somewhat larger and annually applied for the crop.

3. *The Leguminous Crops (or Fallow).*—Under equal conditions as to manuring, the Leguminous crops, especially the clover, bring much more nitrogen into the course than either of the other crops. Further, the amount of nitrogen so brought into the rotation is much greater under the influence of mineral manures, and especially of potash manures, than without manure; whilst under the influence of the mixed mineral and nitrogenous manure the yield of nitrogen is greater still, the leguminous crop utilising the unexhausted nitrogenous manure- and crop-residue. For the successful growth of leguminous crops, however, a liberal supply of available mineral constituents within the soil, especially potash and lime, is essential. Judging from comparable cases, the amount of nitrogen accumulated by the Leguminous crops was much greater when they were grown in rotation, that is only occasionally, than when grown continuously. With fallow instead of a Leguminous crop, there is very much less nitrogen yielded in the rotation, and more liability to loss of it by drainage, and hence so much less brought into the circulation of the farm for food or manure. Lastly, most of the nitrogen of the leguminous crop is retained on the farm; and there is more or less, and sometimes much nitrogenous crop-residue left in the soil for succeeding crops.

4. *The Wheat Crops.*—There was very much more produce of wheat both without manure and with mineral manure, and considerably more with the mineral and nitrogenous manure, when it was grown in rotation than under comparable conditions continuously. Taking the quantities of produce by the mixed mineral and nitrogenous manure the result was that the two cereal crops produced approximately equal amounts of dry substance, and each considerably more than either of the assumed restorative crops—the roots or the leguminous crops. The supply of nitrogen within the soil available to the wheat crop is increased both by fallow and by the growth of a leguminous crop, especially of clover; and the accumulation is the greater when the soil and subsoil are not abnormally exhausted of organic nitrogen.

Upon the whole the results show that the benefits of rotation are very various. They depend on the varying requirements, habits of growth, and capabilities of gathering and assimilating the necessary constituents, of the different crops. The difference in the amounts available within the soil of the various mineral constituents, is one element in the explanation; but the facts relating to the amount, and to the sources, of the nitrogen of the different crops, are of still greater significance. The uses of the different crops have also to be taken into account. The cereals yield more produce for sale in the season of growth in rotation than when grown continuously. The crops alternated with them accumulate very much more of mineral constituents and of nitrogen in their produce; but by far the greater proportion of those constituents remains in circulation in the manure of the farm, whilst the remainder yields highly valuable products for sale in meat and milk. Again, with a variety of crops, the operations of the farm are better distributed over the year, and are therefore more economically performed. Lastly, the opportunities which alternate cropping afford for cleaning the land constitute a prominent element of advantage.

For details of the manuring and produce of the different plots, see pages 100–109.

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AGDELL FIELD.

(Area under experiment, about 3 acres.)

Experiments on an actual Course of Rotation—Turnips, Barley, Leguminous Crop (or Fallow), and Wheat.

These Experiments were commenced in 1848; so that the present season (1898) is the 51st, and the growing crop (Beans) is the third of the Thirteenth Course.

One-third of the land has been continuously unmanured. One-third has, for the first Nine Courses, or 36 years, 1848–83, been manured with Superphosphate of Lime alone, once every four years, that is for the turnip-crop commencing each course; but for the Tenth, Eleventh, Twelfth, and Thirteenth Courses, a complex mineral manure has been applied, as described in foot-note, No. 2. Lastly, one-third has been manured (also for the turnip-crop only), with a complex mineral and Nitrogenous manure, as described in the foot-note No. 3.

From half of each of the three differently manured plots the turnip-crops (roots and leaves) are removed; and on the other half they are either consumed on the land by sheep, or spread and ploughed in. In the case of all the other crops, the total produce is removed from the land.

In the First Course, clover was sown over the whole of each of the three differently manured plots; but in each of the subsequent courses, a leguminous crop was grown on only half of each of the three plots, the other half being left fallow, in the third year of each course. In the Second, Third, and Fourth Courses, clover was sown, but failed; and in them, and in the Fifth and Sixth Courses, beans were taken instead. In the Seventh Course, clover was sown (spring 1873), and gave three cuttings in 1874. In the Eighth Course beans were grown. In the Ninth Course clover was sown (in the spring of 1881), and gave two cuttings in 1882. In the Tenth Course clover was sown (in the spring of 1885), and yielded two cuttings in 1886. In the Eleventh Course clover was sown (with the barley) in 1889, but failed during the winter, and in 1890 beans were grown instead. In the Twelfth Course clover was again sown in April 1893, and gave two cuttings in 1894. In the Thirteenth Course clover was sown (with the barley), April 1897, but failed during the winter, and in 1898 beans were grown instead.

TABLE I. (below), gives the results relating to the portions of each plot from which the turnip-crops were entirely removed; and on which clover or beans were grown.

1 lb. (pound avoir.) per acre = (about) 1·12 Kilogramme per Hectare, or 0·57 Zollverein Pfund. per Prussian Morgen.
1 cwt. (hundredweight) per acre = (about) 125·5 Kilogrammes per Hectare, or 0·64 Centner per Pr. Morgen.

Years.	Description of Crop.	Produce per Acre. Plot 1. Unmanured continuously. Corn (4) (or Roots).	Plot 1. Straw (or Leaf).	Plot 1. Total Produce. (5)	Plot 2. Superphosphate of Lime alone (1), Courses 1–9, Complex Mineral Manure (2), Courses 10–13, for the Turnip Crops only. Corn (4) (or Roots).	Plot 2. Straw (or Leaf).	Plot 2. Total Produce. (5)	Plot 3. Complex Mineral and Nitrogenous Manure, (3) for the Turnip Crops only. Corn (4) (or Roots).	Plot 3. Straw (or Leaf).	Plot 3. Total Produce. (5)
1st Course, 1848–51.										
1848	Norfolk White Turnips	65¼ cwts.	45¼ cwts.	111½ cwts.	225½ cwts.	106¼ cwts.	332 cwts.	218 cwts.	151¼ cwts.	369¾ cwts.
1849	Barley	44⅞ bush.	2983 lbs.	5656 lbs.	29⅛ bush.	2111 lbs.	3841 lbs.	28⅞ bush.	2088 lbs.	3794 lbs.
1850	Clover (calcd. as hay) (6)	..	..	52⅞ cwts.	..	..	56¼ cwts.	..	..	61¾ cwts.
1851	Wheat	28½ bush.	3431 lbs.	5389 lbs.	28 bush.	3371 lbs.	5253 lbs.	28⅛ bush.	3552 lbs.	5500 lbs.
2nd Course, 1852–55.										
1852	Swedish Turnips	26 cwts.	4½ cwts.	30½ cwts.	223¾ cwts.	20½ cwts.	243½ cwts.	396½ cwts.	36½ cwts.	433 cwts.
1853	Barley	34⅜ bush.	2430 lbs.	4464 lbs.	28⅛ bush.	1873 lbs.	3560 lbs.	38¼ bush.	2604 lbs.	4873 lbs.
1854	Beans	5⅛ bush.	1055 lbs.	1445 lbs.	5⅞ bush.	1103 lbs.	1534 lbs.	9⅞ bush.	1355 lbs.	2065 lbs.
1855	Wheat	35¼ bush.	3619 lbs.	5859 lbs.	35¾ bush.	3525 lbs.	5789 lbs.	37⅞ bush.	3942 lbs.	6371 lbs.
3rd Course, 1856–59.										
1856	Swedish Turnips	32 cwts.	2¼ cwts.	34½ cwts.	136 cwts.	7½ cwts.	143½ cwts.	333¾ cwts.	12½ cwts.	346¼ cwts.
1857	Barley	48½ bush.	2600 lbs.	5337 lbs.	28½ bush.	1475 lbs.	3076 lbs.	48 bush.	2435 lbs.	5168 lbs.
1858	Beans	6¼ bush.	1100 lbs.	1515 lbs.	6⅛ bush.	1155 lbs.	1605 lbs.	12⅜ bush.	1520 lbs.	2357 lbs.
1859	Wheat	35¼ bush.	4030 lbs.	6262 lbs.	34¾ bush.	3930 lbs.	6120 lbs.	39⅝ bush.	4610 lbs.	7154 lbs.
4th Course, 1860–63.										
1860	Swedish Turnips	1 cwt.	(6¼ lbs.)	1 cwt.	29¼ cwts.	1½ cwt.	30¾ cwts.	87½ cwts.	3½ cwts.	90¾ cwts.
1861	Barley	38⅜ bush.	2522 lbs.	4718 lbs.	30⅜ bush.	2000 lbs.	3775 lbs.	60⅜ bush.	3940 lbs.	7391 lbs.
1862	Beans	29 bush.	1840 lbs.	3661 lbs.	29⅝ bush.	2150 lbs.	4040 lbs.	43⅜ bush.	3280 lbs.	5990 lbs.
1863	Wheat	34⅓ bush.	3468 lbs.	5621 lbs.	34⅝ bush.	3390 lbs.	5619 lbs.	46¼ bush.	4698 lbs.	7627 lbs.
5th Course, 1864–67.										
1864	Swedish Turnips	8¾ cwts.	0¾ cwt.	9½ cwts.	68 cwts.	4¾ cwts.	72¾ cwts.	176¼ cwts.	8¾ cwts.	185 cwts.
1865	Barley	39 bush.	2154 lbs.	4182 lbs.	33½ bush.	1615 lbs.	3394 lbs.	47½ bush.	2595 lbs.	5148 lbs.
1866	Beans	10¼ bush.	1013 lbs.	1689 lbs.	7⅜ bush.	978 lbs.	1463 lbs.	20¼ bush.	1990 lbs.	3343 lbs.
1867	Wheat	21 bush.	2143 lbs.	3473 lbs.	19¼ bush.	1966 lbs.	3222 lbs.	23¾ bush.	3003 lbs.	4567 lbs.

6th Course, 1868–71.											
1868	Swedish Turnips . .	Failed, and ploughed up.			Failed, and ploughed up.			Failed, and ploughed up.			
1869	Barley	24⅝ bush.	1948 lbs.	3358 lbs.	28¾ bush.	2025 lbs.	3686 lbs.	42⅞ bush.	3309 lbs.	5800 lbs.	
1870	Beans	13⅜ bush.	738 lbs.	1591 lbs.	15⅝ bush.	768 lbs.	1778 lbs.	24⅝ bush.	1056 lbs.	2664 lbs.	
1871	Wheat	20⅝ bush.	2799 lbs.	4092 lbs.	23⅜ bush.	3048 lbs.	4521 lbs.	24 bush.	3440 lbs.	4942 lbs.	
7th Course, 1872–75.											
1872	Swedish Turnips . .	34½ cwts.	8¾ cwts.	42⅝ cwts.	170⅝ cwts.	17⅜ cwts.	188 cwts.	339⅞ cwts.	35¾ cwts.	375⅝ cwts.	
1873	Barley	23½ bush.	1343 lbs.	2717 lbs.	20¾ bush.	1565 lbs.	2875 lbs.	31⅛ bush.	1722 lbs.	3573 lbs.	
1874	Clover (calcd as hay) (7)	..	..	25⅜ cwts.	..	..	45½ cwts.	..	..	70⅝ cwts.	
1875	Wheat	21⅝ bush.	2430 lbs.	3784 lbs.	28½ bush.	3536 lbs.	5328 lbs.	31⅞ bush.	4685 lbs.	6699 lbs.	
8th Course, 1876–79.											
1876	Swedish Turnips . .	17¼ cwts.	5 cwts.	22¼ cwts.	189¼ cwts.	28½ cwts.	216¾ cwts.	356 cwts.	55½ cwts.	411½ cwts.	
1877	Barley	23½ bush.	1291 lbs.	2623 lbs.	24½ bush.	1174 lbs.	2558 lbs.	34⅜ bush.	1918 lbs.	3890 lbs.	
1878	Beans	8⅜ bush.	740 lbs.	1301 lbs.	7⅜ bush.	1045 lbs.	1557 lbs.	20¼ bush.	1655 lbs.	2963 lbs.	
1879	Wheat	10⅜ bush.	1324 lbs.	1987 lbs.	14⅜ bush.	1771 lbs.	2729 lbs.	13 bush.	1658 lbs.	2493 lbs.	
9th Course, 1880–83.											
1880	Swedish Turnips . .	14 cwts.	2¼ cwts.	16¼ cwts.	199½ cwts.	11⅜ cwts.	211¼ cwts.	439½ cwts.	43½ cwts.	482¾ cwts.	
1881	Barley	26⅜ bush.	1484 lbs.	2922 lbs.	21⅓ bush.	1259 lbs.	2641 lbs.	35⅜ bush.	1853 lbs.	3857 lbs.	
1882	Clover (calcd. as hay) (6)	..	..	26¼ cwts.	..	..	59⅜ cwts.	..	..	79¼ cwts.	
1883	Wheat	29⅜ bush.	2280 lbs.	4175 lbs.	36½ bush.	3021 lbs.	5400 lbs.	45⅓ bush.	4024 lbs.	6921 lbs.	
10th Course, 1884–87.											
1884	Swedish Turnips . .	5 cwts.	3½ cwts.	8½ cwts.	173½ cwts.	20½ cwts.	193¾ cwts.	286⅜ cwts.	63½ cwts.	350 cwts.	
1885	Barley	12⅕ bush.	1270 lbs.	1960 lbs.	19⅗ bush.	1441 lbs.	2538 lbs.	34⅜ bush.	2461 lbs.	4426 lbs.	
1886	Clover (weighed as hay) (8)	..	..	11½ cwts.	..	..	44 cwts.	..	..	29 cwts.	
1887	Wheat	25⅝ bush.	1859 lbs.	3483 lbs.	42½ bush.	3298 lbs.	5994 lbs.	42½ bush.	3423 lbs.	6103 lbs.	
11th Course, 1888–91.											
1888	Swedish Turnips . .	2¼ cwts.	1⅞ cwts.	4⅛ cwts.	207⅞ cwts.	21½ cwts.	228⅝ cwts.	472⅜ cwts.	45⅝ cwts.	518¼ cwts.	
1889	Barley	11 bush.	931 lbs.	1510 lbs.	21⅜ bush.	1221 lbs.	2402 lbs.	26⅝ bush.	1685 lbs.	3134 lbs.	
1890	Beans	7 bush.	603 lbs.	1079 lbs.	24⅛ bush.	1764 lbs.	3441 lbs.	15⅛ bush.	1102 lbs.	2145 lbs.	
1891	Wheat	29½ bush.	2598 lbs.	4371 lbs.	42¼ bush.	3995 lbs.	6546 lbs.	44⅜ bush.	4575 lbs.	7250 lbs.	
12th Course, 1892–95.											
1892	Swedish Turnips . .	6⅜ cwts.	0½ cwt.	7¼ cwts.	202⅜ cwts.	3⅞ cwts.	206½ cwts.	473 cwts.	12 cwts.	485 cwts.	
1893	Barley	16⅜ bush.	1440 lbs.	2446 lbs.	15⅜ bush.	1339 lbs.	2295 lbs.	20½ bush.	1639 lbs.	2890 lbs.	
1894	Clover (weighed as hay) (6)	..	..	15⅜ cwts.	..	..	54½ cwts.	..	..	69⅜ cwts.	
1895	Wheat	23½ bush.	1713 lbs.	3267 lbs.	37 bush.	2650 lbs.	5034 lbs.	39 bush.	2683 lbs.	5126 lbs.	
13th Course, 1896–99.											
1896	Swedish Turnips . .	7½ cwts.	1½ cwts.	8⅝ cwts.	215½ cwts.	14¼ cwts.	229⅞ cwts.	343½ cwts.	53⅜ cwts.	397 cwts.	
1897	Barley	11⅗ bush.	1251 lbs.	1927 lbs.	22½ bush.	1790 lbs.	3064 lbs.	30½ bush.	2328 lbs.	4085 lbs.	
1898	Clover or Beans . . .										
1899	Wheat										

(1) First Course—100 lbs. Bone-ash, and 100 lbs. Sulphuric Acid (sp. gr. 1·7); Second Course—160 lbs. Bone-ash, 120 lbs. Sulphuric Acid; Third, Fourth, Fifth, Sixth, Seventh, Eighth, Ninth, and Tenth Courses—200 lbs. Bone-ash, and 150 lbs. Sulphuric Acid, *per acre*; Eleventh and Twelfth Courses—made from high percentage mineral phosphates, and containing 37 per cent., or more, of soluble phosphate.

(2) For the Tenth Course, in addition to the Superphosphate for the Swedish Turnips—300 lbs. Sulphate Potash, 200 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia were applied February 29, 1884, and harrowed in; and the same quantities were applied again before the final ploughing and preparation of the land for the sowing of the seed in May. For the Swedes of the Eleventh and Twelfth Courses the same mineral manures (which are the same as the mineral manures of Plot 3 for the third and subsequent Courses) were again applied, but only once for each of these two Courses. For the Swedes of the Thirteenth Course—500 lbs. Sulphate of Potash, 100 lbs. Sulphate of Soda, 200 lbs. Sulphate of Magnesia, and 600 lbs. Basic Slag, per acre.

(3) First Course—100 lbs. Pearl-ash, 100 lbs. Bone-ash, 100 lbs. Sulphuric Acid, 100 lbs. Sulphate of Ammonia, 100 lbs. Muriate of Ammonia, and 1000 lbs. Rape-Cake; Second Course—300 lbs. Sulphate of Potash, 100 lbs. Sulphate of Soda, 100 lbs. Sulphate of Magnesia, 160 lbs. Bone-ash, 120 lbs. Sulphuric Acid, 100 lbs. Sulphate of Ammonia, 100 lbs. Muriate of Ammonia, and 2000 lbs. Rape-cake; Third, Fourth, Fifth, Sixth, Seventh, Eighth, Ninth, and Tenth Courses—300 lbs. Sulphate of Potash, 200 lbs. Sulphate of Soda, 100 lbs. Sulphate of Magnesia, 200 lbs. Bone-ash, 150 lbs. Sulphuric Acid, 100 lbs. Sulphate of Ammonia, 100 lbs. Muriate of Ammonia, and 2000 lbs. Rape-cake, *per acre*; Eleventh and Twelfth Courses—the same in other respects as in Courses 3–10, but the Superphosphate made from high percentage mineral phosphates, and containing 37 per cent., or more, of soluble phosphate. For the Swedes of the Thirteenth Course—500 lbs. Sulphate of Potash, 100 lbs. Sulphate of Soda, 200 lbs. Sulphate of Magnesia, 600 lbs. Basic Slag, 2000 lbs. Rape-cake, 100 lbs. Sulphate of Ammonia, and 100 lbs. Muriate of Ammonia, per acre.

(4) The quantities given in *Bushels* represent the *Dressed* Corn only.

(5) The "Total Produce" of the Corn-crops includes Dressed Corn, Offal Corn, Straw, and Chaff.

(6) Two cuttings.

(7) Three cuttings.

[For Summary Table of the above results, see pp. 108–9.]

AGDELL FIELD.

(Area under experiment, about 3 acres.)

Experiments on an Actual Course of Rotation—Turnips, Barley, Leguminous Crop (or Fallow), and Wheat.

These Experiments were commenced in 1848; so that the present season, 1898, is the 51st, and the growing crop (Beans) is the third of the Thirteenth Course.

One-third of the land has been continuously unmanured. One-third has, for the first Nine Courses, or 36 years, 1848–83, been manured with Superphosphate of Lime alone, once every four years, that is for the turnip-crop commencing each course; but for the Tenth, Eleventh, Twelfth, and Thirteenth Courses, a complex mineral manure has been applied, as described in foot-note, No. 2. Lastly, one-third has been manured (also for the turnip-crop only), with a complex mineral and Nitrogenous manure, as described in the foot-note, No. 3.

From half of each of the three differently manured plots, the turnip-crops (roots and leaves) are removed; and on the other half they are either consumed on the land by sheep, or spread and ploughed in. In the case of all the other crops, the total produce is removed from the land.

In the First Course, clover was sown over the whole of each of the three differently manured plots; but in each of the subsequent courses, a leguminous crop was grown on only half of each of the three plots, the other half being left fallow, in the third year of each course. In the Second, Third, and Fourth Courses, clover was sown, but failed; and in them, and in the Fifth and Sixth Courses, beans were taken instead. In the Seventh Course, clover was sown (spring 1873), and gave three cuttings in 1874. In the Eighth Course beans were grown. In the Ninth Course clover was sown (in the spring of 1881), and gave two cuttings in 1882. In the Tenth Course clover was sown (in the spring of 1885), and yielded two cuttings in 1886. In the Eleventh Course clover was sown (with the barley), in 1889, but failed during the winter, and in 1890 beans were grown instead. In the Twelfth Course clover was again sown in April 1893, and gave two cuttings in 1894. In the Thirteenth Course clover was sown (with the barley), April 1897, but failed during the winter, and in 1898 beans were grown instead.

Table II. (below), gives the results relating to the portions of each plot from which the turnip-crops were entirely removed; and on which, in the third year of each course (excepting the first, 1850, when clover was grown), the land was left fallow.

1 lb. (pound avoir.) per acre = (about) 1·12 Kilogramme per Hectare, or 0·57 Zollverein Pfund. per Prussian Morgen.
1 cwt. (hundredweight) per acre = (about) 125·5 Kilogrammes per Hectare, or 0·64 Centner per Pr. Morgen.

Years.	Description of Crop.	Produce per Acre. Plot 1. Unmanured continuously. Corn (4) (or Roots).	Plot 1. Straw (or Leaf).	Plot 1. Total Produce.(5)	Plot 2. Superphosphate of Lime alone (1), Courses 1–9, Complex Mineral Manure (2), Courses 10–13, for the Turnip Crops only. Corn (4) (or Roots).	Plot 2. Straw (or Leaf).	Plot 2. Total Produce.(5)	Plot 3. Complex Mineral and Nitrogenous Manure(3), for the Turnip Crops only. Corn (4) (or Roots).	Plot 3. Straw (or Leaf).	Plot 3. Total Produce.(5)
1st Course, 1848–51.										
1848	Swedish Turnips	175¼ cwts.	19¾ cwts.	195 cwts.	292 cwts.	35 cwts.	327 cwts.	394½ cwts.	46½ cwts.	441 cwts.
1849	Barley	33⅜ bush.	2200 lbs.	4149 lbs.	29⅛ bush.	1870 lbs.	3575 lbs.	37 bush.	2842 lbs.	5026 lbs.
1850	Clover (calcd as hay) (6)	..	..	57¼ cwts.	..	..	60¾ cwts.	..	..	63¾ cwts.
1851	Wheat	30½ bush.	3273 lbs.	5290 lbs.	31⅜ bush.	3497 lbs.	5617 lbs.	30½ bush.	3610 lbs.	5642 lbs.
2nd Course, 1852–55.										
1852	Swedish Turnips	37 cwts.	5¾ cwts.	42¾ cwts.	256¾ cwts.	22½ cwts.	279½ cwts.	408½ cwts.	40 cwts.	448½ cwts.
1853	Barley	32⅛ bush.	2187 lbs.	4046 lbs.	32 bush.	2003 lbs.	3876 lbs.	37⅝ bush.	2595 lbs.	4849 lbs.
1854	Fallow	..	..	..	..	..	..	..	..	..
1855	Wheat	37⅜ bush.	4295 lbs.	6735 lbs.	38⅞ bush.	4286 lbs.	6756 lbs.	38¼ bush.	4952 lbs.	7428 lbs.
3rd Course, 1856–59.										
1856	Swedish Turnips	45½ cwts.	2¼ cwts.	47¾ cwts.	170½ cwts.	8 cwts.	178½ cwts.	328½ cwts.	11½ cwts.	339¾ cwts.
1857	Barley	43¾ bush.	2330 lbs.	4777 lbs.	30⅜ bush.	1545 lbs.	3272 lbs.	47½ bush.	2400 lbs.	5091 lbs.
1858	Fallow	..	..	..	..	..	..	..	..	..
1859	Wheat	35⅜ bush.	4315 lbs.	6582 lbs.	37½ bush.	4310 lbs.	6671 lbs.	42⅔ bush.	5330 lbs.	8066 lbs.
4th Course, 1860–63.										
1860	Swedish Turnips	1⅜ cwts.	0⅛ cwt.	1⅝ cwts.	33⅜ cwts.	2 cwts.	35⅜ cwts.	87½ cwts.	3½ cwts.	91 cwts.
1861	Barley	35½ bush.	2190 lbs.	4248 lbs.	32⅔ bush.	1954 lbs.	3807 lbs.	60⅝ bush.	3920 lbs.	7419 lbs.
1862	Fallow	..	..	..	..	..	..	..	..	..
1863	Wheat	45 bush.	4563 lbs.	7446 lbs.	46 bush.	4690 lbs.	7626 lbs.	52⅝ bush.	5495 lbs.	8837 lbs.
5th Course, 1864–67.										
1864	Swedish Turnips	7½ cwts.	0¾ cwt.	8¼ cwts.	52¾ cwts.	4½ cwts.	57¼ cwts.	182½ cwts.	9 cwts.	191½ cwts.
1865	Barley	34½ bush.	1828 lbs.	3659 lbs.	31¼ bush.	1509 lbs.	3170 lbs.	44⅝ bush.	2398 lbs.	4799 lbs.
1866	Fallow	..	..	..	..	..	..	..	..	..
1867	Wheat	27½ bush.	2654 lbs.	4330 lbs.	26½ bush.	2774 lbs.	4420 lbs.	22⅜ bush.	2850 lbs.	4328 lbs.

6th Course, 1868–71.											
1868	Swedish Turnips . .	Failed, and ploughed up.			Failed, and ploughed up.			Failed, and ploughed up.			
1869	Barley	21⅜ bush.	1628 lbs.	2881 lbs.	25½ bush.	1873 lbs.	3328 lbs.	39¾ bush.	3064 lbs.	5414 lbs.	
1870	Fallow	..	..	..	..	..	..	..	..	..	
1871	Wheat	11¼ bush.	2075 lbs.	3004 lbs.	16½ bush.	2128 lbs.	3133 lbs.	17⅜ bush.	2628 lbs.	3747 lbs.	
7th Course, 1872–75.											
1872	Swedish Turnips . .	51⅞ cwts.	8½ cwts.	60 cwts.	142½ cwts.	14⅝ cwts.	156⅞ cwts.	332 cwts.	34½ cwts.	366½ cwts.	
1873	Barley	20⅜ bush.	1374 lbs.	2596 lbs.	22⅛ bush.	1370 lbs.	2713 lbs.	31½ bush.	1626 lbs.	3412 lbs.	
1874	Fallow	..	..	..	..	..	..	..	..	..	
1875	Wheat	24⅜ bush.	2833 lbs.	4412 lbs.	28⅝ bush.	3230 lbs.	5065 lbs.	29½ bush.	3623 lbs.	5448 lbs.	
8th Course, 1876–79.											
1876	Swedish Turnips . .	31½ cwts.	5½ cwts.	36¾ cwts.	193¾ cwts.	17 cwts.	210¼ cwts.	309¾ cwts.	34⅜ cwts.	344⅛ cwts.	
1877	Barley	23 bush.	1244 lbs.	2602 lbs.	21 bush.	1054 lbs.	2304 lbs.	30¾ bush.	1625 lbs.	3406 lbs.	
1878	Fallow	..	..	..	..	..	..	..	..	..	
1879	Wheat	10⅜ bush.	1493 lbs.	2162 lbs.	14⅝ bush.	1956 lbs.	2905 lbs.	12⅜ bush.	1691 lbs.	2478 lbs.	
9th Course, 1880–83.											
1880	Swedish Turnips . .	32⅝ cwts.	3⅞ cwts.	36½ cwts.	224 cwts.	12¼ cwts.	236½ cwts.	450¼ cwts.	36 cwts.	486¼ cwts.	
1881	Barley	29⅜ bush.	1556 lbs.	3170 lbs.	24¼ bush.	1239 lbs.	2576 lbs.	33⅜ bush.	1755 lbs.	3651 lbs.	
1882	Fallow	..	..	..	..	..	..	..	..	..	
1883	Wheat	33½ bush	2994 lbs.	5140 lbs.	38½ bush.	3686 lbs.	6208 lbs.	37¼ bush.	3689 lbs.	6132 lbs.	
10th Course, 1884–87.											
1884	Swedish Turnips . .	17⅞ cwts.	7⅜ cwts.	25¼ cwts.	159⅜ cwts.	18⅞ cwts.	178¼ cwts.	298¼ cwts.	55¼ cwts.	353½ cwts.	
1885	Barley	15½ bush.	1518 lbs.	2402 lbs.	12⅞ bush.	1043 lbs.	1833 lbs.	19 bush.	1528 lbs.	2643 lbs.	
1886	Fallow	..	..	..	..	..	..	..	..	..	
1887	Wheat	34⅜ bush.	2505 lbs.	4689 lbs.	41⅜ bush.	3465 lbs.	6103 lbs.	39½ bush.	3308 lbs.	5894 lbs.	
11th Course, 1888–91.											
1888	Swedish Turnips . .	15 cwts.	7⅛ cwts.	22⅛ cwts.	142⅞ cwts.	15¼ cwts.	158⅛ cwts.	431¼ cwts.	37⅞ cwts.	469⅛ cwts.	
1889	Barley	15¼ bush.	953 lbs.	1789 lbs.	15⅕ bush.	965 lbs.	1775 lbs.	20 bush.	1231 lbs.	2362 lbs.	
1890	Fallow	..	..	..	..	..	..	..	..	..	
1891	Wheat	32 bush.	2941 lbs.	4868 lbs.	36 bush.	3586 lbs.	5742 lbs.	41 bush.	4288 lbs.	6748 lbs.	
12th Course, 1892–95.											
1892	Swedish Turnips . .	9⅞ cwts.	1⅛ cwt.	11 cwts.	226⅛ cwts.	4⅛ cwts.	230¼ cwts.	523⅛ cwts.	15⅝ cwts.	538¾ cwts.	
1893	Barley	19⅜ bush.	1614 lbs.	2784 lbs.	13 bush.	1203 lbs.	1998 lbs.	18⅝ bush.	1597 lbs.	2756 lbs.	
1894	Fallow	..	..	..	..	..	..	..	..	..	
1895	Wheat	21⅜ bush.	1630 lbs.	3066 lbs.	28¼ bush.	2188 lbs.	4011 lbs.	32⅝ bush.	2368 lbs.	4442 lbs.	
13th Course, 1896–99.											
1896	Swedish Turnips . .	15¼ cwts.	3¼ cwts.	18½ cwts.	161 cwts.	8¾ cwts.	169⅝ cwts.	345 cwts.	35 cwts.	380 cwts.	
1897	Barley	11½ bush.	914 lbs.	1609 lbs.	12¼ bush.	969 lbs.	1677 lbs.	21¼ bush.	1465 lbs.	2639 lbs.	
1898	Fallow										
1899	Wheat										

(1) First Course—100 lbs. Bone-ash, and 100 lbs. Sulphuric Acid (sp. gr. 1·7); Second Course—160 lbs. Bone-ash, 120 lbs. Sulphuric Acid; Third, Fourth, Fifth, Sixth, Seventh, Eighth, Ninth, and Tenth Courses—200 lbs. Bone-ash, and 150 lbs. Sulphuric Acid, *per acre;* Eleventh and Twelfth Courses—made from high percentage mineral phosphates, and containing 37 per cent., or more, of soluble phosphate.

(2) For the Tenth Course, in addition to the Superphosphate for the Swedish Turnips—300 lbs. Sulphate Potash, 200 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia were applied February 29, 1884, and harrowed in; and the same quantities were applied again before the final ploughing and preparation of the land for the sowing of the seed in May. For the Swedes of the Eleventh and Twelfth Courses the same mineral manures (which are the same as the mineral manures of Plot 3 for the Third and subsequent Courses) were again applied, but only once for each of these two Courses. For the Swedes of the Thirteenth Course—500 lbs. Sulphate of Potash, 100 lbs. Sulphate of Soda, 200 lbs. Sulphate of Magnesia, and 600 lbs. Basic Slag, per acre.

(3) First Course—100 lbs. Pearl-ash, 100 lbs. Bone-ash, 100 lbs. Sulphuric Acid, 100 lbs. Sulphate of Ammonia, 100 lbs. Muriate of Ammonia, and 1000 lbs. Rape-cake; Second Course—300 lbs. Sulphate of Potash, 100 lbs. Sulphate of Soda, 100 lbs. Sulphate of Magnesia, 160 lbs. Bone-ash, 120 lbs. Sulphuric Acid, 100 lbs. Sulphate of Ammonia, 100 lbs. Muriate of Ammonia, and 2000 lbs. Rape-cake; Third, Fourth, Fifth, Sixth, Seventh, Eighth, Ninth, and Tenth Courses—300 lbs. Sulphate of Potash, 200 lbs. Sulphate of Soda, 100 lbs. Sulphate of Magnesia, 200 lbs. Bone-ash, 150 lbs. Sulphuric Acid, 100 lbs. Sulphate of Ammonia, 100 lbs. Muriate of Ammonia, and 2000 lbs. Rape-cake, *per acre;* Eleventh and Twelfth Courses—the same in other respects as in Courses 3-10, but the Superphosphate made from high percentage mineral phosphates, and containing 37 per cent., or more, of soluble phosphate. For the Swedes of the Thirteenth Course—500 lbs. Sulphate of Potash, 100 lbs. Sulphate of Soda, 200 lbs. Sulphate of Magnesia, 600 lbs. Basic Slag, 2000 lbs. Rape-cake, 100 lbs. Sulphate of Ammonia, and 100 lbs. Muriate of Ammonia, per acre.

(4) The quantities given in *Bushels* represent the *Dressed* Corn only.

(5) The "Total Produce" of the Corn-crops includes Dressed Corn, Offal Corn, Straw, and Chaff.

(6) Two cuttings.

[For Summary Table of the above results, see pp. 108-9.]

AGDELL FIELD.

(Area under experiment, about 3 acres.)

Experiments on an Actual Course of Rotation—Turnips, Barley, Leguminous Crop (or Fallow), and Wheat.

These Experiments were commenced in 1848; so that the present season, 1898, is the 51st, and the growing crop (Beans) is the third of the Thirteenth Course.

One-third of the land has been continuously unmanured. One-third has, for the first Nine Courses, or 36 years, 1848–83, been manured with Superphosphate of Lime alone, once every four years, that is, for the turnip-crop commencing each course; but for the Tenth, Eleventh, Twelfth, and Thirteenth Courses, a complex mineral manure has been applied, as described in foot-note, No. 2. Lastly, one-third has been manured (also for the turnip-crop only), with a complex mineral and Nitrogenous manure, as described in the foot-note, No. 3.

From half of each of the three differently manured plots, the turnip-crops (roots and leaves) are removed; and on the other half they are either consumed on the land by sheep, or spread and ploughed in. In the case of all the other crops, the total produce is removed from the land.

In the First Course, clover was sown over the whole of each of the three differently manured plots; but in each of the subsequent courses a leguminous crop was grown on only half of each of the three plots, the other half being left fallow, in the third year of each course. In the Second, Third, and Fourth Courses, clover was sown, but failed; and in them, and in the Fifth and Sixth Courses, beans were taken instead. In the Seventh Course, clover was sown (spring 1873), and gave three cuttings in 1874. In the Eighth Course beans were grown. In the Ninth Course clover was sown (in the spring of 1881), and gave two cuttings in 1882. In the Tenth Course clover was sown (in the spring of 1885), and yielded two cuttings in 1886. In the Eleventh Course clover was sown (with the barley) in 1889, but failed during the winter, and in 1890 beans were grown instead. In the Twelfth Course clover was again sown in April 1893, and gave two cuttings in 1894. In the Thirteenth Course clover was sown (with the barley), April 1897, but failed during the winter, and in 1898 beans were grown instead.

Table III. (below), gives the results relating to the portions of each plot on which the turnip-crops were either fed off by sheep, or cut and spread on the land; and on which clover or beans were grown.

1 lb. (pound avoir.) per acre = (about) 1·12 Kilogramme per Hectare, or 0·57 Zollverein Pfund. per Prussian Morgen.
1 cwt. (hundredweight) per acre = (about) 125·5 Kilogrammes per Hectare, or 0·64 Centner per Pr. Morgen.

Years.	Description of Crop.	Produce per Acre. Plot 1. Unmanured continuously. Corn (4) (or Roots).	Straw (or Leaf).	Total Produce.(5)	Plot 2. Superphosphate of Lime alone(1), Courses 1–9, Complex Mineral Manure(2), Courses 10–13, for the Turnip Crops only. Corn (4) (or Roots).	Straw (or Leaf).	Total Produce.(5)	Plot 3. Complex Mineral and Nitrogenous Manure(3), for the Turnip Crops only. Corn (4) (or Roots).	Straw (or Leaf).	Total Produce.(5)
1st Course, 1848–51.										
1848	Norfolk White Turnips	109 cwts.	67⅜ cwts.	176¼ cwts.	220¾ cwts.	90 cwts.	310¾ cwts.	229 cwts.	151¼ cwts.	380¼ cwts.
1849	Barley	48 bush.	3225 lbs.	6046 lbs.	42¾ bush.	3327 lbs.	5885 lbs.	42⅞ bush.	3646 lbs.	6206 lbs.
1850	Clover (calcd as hay) (6)	..	..	48¼ cwts.	..	..	49⅝ cwts.	..	..	60¼ cwts.
1851	Wheat	30⅜ bush.	3760 lbs.	5855 lbs.	32 bush.	4014 lbs.	6176 lbs.	31¼ bush.	4035 lbs.	6169 lbs.
2nd Course, 1852–55.										
1852	Swedish Turnips	19½ cwts.	3¼ cwts.	22⅝ cwts.	250¼ cwts.	22 cwts.	272¼ cwts.	386 cwts.	33 cwts.	419 cwts.
1853	Barley	28⅝ bush.	2077 lbs.	3817 lbs.	38 bush.	2756 lbs.	5058 lbs.	35⅝ bush.	2981 lbs.	5190 lbs.
1854	Beans	5½ bush.	953 lbs.	1367 lbs.	10⅝ bush.	1378 lbs.	2124 lbs.	13⅜ bush.	1605 lbs.	2544 lbs.
1855	Wheat	34¼ bush.	3351 lbs.	5526 lbs.	36⅜ bush.	3611 lbs.	5921 lbs.	40⅛ bush.	4370 lbs.	6992 lbs.
3rd Course, 1856–59.										
1856	Swedish Turnips	20¼ cwts.	1¼ cwts.	21½ cwts.	196 cwts.	14¼ cwts.	210½ cwts.	341¼ cwts.	11¾ cwts.	353 cwts.
1857	Barley	40½ bush.	2312 lbs.	4558 lbs.	52⅝ bush.	2780 lbs.	5741 lbs.	63¾ bush.	1760 lbs.	6930 lbs.
1858	Beans	5½ bush.	965 lbs.	1307 lbs.	8⅝ bush.	1320 lbs.	1895 lbs.	14⅝ bush.	1760 lbs.	2754 lbs.
1859	Wheat	30½ bush.	3355 lbs.	5265 lbs.	37¼ bush.	4320 lbs.	6689 lbs.	38⅝ bush.	4955 lbs.	7417 lbs.
4th Course, 1860–63.										
1860	Swedish Turnips	1 cwt.	(5 lbs.)	1 cwt.	38¾ cwts.	1¾ cwt.	40½ cwts.	72 cwts.	4½ cwts.	76½ cwts.
1861	Barley	29⅝ bush.	1970 lbs.	3635 lbs.	42½ bush.	2553 lbs.	4982 lbs.	54⅜ bush.	3940 lbs.	7148 lbs.
1862	Beans	27 bush.	1845 lbs.	3546 lbs.	30 bush.	2155 lbs.	4027 lbs.	41½ bush.	2945 lbs.	5520 lbs.
1863	Wheat	30⅓ bush.	3008 lbs.	4941 lbs.	41⅝ bush.	3888 lbs.	6562 lbs.	44⅝ bush.	4919 lbs.	7721 lbs.
5th Course, 1864–67.										
1864	Swedish Turnips	8½ cwts.	1 cwt.	9½ cwts.	78¾ cwts.	4¾ cwts.	83½ cwts.	168½ cwts.	8¾ cwts.	177½ cwts.
1865	Barley	27⅝ bush.	1460 lbs.	2961 lbs.	41¼ bush.	2244 lbs.	4457 lbs.	43⅜ bush.	2958 lbs.	5308 lbs.
1866	Beans	8¾ bush.	905 lbs.	1485 lbs.	10 bush.	1835 lbs.	2481 lbs.	24⅜ bush.	2155 lbs.	3782 lbs.
1867	Wheat	15½ bush.	1524 lbs.	2506 lbs.	25 bush.	2648 lbs.	4242 lbs.	21¼ bush.	1654 lbs.	3023 lbs.

		Failed, and ploughed up.			Failed, and ploughed up.			Failed, and ploughed up.			
6th Course, 1868–71.											
1868	Swedish Turnips . .							42¼ bush.	3229 lbs.	5701 lbs.	
1869	Barley	25⅝ bush.	1944 lbs.	3387 lbs.	33½ bush.	2401 lbs.	4313 lbs.	26⅜ bush.	1008 lbs.	2746 lbs.	
1870	Beans	17⅞ bush.	710 lbs.	1854 lbs.	15⅜ bush.	878 lbs.	1867 lbs.	25¼ bush.	3644 lbs.	5236 lbs.	
1871	Wheat	21⅜ bush.	2655 lbs.	3994 lbs.	23 bush.	2980 lbs.	4404 lbs.				
7th Course, 1872–75.											
1872	Swedish Turnips . .	29½ cwts.	7⅝ cwts.	37¼ cwts.	190½ cwts.	19½ cwts.	210 cwts.	330 cwts.	39 cwts.	369 cwts.	
1873	Barley	22⅞ bush.	1495 lbs.	2844 lbs.	29⅜ bush.	1841 lbs.	3575 lbs.	45⅛ bush.	2456 lbs.	5018 lbs.	
1874	Clover (calcd as hay)(7)	..	..	22¼ cwts.	..	..	55¼ cwts.	..	..	68⅞ cwts.	
1875	Wheat	19⅜ bush.	2353 lbs.	3642 lbs.	31¼ bush.	3928 lbs.	5954 lbs.	30½ bush.	4385 lbs.	6292 lbs.	
8th Course, 1876–79.											
1876	Swedish Turnips . .	21 cwts.	5 cwts.	26 cwts.	225¾ cwts.	27½ cwts.	253¼ cwts.	359¼ cwts.	63 cwts.	422¼ cwts.	
1877	Barley	23⅜ bush.	1341 lbs.	2673 lbs.	38⅜ bush.	1994 lbs.	4157 lbs.	49⅛ bush.	3125 lbs.	5963 lbs.	
1878	Beans	7⅜ bush.	775 lbs.	1255 lbs.	13⅞ bush.	1350 lbs.	2241 lbs.	26⅜ bush.	1880 lbs.	3617 lbs.	
1879	Wheat	8⅞ bush.	1219 lbs.	1800 lbs.	15½ bush.	1771 lbs.	2781 lbs.	14 bush.	2138 lbs.	3034 lbs.	
9th Course, 1880–83.											
1880	Swedish Turnips . .	21 cwts.	3 cwts.	24 cwts.	223¾ cwts.	11 cwts.	234¾ cwts.	446¾ cwts.	38¾ cwts.	485 cwts.	
1881	Barley	25¾ bush.	1468 lbs.	2929 lbs.	28¼ bush.	1430 lbs.	3051 lbs.	50½ bush.	3078 lbs.	5964 lbs.	
1882	Clover (calcd as hay)(6)	..	..	22¼ cwts.	..	..	70⅜ cwts.	..	..	83¾ cwts.	
1883	Wheat	25¾ bush.	2060 lbs.	3741 lbs.	40 bush.	3275 lbs.	5901 lbs.	50¼ bush.	4505 lbs.	7743 lbs.	
10th Course, 1884–87.											
1884	Swedish Turnips . .	12 cwts.	5 cwts.	17 cwts.	206 cwts.	23 cwts.	229 cwts.	280⅜ cwts.	63¾ cwts.	344½ cwts.	
1885	Barley	16 bush.	1379 lbs.	2235 lbs.	32½ bush.	2358 lbs.	4193 lbs.	44⅜ bush.	3386 lbs.	5946 lbs.	
1886	Clover(weighd as hay)(6)	..	..	11⅜ cwts.	..	..	42 cwts.	..	..	32½ cwts.	
1887	Wheat	27¼ bush.	1844 lbs.	3550 lbs.	44¼ bush.	3468 lbs.	6332 lbs.	43¼ bush.	3645 lbs.	6409 lbs.	
11th Course, 1888–91.											
1888	Swedish Turnips . .	8 cwts.	3½ cwts.	11½ cwts.	249½ cwts.	23 cwts.	272½ cwts.	417⅝ cwts.	40½ cwts.	458⅛ cwts.	
1889	Barley	12⅝ bush.	865 lbs.	1530 lbs.	29⅜ bush.	1613 lbs.	3250 lbs.	25½ bush.	2030 lbs.	3409 lbs.	
1890	Beans	8¼ bush.	633 lbs.	1197 lbs.	24 bush.	1630 lbs.	3269 lbs.	16½ bush.	1059 lbs.	2195 lbs.	
1891	Wheat	26½ bush.	2318 lbs.	3921 lbs.	50½ bush.	5017 lbs.	8034 lbs.	42 bush.	4309 lbs.	6811 lbs.	
12th Course, 1892–95.											
1892	Swedish Turnips . .	6¼ cwts.	0¼ cwt.	6½ cwts.	254½ cwts.	4½ cwts.	258⅝ cwts.	333⅞ cwts.	8⅜ cwts.	342¼ cwts.	
1893	Barley	14¼ bush.	1358 lbs.	2226 lbs.	19⅝ bush.	1466 lbs.	2877 lbs.	25½ bush.	2100 lbs.	3694 lbs.	
1894	Clover (weighd as hay)(6)	..	..	17½ cwts.	..	..	64¾ cwts.	..	..	83¾ cwts.	
1895	Wheat	22½ bush.	1619 lbs.	3119 lbs.	39⅜ bush.	2831 lbs.	5325 lbs.	40 bush.	2760 lbs.	5292 lbs.	
13th Course, 1896–99.											
1896	Swedish Turnips . .	11¼ cwts.	2½ cwts.	13¾ cwts.	240¾ cwts.	18½ cwts.	259¼ cwts.	319½ cwts.	61½ cwts.	380½ cwts.	
1897	Barley	11⅛ bush.	986 lbs.	1677 lbs.	37⅜ bush.	2794 lbs.	4919 lbs.	42¾ bush.	3353 lbs.	5742 lbs.	
1898	Clover or Beans . .										
1899	Wheat										

(1) First Course—100 lbs. Bone-ash, and 100 lbs. Sulphuric Acid (sp. gr. 1·7); Second Course—160 lbs. Bone-ash, 120 lbs. Sulphuric Acid; Third, Fourth, Fifth, Sixth, Seventh, Eighth, Ninth, and Tenth Courses—200 lbs. Bone-ash, and 150 lbs. Sulphuric Acid, *per acre;* Eleventh and Twelfth Courses—made from high percentage mineral phosphates, and containing 37 per cent., or more, of soluble phosphate.

(2) For the Tenth Course, in addition to the Superphosphate for the Swedish Turnips—300 lbs. Sulphate Potash, 200 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia were applied February 29, 1884, and harrowed in; and the same quantities were applied again before the final ploughing and preparation of the land for the sowing of the seed in May. For the Swedes of the Eleventh and Twelfth Courses the same mineral manures (which are the same as the mineral manures of Plot 3 for the Third and subsequent Courses) were again applied, but only once for each of these two Courses. For the Swedes of the Thirteenth Course—500 lbs. Sulphate of Potash, 100 lbs. Sulphate of Soda, 200 lbs. Sulphate of Magnesia, and 600 lbs. Basic Slag, per acre.

(3) First Course—100 lbs. Pearl-ash, 100 lbs. Bone-ash, 100 lbs. Sulphuric Acid, 100 lbs. Sulphate of Ammonia, 100 lbs. Muriate of Ammonia, and 1000 lbs. Rape-cake; Second Course—300 lbs. Sulphate of Potash, 100 lbs. Sulphate of Soda, 100 lbs. Sulphate of Magnesia, 160 lbs. Bone-ash, 120 lbs. Sulphuric Acid, 100 lbs. Sulphate of Ammonia, 100 lbs. Muriate of Ammonia, and 2000 lbs. Rape-cake; Third, Fourth, Fifth, Sixth, Seventh, Eighth, Ninth, and Tenth Courses—300 lbs. Sulphate of Potash, 200 lbs. Sulphate of Soda, 100 lbs. Sulphate of Magnesia, 200 lbs. Bone-ash, 150 lbs. Sulphuric Acid, 100 lbs. Sulphate of Ammonia, 100 lbs. Muriate of Ammonia, and 2000 lbs. Rape-cake, *per acre;* Eleventh and Twelfth Courses—the same in other respects as in Courses 3–10, but the Superphosphate made from high percentage mineral phosphates, and containing 37 per cent., or more, of soluble phosphate. For the Swedes of the Thirteenth Course—500 lbs. Sulphate of Potash, 100 lbs. Sulphate of Soda, 200 lbs. Sulphate of Magnesia, 600 lbs. Basic Slag, 2000 lbs. Rape-cake, 100 lbs. Sulphate of Ammonia, and 100 lbs. Muriate of Ammonia, per acre.

(4) The quantities given in *Bushels* represent the *Dressed* Corn only.

(5) The "Total Produce" of the Corn-crops includes Dressed Corn, Offal Corn, Straw, and Chaff.

(6) Two cuttings. (7) Three Cuttings.

[For Summary Table of the above results, see pp. 108–9.]

AGDELL FIELD.

(Area under experiment, about 3 acres.)

Experiments on an Actual Course of Rotation—Turnips, Barley, Leguminous Crop (or Fallow), and Wheat.

These Experiments were commenced in 1848; so that the present season, 1898, is the 51st, and the growing crop (Beans) is the third of the Thirteenth Course.

One-third of the land has been continuously unmanured. One-third has, for the first Nine Courses, or 36 years, 1848–83, been manured with Superphosphate of Lime alone, once every four years, that is for the turnip-crop commencing each course; but for the Tenth, Eleventh, Twelfth, and Thirteenth Courses, a complex mineral manure has been applied, as described in foot-note, No. 2. Lastly, one-third has been manured (also for the turnip-crop only), with a complex mineral and Nitrogenous manure, as described in the foot-note, No. 3.

From half of each of the three differently manured plots, the turnip-crops (roots and leaves) are removed; and on the other half they are either consumed on the land by sheep, or spread and ploughed in. In the case of all the other crops, the total produce is removed from the land.

In the First Course, clover was sown over the whole of each of the three differently manured plots; but in each of the subsequent courses, a leguminous crop was grown on only half of each of the three plots, the other half being left fallow, in the third year of each course. In the Second, Third, and Fourth Courses, clover was sown, but failed; and in them, and in the Fifth and Sixth Courses, beans were taken instead. In the Seventh Course, clover was sown (spring 1873), and gave three cuttings in 1874. In the Eighth Course beans were grown. In the Ninth Course clover was sown (in the spring of 1881), and gave two cuttings in 1882. In the Tenth Course clover was sown (in the spring of 1885), and yielded two cuttings in 1886. In the Eleventh Course clover was sown (with the barley), in 1889, but failed during the winter, and in 1890 beans were grown instead. In the Twelfth Course clover was again sown in April 1893, and gave two cuttings in 1894. In the Thirteenth Course clover was sown (with the barley), April 1897, but failed during the winter, and in 1898 beans were grown instead.

Table IV. (below), gives the results relating to the portions of each plot on which the turnip-crops were either fed off by sheep, or cut and spread on the land; and on which, in the third year of each course (excepting the first, 1850, when clover was grown), the land was left fallow.

1 lb. (pound avoir.) per acre = (about) 1·12 Kilogramme per Hectare, or 0·57 Zollverein Pfund. per Prussian Morgen.
1 cwt. (hundredweight) per acre = (about) 125·5 Kilogrammes per Hectare, or 0·64 Centner per Pr. Morgen.

Years.	Description of Crop.	Produce per Acre. Plot 1. Unmanured continuously. Corn (4) (or Roots).	Straw (or Leaf).	Total Produce. (5)	Plot 2. Superphosphate of Lime, alone, (1) Courses 1–9, Complex Mineral Manures (2), Courses 10–13; for the Turnip Crops only. Corn (4) (or Roots).	Straw (or Leaf).	Total Produce. (5)	Plot 3. Complex Mineral and Nitrogenous Manure, (3) for the Turnip Crops only. Corn (4) (or Roots).	Straw (or Leaf).	Total Produce. (5)
1st Course, 1848–51.										
1848	Swedish Turnips	17¾ cwts.	20½ cwts.	193¼ cwts.	345 cwts.	39¾ cwts.	384¾ cwts.	429 cwts.	46¾ cwts.	475¾ cwts.
1849	Barley	44⅝ bush.	3139 lbs.	5785 lbs.	41 bush.	3209 lbs.	5708 lbs.	44⅛ bush.	3709 lbs.	6344 lbs.
1850	Clover (calcd as hay) (6)	..	..	62¾ cwts.	..	..	60⅛ cwts.	..	..	65 cwts.
1851	Wheat	31¼ bush.	3498 lbs.	5584 lbs.	32⅞ bush.	3834 lbs.	6062 lbs.	27⅛ bush.	3969 lbs.	5801 lbs.
2nd Course, 1852–55.										
1852	Swedish Turnips	27¼ cwts.	4 cwts.	31¼ cwts.	273¼ cwts	22¼ cwts.	295½ cwts.	390¾ cwts.	37¾ cwts.	428½ cwts.
1853	Barley	33 bush.	2210 lbs.	4161 lbs.	39⅞ bush.	2729 lbs.	5110 lbs.	37⅛ bush.	3323 lbs.	5672 lbs.
1854	Fallow	..	..	..	..	..	..	..	..	..
1855	Wheat	37½ bush.	4070 lbs.	6473 lbs.	37⅝ bush.	4492 lbs.	6961 lbs.	37⅜ bush.	5107 lbs.	7499 lbs.
3rd Course, 1856–59.										
1856	Swedish Turnips	34 cwts.	2 cwts.	36 cwts.	193¾ cwts.	12¼ cwts.	206 cwts.	339¾ cwts.	12¼ cwts.	351¼ cwts.
1857	Barley	44¼ bush.	2430 lbs.	4912 lbs.	48¾ bush.	2595 lbs.	5326 lbs.	66⅝ bush.	3570 lbs.	7261 lbs.
1858	Fallow	..	..	..	..	..	..	..	..	..
1859	Wheat	35½ bush.	4045 lbs.	6270 lbs.	39⅝ bush.	4720 lbs.	7242 lbs.	40¼ bush.	5545 lbs.	8136 lbs.
4th Course, 1860–63.										
1860	Swedish Turnips	1¼ cwt.	¼ cwt.	1¾ cwt.	40¾ cwts.	2 cwts.	42¾ cwts.	87 cwts.	5¼ cwts.	92¾ cwts.
1861	Barley	33 bush.	2018 lbs.	3871 lbs.	40⅝ bush.	2475 lbs.	4803 lbs.	57¾ bush.	4175 lbs.	7554 lbs.
1862	Fallow	..	..	..	..	..	..	..	..	..
1863	Wheat	42 bush.	4295 lbs.	6999 lbs.	49⅛ bush.	5051 lbs.	8194 lbs.	49 bush.	5638 lbs.	8747 lbs.
5th Course, 1864–67.										
1864	Swedish Turnips	9 cwts.	¾ cwt.	9¾ cwts.	79½ cwts.	5½ cwts.	84¾ cwts.	185½ cwts.	9½ cwts.	195 cwts.
1865	Barley	35⅜ bush.	1809 lbs.	3695 lbs.	39½ bush.	2043 lbs.	4122 lbs.	46⅝ bush.	3274 lbs.	5753 lbs.
1866	Fallow	..	..	..	..	..	..	..	..	..
1867	Wheat	23⅛ bush.	2598 lbs.	4126 lbs.	27⅛ bush.	2989 lbs.	4702 lbs.	19⅞ bush.	2905 lbs.	4180 lbs.

6th Course, 1868–71.										
1868	Swedish Turnips	Failed and ploughed up.			Failed and ploughed up.			Failed and ploughed up.		
1869	Barley	21 bush.	1648 lbs.	2843 lbs.	30⅛ bush.	2265 lbs.	3999 lbs.	38⅜ bush.	3244 lbs.	5491 lbs.
1870	Fallow	..	..	..	..	..	..	..	..	..
1871	Wheat	14½ bush.	1946 lbs.	2840 lbs.	15⅜ bush.	2240 lbs.	3193 lbs.	17¼ bush.	2363 lbs.	3925 lbs.
7th Course, 1872–75.										
1872	Swedish Turnips	49⅓ cwts.	7¼ cwts.	56½ cwts.	167½ cwts.	17⅜ cwts.	184⅞ cwts.	331½ cwts.	33½ cwts.	364¾ cwts.
1873	Barley	20⅗ bush.	1311 lbs.	2536 lbs.	27 bush.	1611 lbs.	3209 lbs.	47 bush.	2796 lbs.	5478 lbs.
1874	Fallow	..	..	..	..	..	..	..	..	..
1875	Wheat	24½ bush.	2851 lbs.	4396 lbs.	30⅜ bush.	3525 lbs.	5443 lbs.	30 bush.	4085 lbs.	5942 lbs.
8th Course, 1876–79.										
1876	Swedish Turnips	32¼ cwts.	5⅛ cwts.	37⅜ cwts.	208½ cwts.	16½ cwts.	224¾ cwts.	377½ cwts.	40¾ cwts.	418 cwts.
1877	Barley	22½ bush.	1275 lbs.	2609 lbs.	31⅜ bush.	1706 lbs.	3530 lbs.	44⅝ bush.	2646 lbs.	5217 lbs.
1878	Fallow	..	..	..	..	..	..	..	..	..
1879	Wheat	11¾ bush.	1612 lbs.	2351 lbs.	14½ bush.	1843 lbs.	2755 lbs.	10⅜ bush.	1426 lbs.	2100 lbs.
9th Course, 1880–83.										
1880	Swedish Turnips	38¼ cwts.	4 cwts.	42¼ cwts.	238¾ cwts.	12⅞ cwts.	251⅝ cwts.	447½ cwts.	38 cwts.	485½ cwts.
1881	Barley	31⅝ bush.	1568 lbs.	3297 lbs.	28½ bush.	1500 lbs.	3083 lbs.	47⅞ bush.	2993 lbs.	5720 lbs.
1882	Fallow	..	..	..	..	..	..	..	..	..
1883	Wheat	34½ bush.	3231 lbs.	5445 lbs.	40½ bush.	4110 lbs.	6778 lbs.	39¼ bush.	4028 lbs.	6536 lbs.
10th Course, 1884–87.										
1884	Swedish Turnips	20¾ cwts.	7 cwts.	27¼ cwts.	172½ cwts.	18¾ cwts.	191¼ cwts.	296½ cwts.	66¼ cwts.	362⅛ cwts.
1885	Barley	22⅜ bush.	1768 lbs.	3056 lbs.	17⅛ bush.	1480 lbs.	2576 lbs.	32½ bush.	2778 lbs.	4624 lbs.
1886	Fallow	..	..	..	..	..	..	..	..	..
1887	Wheat	33½ bush.	2655 lbs.	4811 lbs.	40½ bush.	3480 lbs.	6105 lbs.	41 bush.	3763 lbs.	6410 lbs.
11th Course, 1888–91.										
1888	Swedish Turnips	23 cwts.	7⅝ cwts.	30⅝ cwts.	166 cwts.	16 cwts.	182 cwts.	423⅞ cwts.	35 cwts.	458¾ cwts.
1889	Barley	16⅞ bush.	996 lbs.	1898 lbs.	19½ bush.	1135 lbs.	2248 lbs.	23½ bush.	1776 lbs.	3045 lbs.
1890	Fallow	..	..	..	..	..	..	..	..	..
1891	Wheat	31¼ bush.	2898 lbs.	4763 lbs.	40 bush.	4103 lbs.	6509 lbs.	45½ bush.	4938 lbs.	7610 lbs.
12th Course, 1892–95.										
1892	Swedish Turnips	12⅜ cwts.	1 cwt.	13⅜ cwts.	263½ cwts.	4½ cwts.	267⅝ cwts.	500¾ cwts.	11⅜ cwts.	512½ cwts.
1893	Barley	19 bush.	1639 lbs.	2758 lbs.	15¾ bush.	1245 lbs.	2160 lbs.	25⅜ bush.	1979 lbs.	3567 lbs.
1894	Fallow	..	..	..	..	..	..	..	..	..
1895	Wheat	22½ bush.	1728 lbs.	3196 lbs.	32 bush.	2403 lbs.	4428 lbs.	32½ bush.	2575 lbs.	4651 lbs.
13th Course, 1896–99.										
1896	Swedish Turnips	24½ cwts.	4 cwts.	28½ cwts.	177⅛ cwts.	11⅛ cwts.	188⅛ cwts.	331½ cwts.	48 cwts.	379½ cwts.
1897	Barley	13⅛ bush.	1158 lbs.	1945 lbs.	19⅜ bush.	1425 lbs.	2530 lbs.	35⅜ bush.	2570 lbs.	4551 lbs.
1898	Fallow									
1899	Wheat									

(1) First Course—100 lbs. Bone-ash, and 100 lbs. Sulphuric Acid (sp. gr. 1·7); Second Course—160 lbs. Bone-ash, 120 lbs. Sulphuric Acid; Third, Fourth, Fifth, Sixth, Seventh, Eighth, Ninth, and Tenth Courses—200 lbs. Bone-ash, and 150 lbs. Sulphuric Acid, *per acre;* Eleventh and Twelfth Courses—made from high percentage mineral phosphates, and containing 37 per cent., or more, of soluble phosphate.

(2) For the Tenth Course, in addition to the Superphosphate for the Swedish Turnips—300 lbs. Sulphate Potash, 200 lbs. Sulphate Soda, and 100 lbs. Sulphate Magnesia were applied February 29, 1884, and harrowed in; and the same quantities were applied again before the final ploughing and preparation of the land for the sowing of the seed in May. For the Swedes of the Eleventh and Twelfth Courses the same mineral manures (which are the same as the mineral manures of Plot 3 for the Third and subsequent Courses) were again applied, but only once for each of these two Courses. For the Swedes of the Thirteenth Course—500 lbs. Sulphate of Potash, 100 lbs. Sulphate of Soda, 200 lbs. Sulphate of Magnesia, and 600 lbs. Basic Slag, per acre.

(3) First Course—100 lbs. Pearl-ash, 100 lbs. Bone-ash, 100 lbs. Sulphuric Acid, 100 lbs. Sulphate of Ammonia, 100 lbs. Muriate of Ammonia, and 1000 lbs. Rape-cake; Second Course—300 lbs. Sulphate of Potash, 100 lbs. Sulphate of Soda, 100 lbs. Sulphate of Magnesia, 160 lbs. Bone-ash, 120 lbs. Sulphuric Acid, 100 lbs. Sulphate of Ammonia, 100 lbs. Muriate of Ammonia, and 2000 lbs. Rape-cake; Third, Fourth, Fifth, Sixth, Seventh, Eighth, Ninth, and Tenth Courses—300 lbs. Sulphate of Potash, 200 lbs. Sulphate of Soda, 100 lbs. Sulphate of Magnesia, 200 lbs. Bone-ash, 150 lbs. Sulphuric Acid, 100 lbs. Sulphate of Ammonia, 100 lbs. Muriate of Ammonia, and 2000 lbs. Rape-cake, *per acre;* Eleventh and Twelfth Courses—the same in other respects as in Courses 3–10, but the Superphosphate made from high percentage mineral phosphates, and containing 37 per cent., or more, of soluble phosphate. For the Swedes of the Thirteenth Course—500 lbs. Sulphate of Potash, 100 lbs. Sulphate of Soda, 200 lbs. Sulphate of Magnesia, 600 lbs. Basic Slag, 2000 lbs. Rape-cake, 100 lbs. Sulphate of Ammonia, and 100 lbs. Muriate of Ammonia, per acre.

(4) The quantities given in *Bushels* represent the *Dressed* Corn only.

(5) The "Total Produce" of the Corn-crops includes Dressed Corn, Offal Corn, Straw, and Chaff.

(6) Two cuttings.

[For Summary Table of the above results, see pp. 108-9.]

AGDELL FIELD.

(Area under experiment, about 3 acres.)

Experiments on an Actual Course of Rotation—Turnips, Barley, Leguminous Crop (or Fallow), and Wheat.

SUMMARIES OF THE RESULTS GIVEN IN TABLES I., II., III., AND IV. (pp. 100–1, 102–3, 104–5, and 106–7), RESPECTIVELY.

As the Table shows, *averages* are given for each of the four portions of the experimental land, for which Tables I., II., III., and IV., respectively, give the details. The averages are given, first of the produce of the eight intermediate Courses (Courses 2–9, 1852–1883); that is, excluding the First Course, when the land was in somewhat uneven condition, and when (as the detailed Tables show), on some portions Norfolk Whites, and on others Swedish Turnips, were grown; excluding also the Tenth, Eleventh, and Twelfth Courses, on account of the change in the Mineral Manures used on Plot 2. Averages are also given of the produce of the Tenth, Eleventh, and Twelfth Courses, that is, after the change in the Mineral Manures applied to Plot 2. For full particulars of the manures applied to Plot 2, and also of those applied to Plot 3, see Foot-notes 1, 2, and 3, on pages 101, 103, 105, or 107.

1 lb. (pound avoir.) per acre = (about) 1·12 Kilogramme per Hectare, or 0·57 Zollverein Pfund. per Prussian Morgen
1 cwt. (hundredweight) per acre = (about) 125·5 Kilogrammes per Hectare, or 0·64 Centner per Pr. Morgen.

Years.	Description of Crop.	Produce per Acre. Plot 1. Unmanured continuously. Corn (1) (or Roots).	Plot 1. Straw (or Leaf).	Plot 1. Total Produce. (2)	Plot 2. Superphosphate of Lime, alone, Courses 1–9, Complex Mineral Manure, Courses 10–12, for the Turnip Crops only. Corn (1) (or Roots).	Plot 2. Straw (or Leaf).	Plot 2. Total Produce.(2)	Plot 3. Complex Mineral and Nitrogenous Manure, for the Turnip Crops only. Corn (1) (or Roots).	Plot 3. Straw (or Leaf).	Plot 3. Total Produce.(2)
Summary of Table I. (pp. 100–1):—Results relating to the portions of each plot from which the turnip-crops were entirely removed; and on which clover or beans were grown.										
Average of 8 Courses (Courses 2–9), 1852–1883.										
1852, '56, '60, '64, '72, '76, '80	Swedish Turnips	16⅝ cwts.	3 cwts.	19⅜ cwts.	126⅞ cwts.	11½ cwts.	138⅜ cwts.	266½ cwts.	24⅜ cwts.	290¾ cwts.
1853, '57, '61, '65, '69, '73, '77, '81	Barley	32⅝ bush.	1971 lbs.	3790 lbs.	27⅜ bush.	1623 lbs.	3196 lbs.	42⅜ bush.	2547 lbs.	4962 lbs.
1854, '58, '62, '66, '70, '74, '78, '82	Clover, 1874, and '82 (as hay)	..	..	25¾ cwts.	..	..	52⅝ cwts.	..	..	75 cwts.
	Beans	12½ bush.	1081 lbs.	1867 lbs.	12½ bush.	1200 lbs.	1996 lbs.	21⅛ bush.	1809 lbs.	3230 lbs.
1855, '59, '63, '67, '71, '75, '79, '83	Wheat	26 bush.	2762 lbs.	4407 lbs.	28½ bush.	3023 lbs.	4841 lbs.	32⅝ bush.	3758 lbs.	5847 lbs.
Average of 3 Courses (Courses 10, 11, and 12), 1884–1895.										
1884, 1888 and 1892	Swedish Turnips	4⅝ cwts.	1⅞ cwts.	6½ cwts.	194½ cwts.	15¼ cwts.	209½ cwts.	410⅜ cwts.	40⅜ cwts.	451⅛ cwts.
1885, 1889 and 1893	Barley	13⅜ bush.	1214 lbs.	1972 lbs.	19⅓ bush.	1334 lbs.	2412 lbs.	27¼ bush.	1928 lbs.	3483 lbs.
1886, 1890 and 1894	Clover, 1886 and 1894 (as hay)	..	..	13½ cwts.	..	..	49¼ cwts.	..	..	49¼ cwts.
	Beans, 1890	7 bush.	603 lbs.	1079 lbs.	24⅝ bush.	1764 lbs.	3441 lbs.	15½ bush.	1102 lbs.	2145 lbs.
1887, 1891 and 1895	Wheat	26⅛ bush.	2057 lbs.	3707 lbs.	40½ bush.	3314 lbs.	5858 lbs.	41⅜ bush.	3560 lbs.	6160 lbs.

SUMMARY of TABLE II. (pp. 102–3):—Results relating to the portions of each plot from which the turnip-crops were entirely removed; and on which, in the third year of each course (excepting the first, 1850, when clover was grown), the land was left fallow.

AVERAGE OF 8 COURSES (COURSES 2–9), 1852–1883.

1852, '56, '60, '64, '72, '76, '80	Swedish Turnips	26 cwts.	3¼ cwts.	29¼ cwts.	134¼ cwts.	10⅛ cwts.	144¼ cwts.	262⅝ cwts.	21⅛ cwts.	283¼ cwts.
1853, '57, '61, '65, '69, '73, '77, '81	Barley	30 bush.	1792 lbs.	3497 lbs.	27⅜ bush.	1568 lbs.	3131 lbs.	40¾ bush.	2423 lbs.	4755 lbs.
1854, '58, '62, '66, '70, '74, '78, '82	Fallow	..	..	..	..	..	..	..	..	..
1855, '59, '63, '67, '71, '75, '79, '83	Wheat	28⅜ bush.	3153 lbs.	4976 lbs.	30¾ bush.	3383 lbs.	5348 lbs.	31½ bush.	3782 lbs.	5808 lbs.

AVERAGE OF 3 COURSES (COURSES 10, 11, AND 12), 1884–1895.

1884, 1888 and 1892	Swedish Turnips	14¼ cwts.	5¼ cwts.	19¼ cwts.	176¼ cwts.	12⅜ cwts.	188⅞ cwts.	417½ cwts.	36¼ cwts.	453¾ cwts.
1885, 1889 and 1893	Barley	17 bush.	1362 lbs.	2325 lbs.	13⅜ bush.	1070 lbs.	1869 lbs.	19¾ bush.	1452 lbs.	2587 lbs.
1886, 1890 and 1894	Fallow	..	..	..	..	..	..	..	..	..
1887, 1891 and 1895	Wheat	29½ bush.	2359 lbs.	4208 lbs.	35¼ bush.	3080 lbs.	5285 lbs.	37¾ bush.	3321 lbs.	5695 lbs.

SUMMARY OF TABLE III. (pp. 104–5):—Results relating to the portions of each plot on which the turnip-crops were either fed off by sheep, or cut and spread on the land; and on which clover or beans were grown.

AVERAGE OF 8 COURSES (COURSES 2–9), 1852–1883.

1852, '56, '60, '64, '72, '76, '80	Swedish Turnips	15½ cwts.	2⅜ cwts.	17¾ cwts.	150½ cwts.	12⅜ cwts.	163⅛ cwts.	262⅞ cwts.	24⅞ cwts.	287¾ cwts.
1853, '57, '61, '65, '69, '73, '77, '81	Barley	28 bush.	1758 lbs.	3351 lbs.	38 bush.	2250 lbs.	4417 lbs.	47⅝ bush.	3146 lbs.	5903 lbs.
1854, '58, '62, 66, '70, '74, '78, '82	Clover, 1874, and '82 (as hay)	..	..	22½ cwts.	..	..	63 cwts.	..	..	76½ cwts.
	Beans	12 bush.	1026 lbs.	1802 lbs.	14⅜ bush.	1486 lbs.	2439 lbs.	24½ bush.	1892 lbs.	3494 lbs.
1855, '59, '63, '67, '71, '75, '79, '83	Wheat	23¼ bush.	2441 lbs.	3927 lbs.	31⅜ bush.	3303 lbs.	5307 lbs.	33¼ bush.	3821 lbs.	5932 lbs.

AVERAGE OF 3 COURSES (COURSES 10, 11, AND 12), 1884–1895.

1884, 1888 and 1892	Swedish Turnips	8¾ cwts.	2⅞ cwts.	11⅝ cwts.	236 cwts.	16¾ cwts.	253⅜ cwts.	344⅓ cwts.	37½ cwts.	381⅝ cwts.
1885, 1889 and 1893	Barley	14½ bush.	1201 lbs.	1997 lbs.	27½ bush.	1812 lbs.	3373 lbs.	31⅞ bush.	2505 lbs.	4350 lbs.
1886, 1890 and 1894	Clover 1886 and 1894 (as hay)	..	..	14½ cwts.	..	..	53⅜ cwts.	..	..	58⅓ cwts.
	Beans 1890	8¼ bush.	633 lbs.	1197 lbs.	24 bush	1630 lbs.	3269 lbs.	16⅜ bush.	1059 lbs.	2195 lbs.
1887, 1891 and 1895	Wheat	25⅝ bush.	1927 lbs.	3530 lbs.	44⅞ bush	3772 lbs.	6564 lbs.	41⅜ bush.	3571 lbs.	6171 lbs.

SUMMARY OF TABLE IV. (pp. 106–7):—Results relating to the portions of each plot on which the turnip-crops were either fed off by sheep, or cut and spread on the land; and on which, in the third year of each course (excepting the first, 1850, when clover was grown), the land was left fallow.

AVERAGE OF 8 COURSES (COURSES 2–9), 1852–1883.

1852, '56, '60, '64, '72, '76, '80	Swedish Turnips	24 cwts.	2⅞ cwts.	26⅞ cwts.	150¼ cwts.	11 cwts.	161¼ cwts.	269¾ cwts.	22¼ cwts.	292 cwts.
1853, '57, '61, '65, '69, '73, '77, '81	Barley	30⅛ bush.	1784 lbs.	3491 lbs.	35⅝ bush.	2116 lbs.	4148 lbs.	48⅜ bush.	3253 lbs.	6018 lbs.
1854, '58, '62, '66, '70, '74, '78, '82	Fallow	..	..	..	..	..	..	..	..	..
1855, '59, '63, '67, '71, '75, '79, '83	Wheat	27⅞ bush.	3081 lbs.	4863 lbs.	31⅝ bush.	3621 lbs.	5659 lbs.	30½ bush.	3950 lbs.	5883 lbs.

AVERAGE OF 3 COURSES (COURSES 10, 11, AND 12), 1884–1895.

1884, 1888 and 1892	Swedish Turnips	18½ cwts.	5½ cwts.	23¾ cwts.	200½ cwts.	13½ cwts.	213⅝ cwts.	406⅞ cwts.	37⅝ cwts.	444⅝ cwts.
1885, 1889 and 1893	Barley	19¼ bush.	1468 lbs.	2571 lbs.	17⅜ bush.	1287 lbs.	2328 lbs.	27¼ bush.	2178 lbs.	3745 lbs.
1886, 1890 and 1894	Fallow	..	..	..	..	..	..	..	..	..
1887, 1891 and 1895	Wheat	29½ bush.	2427 lbs.	4257 lbs.	37⅝ bush.	3329 lbs.	5681 lbs.	39½ bush.	3759 lbs.	6224 lbs.

(1) The quantities given in *Bushels* represent the *Dressed* Corn only.

(2) The "Total Produce" of the Corn-crops includes Dressed Corn, Offal Corn, Straw, and Chaff.

RESULTS OF EXPERIMENTS WITH DIFFERENT DESCRIPTIONS OF

DESCRIPTIONS OF WHEAT.	1871; Sawpit Field; 3 cwts. Guano; after Mangels, carted off.	1872; Foster's Field; 2 cwts. Superphosphate, 2 cwts. Nitrate Soda; after Roots, carted off.	1873; Long Hoos Field; 1½ cwt. Nitrate; after Mangels (with Dung), carted off.	1874; Upper Harpenden Field; 2 cwts. Nitrate; after Mangels (with Dung), carted off.	1875; Little Knott-Wood Field; 1½ cwt. Nitrate Soda; after Mangels (with Dung), 1874, carted off.
DRESSED CORN					
1. White-chaff (Red)	. ..	.. ..	40⅝	55⅛	40¼
2. Rivett's (Red)	.. ..	.. ..	48⅛	67	48⅜
3. Chubb Wheat (Red)	28⅜	40	35¾	50½	38½
4. Red-chaff (White)	32¾	37	35¼	48¾	34¼
5. Browick (Red)	35¼	40½	38½	51⅛	38½
6. Red Wonder	31¼	43¾	37⅛	55⅛	33¼
7. Burwell (Old Red Lammas)	31⅛	41¼	35⅛	47½	38½
8. Bristol Red	29⅜	44⅜	39½	53⅜	31⅝
9. Red Nursery	34⅛	45¼	27⅛	41⅛	39
10. Red Langham	30¾	43¾	34⅛	53⅛	34⅞
11. Woolly Ear (White)	31¼	42¾	37	51¼	36⅛
12. Hardcastle (White)	.. ..	40½	42	49⅝	33⅞
13. Golden Drop (Red), Hallett's	39½	49¾	44¼	51¾	38⅛
14. Victoria White, Hallett's	33¾	45¼	38¼	44¼	33¾
15. Hunter's White, Hallett's	26⅞	39¾	38⅝	45⅜	26⅜
16. Original Red, Hallett's	30	35¼	36⅜	43⅝	26
17. White Chiddam	26⅞	38¾	31⅝	42	32⅜
18. Red Rostock	37	.. ..	46¼	53¾	37⅜
19. Casey's White	29⅞	42⅛	37½	52⅛	39
20. Golden Rough-chaff (Red)	33	39¼	38½	52⅛	38¾
21. Bole's Prolific (Red)	33⅝	42¾	45¼	48⅛	43¾
22. Club Wheat (Red)	36	45¾	47½	59⅝	46⅝
23. Main's Standing White	.. ..	.. ..	.. ..	.. ..	.. ..
24. Main's Rough-chaff (White)	.. ..	.. ..	.. ..	.. ..	.. ..
25. Belgian (White)	.. ..	.. ..	.. ..	.. ..	.. ..
26. Webb's Challenge (White)	.. ..	.. ..	.. ..	.. ..	.. ..
Means	32¼	42¼	38⅞	50⅜	36⅜
WEIGHT PER					
1. White-chaff (Red)	.. ..	.. ..	58½	61⅝	61
2. Rivett's (Red)	.. ..	.. ..	57⅛	58⅛	58⅛
3. Chubb Wheat (Red)	60¼	61⅞	59⅛	61⅛	59½
4. Red-chaff (White)	61⅝	62¾	60¾	61½	60¼
5. Browick (Red)	60	61⅜	59½	61¼	59⅞
6. Red Wonder	59	60⅞	60	62¼	60¾
7. Burwell (Old Red Lammas)	62	63	61½	63½	61½
8. Bristol Red	60⅞	61½	60½	61⅝	60½
9. Red Nursery	63	65	62	65¼	62¼
10. Red Langham	60⅜	61¼	60½	63	60⅜
11. Woolly Ear (White)	61⅛	62⅛	61⅛	62¾	57¾
12. Hardcastle (White)	.. ..	61⅞	59¾	63	59⅞
13. Golden Drop (Red), Hallett's	61⅜	63	59¾	63	61⅛
14. Victoria White, Hallett's	61	62⅝	59¾	62¼	61⅜
15. Hunter's White, Hallett's	59¼	61¾	57¼	61⅛	60½
16. Original Red, Hallett's	58⅝	60	56⅛	60¾	58⅛
17. White Chiddam	62¼	63	59¼	62¾	61¾
18. Red Rostock	60⅛	.. ..	56¾	59⅞	59¾
19. Casey's White	60⅜	61½	58¾	60¾	60
20. Golden Rough-chaff (Red)	61⅝	62½	59¾	62½	61¾
21. Bole's Prolific (Red)	61½	62⅜	57½	62	60⅞
22. Club Wheat (Red)	60⅜	61⅞	58¼	61⅞	61¾
23. Main's Standing White	.. ..	.. ..	.. ..	.. ..	.. ..
24. Main's Rough-chaff (White)	.. ..	.. ..	.. ..	.. ..	.. ..
25. Belgian (White)	.. ..	.. ..	.. ..	.. ..	.. ..
26. Webb's Challenge (White)	.. ..	.. ..	.. ..	.. ..	.. ..
Means	60¾	62⅛	59¼	61⅞	60¼

(1) All the crops were more or less affected by wire-worm, large bare patches appearing on many plots; and much grain was immature and blighted.

(2) Owing doubtless in great part to the imperfect development of the grain from the crop of 1879, much of the wheat sown for the crop of 1880 did not germinate at all, and of that which did come up a great deal was afterwards destroyed by wire-worm, so that up to the end of March it was a question whether there would be a plant left in the field worth saving. With the thin wheat plant there was an extraordinary growth of weeds, which the wet month of July much favoured and made it impossible to keep under. The white

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WHEAT, 12 Years, 1871–1882, each Year in a different Field.

1876; Harpenden Field; 2 cwts. Nitrate Soda; after Mangels (with Dung), 1875, carted off.	**1877;** Sawpit Field; 1¾ cwt. Nitrate Soda; after Mangels (with Dung), 1876, carted off.	**1878;** Foster's Field; 2 cwts. Nitrate, after White Turnips (with Dung and Artificial), 1877, part Fed, part carted off.	**1879;**(1) Little Knott-Wood Field; 2 cwts. Nitrate; after Clover. First and second Crops, as Hay; afterwards Fed.	**1880;**(2) Harpenden Field; 50 bushels of Soot; after Clover unmanured. One Crop as Hay; afterwards Fed.	**1881;** Rickyard Field; 1½ cwt. Nitrate Soda; after Mangels (with Dung and Guano), 1880, carted off.	**1882;**(4) Foster's Field; 2 cwts. Nitrate Soda; after Fallow 1881.	(3) Averages, 8 Years, **1871** to **1878** inclusive.	Nos.
PER ACRE. Bushels.								
49½	48⅜	59	22¾	28⅛	54½		48⅞	1
42½	49⅝	66⅛	16	22⅜	52¼		53⅝	2
40¼	41½	55⅛	20¾	14⅞	.. ..		41¼	3
43¾	41	.. ..	.. ..	.. ..	.. ..		39	4
39⅛	40⅞	49½	24	19⅝	47¼	Produce damaged; not weighed; see note 4.	41⅝	5
44¼	41⅝	52⅛	22	28¼	45⅞		42⅜	6
38⅜	39	46¼	27	27	44¾		39⅝	7
42⅜	44⅛	52⅙	21⅝	30⅝	46¼		42⅛	8
37½	40⅝	47¾	30⅞	27½	46		39⅛	9
42½	42⅞	50¾	25¼	28⅝	48½		41⅝	10
46⅝	37½	48¼	20	21	44⅛		41⅜	11
44	42⅛	54	21½	24⅜	45⅝		44⅝	12
48⅜	49½	52¾	21	18⅞	50¾		46¾	13
41⅛	42⅝	43⅞	14⅞	15¾	44		40⅜	14
43½	40	42¼	17⅜	22⅝	.. ..		37⅞	15
40⅛	44⅜	.. ..	.. ..	.. ..	.. ..		36½	16
37½	37⅝	49¾	11⅞	27⅜	47⅛		37⅛	17
40	46⅜	57	8½	28⅜	45¾		45⅛	18
45½	43	47¾	15⅜	24⅛	42⅞		42⅛	19
38⅜	36⅜	46¾	14⅜	31¼	41⅝		40⅜	20
41⅜	44¾	52¾	31	24½	46½		44	21
47⅝	49½	61	23½	16⅜	43⅜		49¼	22
.. ..	.. ..	50⅛	32⅛	16½	44¼		50⅛	23
.. ..	.. ..	50⅝	24	15⅞	39⅝		50⅝	24
.. ..	.. ..	52½	21¾	9¾	.. ..		52½	25
.. ..	.. ..	.. ..	.. ..	30¼	39½		.. ..	26
42½	42⅞	51¾	21¼	23⅛	45¾		43½	Means.
BUSHEL. Lbs.								
63	60¾	60⅞	51⅞	54¾	57⅝		61	1
59⅞	60¼	58⅞	49⅛	55⅝	56⅜		58¾	2
62⅞	60¼	61¼	53	53¾	.. ..		60¾	3
63⅛	60¼	.. ..	.. ..	.. ..	.. ..		61⅜	4
62½	60¾	62½	52⅝	54⅞	60⅛	Produce damaged; not weighed; see note 4.	61	5
63	61¼	63	52½	56⅝	60¼		61¼	6
64¾	61¼	64	55¼	58⅛	61		62⅝	7
62¾	59⅜	63⅛	54⅜	57⅛	60¾		61¼	8
66	58¾	62⅜	57¼	59⅝	61⅜		63⅛	9
63⅝	61⅛	63⅛	54½	56¾	59		61⅝	10
63⅝	59⅞	62⅛	52⅛	55⅝	60⅝		61⅜	11
63½	59⅞	61½	52⅜	55⅜	60½		61⅜	12
64¾	61¾	63½	52¾	55¾	61¼		62½	13
63¾	61	61¾	51½	56¼	60⅞		61¾	14
63⅝	59¼	62⅛	55	59¼	.. ..		60¾	15
62¾	59	.. ..	.. ..	.. ..	.. ..		59⅜	16
64⅝	61⅛	61½	54½	58	60⅝		62	17
63⅛	59½	60¼	54	56⅜	60⅞		59⅞	18
63⅛	59⅜	60¾	55⅜	58¼	61⅞		60⅝	19
65⅛	60¾	61¾	54¼	57⅜	62¼		62	20
63⅞	60¼	63⅛	55¼	55⅞	61¾		61½	21
63¼	59⅜	62⅛	52⅞	55⅜	60¾		61⅛	22
.. ..	.. ..	61¾	56¼	57⅛	61		61¾	23
.. ..	.. ..	61⅜	53¼	56¼	61⅛		61⅜	24
.. ..	.. ..	60¾	51¾	53⅞	.. ..		60¾	25
.. ..	.. ..	.. ..	.. ..	59⅛	58⅞		.. ..	26
63½	60¼	62	53½	56⅜	60⅜		61¼	Means.

wheats appeared to suffer most, either from imperfectly developed seed, wire-worm, or blight. The most satisfactory crop was "Webb's Challenge," the seed for which was obtained direct from the seedsman, not grown on the farm, as were the others.

(3) Owing to the produce of 1879 and 1880 being so exceptionally bad, that of those years is not included in the averages; nor is that of 1881.

(4) The crop of 1882 was completely beaten down by the high winds and heavy rains of July, which greatly interfered with the proper maturation of the grain; the produce was therefore not kept separate or weighed; and in some places not even threshed.

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