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# Yields of the Field <br> Experiments 1898 

## Field Experiments

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Plan of the Plots in THE PARK, on whigh Experiments have been made, on the MIXED HERBAGE OF PERMANENT GRASS LAND.

43 jeare, 1856-1898 inclusive.
[For a brief summary of results and conclusions, see opposite page.]


Total area under Experiment about 7 acres.
(1, 2, 3, 4-1, 4-2, 11-1, 11-2, and 12, each $\frac{1}{4}$ acre.
$5,6,7,8,9,10,13$, and 18 , each $\frac{1}{2}$ acre.
14, 15, 16, and 17 , each $\frac{1}{6}$ acre.
( 19 and 20 , each $\frac{1}{8}$ acre.
[For details of the manuring and produce, see pp. 22 and 23.]

## Resulits of Experiments made in THE PaRK,

## On the Mixed Herbage of Permanent Grass-Land.

Theso exporiments 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 Herlage 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 dogree 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 benefficial to beans or clover, the most developed the Leguminous species in the Mixed Herbage, and vice versa. 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 $7 \frac{1}{2}$ 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 fevs 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 $1 \frac{1}{2}$ 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 averago 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 berbage, 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 $7 \frac{1}{2} \mathrm{lb}$. of phosphoric acid, about 25 lb . of potash, and about 30 lb . of nitrogen; that the $1 \frac{1}{2}$ ton of hay grown by the purely mineral mnnures, with its ripened grasses, and large proportion of leguminous herluge, 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 applieation 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 maiatain 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 tho land, with cake or corn. The more a good condition of the herbage is induced and maintained by such meaus, 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 tho form of nitrate of soda, which, however, should seldom be used at the rate of more than 1 cwt ., or at most $1 \frac{1}{2}$ ewt. per acre.

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

Experimints with different Manures on
The Land has probably been luid down with Grass for some oenturies. 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 Mauure has been applied year after year to the same plot.

During the first 19 years of the experiments, 1856-1874, the first erop 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 $\left({ }^{(3)}\right)$. On January 7, 1881, coarsely broken chalk, in the
(Area under experiment,

| Plots, |  |
| :---: | :---: |
|  | Manures, per acre, per Annum. [In 1897, and since, 400 lbs . Basic Slag used throughoutinstead of Superphos.] |
| 1 |  |
| (1 | Unmanured, continuously <br> $3 \frac{1}{2}$ ewts. Superphosphate of Lime ${ }^{(2)}$ |
|  | $3 \frac{1}{2}$ ewts. Superphosphate of Lime, and 400 lbs . Ammonium-salts . $\quad \ddot{0}$ |
| (2 | 400 lbs . Amm.-salts, 42 yrs., 1856-97; 1898, half Unmanured, half 400 lb . Basic Slag, and 500 lb . Sulph. Pot. (1856-68, 13 years, 400 lbs . Ammonium-salts; average produce $30 \frac{1}{2}$ ewts. .. |
| ${ }^{(9)} 6$ | 1869-78, 300 lbs , 1879 and since 500 lbs ., Sulph. Potash, 100 lbs . Sulph. Soda, 100 lbs . Sulph. Magnesia, 32 ewts. Superphosphate ; average produce ( 7 yrs., 1869-75) $31 \frac{1}{4}$ cwts. .. 1856-78, 300 lbs , 1879 and since 500 lbs ., Sulphate Potash, 100 lbs . ${ }^{(4)}$ Sulphate Soda, 100 lbs . Sulphate |
| 7 | Magnesia, and 31 cwts. Superphosphate 1856-61, 6 years, 300 lbs . Sulph. Potash, 200 lbs , Sulph. Soda, 100 lbs . Sulph. Magnesia, and $3 \frac{1}{2}$ ewts. Superphosphate; average produce 36 cwts. .. |
| ${ }^{(3)} 8$ | $\left\{\begin{array}{r} 1862 \text { and since, } 250 \mathrm{lbs} \text {. }{ }^{(6)} \text { Sulphate Soda, } 100 \mathrm{lbs} \text {. Sulphate Magnesia, and } 3 \frac{1}{2} \text { owts. Superphosphate; } \\ \text { average produce }(14 \text { years, } 1862-75) 27 \frac{1}{2} \text { cwts. } \end{array}\right.$ |
| (3) 10 |  |
| (9) 10 |  |
| $11\left\{\begin{array}{l} 1 \\ 2 \end{array}\right.$ | (1856-78, $300 \mathrm{lbs} ., 1879$ and since 500 lbs , Sulph. Potash, 100 lbs , (4) Sulph. Soda, 100 lbs . Sulph. Magnesia, $3 \frac{1}{2}$ ewts. Superphosphate, $600 \mathrm{lbs} .{ }^{(6)}$ Ammonium-salts, and 400 lbs . Silicate Soda ${ }^{(7)}$ |
| 12 | Unmanured continuously $\because \quad \because \quad \ddot{0}$ |
| 13 |  |
| 14 |  |
| 15 | 1876-78, 300 lbs., 1879 and since 500 lbs., Sulphate Potash, 100 lbs. Sulphate Soda, 100 lbs. Sulphate Magnesia, and $3 \frac{1}{2}$ cwts. Superphosphate (275 lbs. Nitrate of Soda, $500 \mathrm{lbs} .(300 \mathrm{lbs}, 1858-78)$, Sulph. Potash, $100 \mathrm{lbs} .(200 \mathrm{lbs}, 1 \ddot{856-63})$ Sulph. Soda, |
| 16 | $\{100 \mathrm{lbs}$. Sulph. Magnesia, and 31 cwts. Superphosphate .. .. .. .. .. .. .. .. .. .. .. $\}$ |
| 17 | 275 lbs. Nitrate of Soda $\quad \ddot{0}$ |
| 18 | $\left\{\begin{array}{c}\text { Mixture supplying the quantity of Potash, Soda, Lime, Magnesia, Phosphoric acid, Silica, and Nitrogen, } \\ \text { contained in } 1 \text { ton of Hay (commencing } 1865 \text { ) }\end{array}\right\}$ |
|  | 275 lbs . Nitrate of Soda, 290 lbs . Sulphate of Potash, and $3 \frac{1}{2}$ cwts. Superpliosphate.(commencing 1872) 327 lbs. Nitrate of Potash, and 31 cwts. Superphosphate (commencing 1872) .. |
|  |  nce, made from high percentage mineral phosphates, and containing 37 per cent., or more, of soluble phosphate. <br> lots 6,8 , and 10, had, besides the Manures specifled, 2000 lbs . Sawdust per acre per annum for the first seven years, 1856-1862, but ct. <br> (4) $200 \mathrm{lbs}, 1856-63$ inclusive. <br> ${ }^{(5)} 500 \mathrm{lbs}$. in 1862 and 1863. <br> $00 \mathrm{lbs} .1856-58$; $400 \mathrm{lbs} .1859-61$; 800 lbs .1862 -'81; 600 lbs .1882 and since. <br> bs, Silicate Soda. siccates did not commence until 1862; 9 years ( $1862-1870$ ), 200 lbs . Siticate Lime, and 200 lbs. Silicate Soda; 1871, and The Manures specified were first applied in 1859 (prevlously, $1856-7$ and 8 , Sawdust only). |

PARK.
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 fincly 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 ferred to, that the effects were sufficiently marked to render it desirable to out 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 887, 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.)

(11) Averages of 8 years, 10 years, and 18 years, as these experiment only commenced in 1865
11) Averages of (he weights of hay per acre were corrected by adding one-flith to the ${ }^{13}$ ) In 1888 and 180 , This corresponds to an unform amount of 162 per cent. of motsture in the first crops of hay,
determined dry substance. (14) As in 1876 the second crops were not removed, those of 1875 , which were, aro brought in instead; and 1888-95) are divided by 20 1887, the second erops were not removed, the aggregate second crops of the per the 20 years. See alsn Note ( ${ }^{15}$ ).
estimating the average amotmt of produce of secon, cond'96, the second crops being got up in bad condition, the produce of hay per acre was corrected
 by adding (ia) On these plots the crop was too small to weigh or remove.
crops of hay.

## 24 )

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.
1,2,3, and 4, of Series O, Series A, and Series C, each $\frac{2}{11}$ acre,
Area of Plots.
$1,2,3$, and 4 , of Series AA, and Series AAS, each $\frac{1}{1}$ acre.
$1 \mathrm{~N}, 2 \mathrm{~N}, 5 \mathrm{O}$, and 5 A , each $\frac{1}{1}$ acre.
6-1 and 6-2, each about acre ( $0 \cdot 137$ acre).
7-1 and 7-2, each about $y$ acre ( $0 \cdot 118$ acre).
The double lines indicate division paths between plot and plot.
[For details of the manuring and produce, see pp. 26 and 27.]

# 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 then 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; butt, 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.

# Experiments on the Growth of BARLEY year after prar 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 47 th 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
(A rea under experiment,

water ${ }^{(1)}$ "Superphosphate of Lime," 1852 to 1887 inclusive, made from 200 lbs . Bone-ash, 150 lbs . Sulphuric acid, sp. gr. 1.7 (and ter) ; 1888, and since, made from high percentage mineral phosphates, and containing 37 per cent,, or more, of soluble phosphate.
${ }^{2}{ }^{2}$ ) 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.
$\left(^{5}\right)$ First 6 years, 1852-7, instead of Nitrate of Soda, 400 lbs . Ammonium-salts per annum ; next 10 years, 1858-67, 200 lbs . monium-salts per annum ; 1868, and since, 275 lbs , Nitrate of Sodn per annum. 275 lbs . Nitrate of Soda is reckoned to contain the same amount of Nitrogen as 200 lbs. "Ammonium-salts."
$\left({ }^{\circ}\right)$ The application of Silicates did not commence until 1864; in 1864-5-6 and 7, 200 lbs . Silicate of Soda and 200 lbs.

## FIELD．

sami Land，without Manurf，and with different deboriptions of Mandre．
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 $4 \frac{1}{4}$ acres．）

| Plous． | Produed prr acre． |  |  |  |  |  |  |  |  |  |  |  |  |  |  | Plors． |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Dressed Arain． |  |  |  |  |  |  |  |  |  | Total Straw． |  |  |  |  |  |
|  | Quantits． |  |  |  |  | Welght per Bushel． |  |  |  |  |  |  |  |  |  |  |
|  | A Perages． |  |  |  | $\begin{aligned} & \text { 4} \\ & \text { den } \end{aligned}$ | Averages． |  |  |  | $\begin{aligned} & \text { 4itald } \\ & \text { 1892, } \end{aligned}$ | Averoges． |  |  | $\begin{gathered} 4 \text { 4thar } \\ \text { Hear } \end{gathered}$ | $\begin{gathered} \text { 4itar } \\ \text { Herr } \end{gathered}$ |  |
|  |  | ${ }_{20}^{28 \mathrm{Yrag},}$ |  |  |  |  |  | ， 14. |  |  |  |  |  |  |  |  |
| 10. | ${ }_{\text {Bugh．}}$ | ${ }_{\text {kneb．}}{ }^{\text {Bra }}$ | ${ }_{\text {Bush }} 16$ | ${ }^{\text {Buab }}$ ， | Bubb． | － | ${ }_{5}^{1 \mathrm{lbs}}$ |  | ${ }^{\text {lbs }}$ | ${ }^{\text {libs }}$ | ${ }^{\text {civts．}}$ | ${ }^{\text {coxta }}$ | Cwts | Cwta． | Cwis． |  |
|  | 24． | ${ }^{17}$ | 21 | ${ }^{138}$ | ${ }_{6}^{64}$ | ${ }^{358}$ | ${ }_{531}^{52}$ |  | 54 | ${ }_{501}^{48}$ | ${ }^{112}$ | ${ }^{7}$ | $10{ }^{96}$ | 8 | ${ }^{51}$ |  |
| 30. 40. 40. | ${ }_{26}^{21}$ | ${ }_{17}^{13_{4}}$ | ${ }_{21}^{174}$ | ${ }_{14}^{11}$ | $\stackrel{3}{51}$ | $\begin{aligned} & 53 \frac{1}{5} 5 \\ & 53, \end{aligned}$ | $52 \frac{1}{51}$ <br> 58 |  | 54． | ${ }^{49}{ }^{49}$ | 113 <br> 13 <br> 1 |  | ${ }^{9} 9$ | －${ }_{8}^{8}$ | 4 | － |
| 1 A ． |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2 A ． | ${ }_{4}^{36}$ | ${ }_{37}^{238}$ | ${ }_{42}^{28}$ | ${ }_{20 \pm}^{142}$ | 12 | ${ }^{52}$ | $52 \%$ <br> 528 |  | 50， | ${ }_{47}^{47}$ | 188 | ${ }_{19}^{12}$ | ${ }_{23}^{15}$ | ${ }_{148}^{101}$ | ${ }^{11}$ | ${ }_{2}^{1} \mathrm{~A}$ ． |
| 3 A ． | 34 | 26量 | 309 | $21^{4}$ | $17 \frac{1}{2}$ | $5{ }^{5}$ | 52 | 524 | ${ }_{54}^{501}$ | ${ }_{49}{ }^{49}$ | ${ }^{20}$ | 1498 | 178 | 143 | ${ }^{15}$ |  |
| 4 A ． | 45 | 41 | 431 | 411 | $30 \frac{1}{2}$ | 54 | 544 | $\pm 548$ | 54 | 518 | 284 | $23 \frac{1}{8}$ | 25 的 | $21 \frac{1}{8}$ | 21 | 4 A ． |
| 1 AA ． | 36 ${ }^{\frac{1}{3}}$ | 274 | 318 | 21 | 17 ${ }^{\text {b }}$ |  |  | 523 |  |  |  |  |  |  |  |  |
| ${ }_{3}^{2} \mathrm{AA}$ ． | 483 | $4^{42^{4}}$ | 45 |  | 329 | 538 | 532 |  | 54 | ${ }_{51}$ | ${ }_{30}{ }^{18}$ | ${ }_{23}{ }^{108}$ | ${ }_{26 \%}$ | ${ }_{20} 12$ | ${ }_{24}^{124}$ | ${ }_{2}^{1} \mathrm{AA}$ ． |
| 3 AA ． | $36{ }^{3}$ | $28 \frac{1}{2}$ | 324 | 25 年 | 214 | ${ }_{52}{ }^{2}$ | ${ }_{52}{ }^{2}$ | $52^{5}$ | 53 | 51］ | ${ }^{233}$ | $17{ }^{17}$ | $20_{4}^{6}$ | $18{ }^{\text {g }}$ | 188 | 3 AA ． |
| 4 AA ． | 488 | $41 \frac{1}{4}$ | 45 | 35 | 301 | $53 \frac{1}{2}$ | $54 \frac{1}{8}$ | 53 年 | $54 \frac{5}{8}$ | $51{ }^{\text {g }}$ | $31{ }^{\frac{3}{1}}$ | $24^{5}$ | $28{ }^{8}$ | 22 | 23\％ | 4 AA ． |
| $\begin{aligned} & 1 \text { AAS. } \\ & 2 \mathrm{AAS} . \end{aligned}$ | ${ }^{377}$ | $33{ }^{3}{ }_{3}^{2}$ $4+3$ | $\left\{\begin{array}{l} 345 \\ 45+5 \end{array}\right.$ | 33 39 | 245 ${ }^{24}$ | 54i | ${ }^{533}$ | （538） | ${ }^{553}$ | 511 | ${ }_{21}^{215}$ | ${ }^{191}$ | ${ }_{26}^{19}$ | ${ }_{20}^{208}$ | ${ }^{211}$ | 1 AAS |
| 3 AAS． | 42 | $36 \pm$ | （12） 38 | 36 | $24{ }_{6}$ | 547 | 54 | （12）$\{54 \times$ | 54 | 521 | 25 | 208 | （12） 222 | 228 | 1978 | 3 AAS． |
| 4 AAS． | $48 \frac{1}{4}$ | 45 | $46 \frac{1}{4}$ | $4{ }^{11_{\text {a }}}$ | 30 | 55888 | $54{ }^{\text {a }}$ | $543_{3}$ | 551 | 523 | 30 $\frac{3}{4}$ | $27{ }^{\text {\％}}$ | 288 | 238 | $22{ }^{8}$ |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| ${ }_{2}^{1} \mathrm{C}$ ． | ${ }^{445}$ | ${ }^{369}$ | ${ }_{425}^{40}$ | ${ }_{\text {302 }}^{36}$ | ${ }_{\text {26 }}^{26}$ | ${ }_{\text {cki }}^{53}$ | ${ }_{5}^{544} 5$ |  | 555 55 | 51 | ${ }_{27}^{264}$ | ${ }_{213}^{20}$ | ${ }_{24}^{23}$ | ${ }^{191}$ | 18 | 1 C |
| 2 c ． | 43 | ${ }^{35}$ | ${ }_{39}{ }^{48}$ | ${ }^{4} 40$ | 25is | ${ }_{53}^{534}$ | ${ }^{54 \frac{1}{2}}$ | ${ }_{54}^{54}$ | ${ }_{54}^{55}$ | 52488 | ${ }_{268}^{27}$ | ${ }_{20}^{21 \frac{1}{2}}$ | ${ }_{238}^{248}$ | ${ }^{20} 8$ | ${ }_{16}^{20}$ |  |
| 40. | 46 | 382 | $42 \frac{1}{2}$ | 37 | 2993 | 535 | 548 | 54 | 56 | 52 | 288 | 217 | 253 | 202 | 191 | 4 C |
| ${ }_{2}^{1} \mathrm{~N}$ ． | $\begin{aligned} & 379 \\ & 419 \end{aligned}$ | 305 35 | （13）${ }_{38}^{34}$ | $\begin{aligned} & 30 \frac{1}{30} \\ & 36 \frac{1}{2} \end{aligned}$ | $\begin{aligned} & 155 \\ & 202 \\ & \frac{1}{2} \end{aligned}$ |  | $\begin{aligned} & 522_{2}^{2} \\ & 539 \end{aligned}$ | （13）$\left\{{ }_{53}^{523}\right.$ |  | 498 | ${ }^{225}$ | ${ }_{20}^{17}$ | （13）$\left\{_{22}^{19}\right.$ | ${ }^{188}$ |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| ${ }^{5} \mathrm{~A}$ ． | ${ }_{20}^{43{ }^{2}}$ | ${ }^{338}$ |  | ${ }_{318}^{318}$ | ${ }^{178}$ | ${ }^{505}$ | ${ }^{53}$ | （15） （1）$^{53}{ }^{3}$ | 56\％ | 52\％ | ${ }^{27}{ }^{\text {\％}}$ | ${ }^{80}$ | （13）$\{244$ |  | 15 |  |
|  |  |  | （4）${ }^{197}$ |  |  |  |  | （4） 538 | （15） | $\left({ }^{(5)}\right.$ | 11 星 | 9 | （4） 10 \％ | （15） | $\left({ }^{(15)}\right.$ |  |
| ${ }_{6}^{6}{ }_{2}^{1}$ | ${ }_{21}^{211_{8}^{\prime}}$ |  | $\begin{aligned} & 1727 \\ & 182 \end{aligned}$ |  |  |  | $\begin{aligned} & 524 \\ & 524 \\ & \hline \end{aligned}$ | $\begin{gathered} 522_{2} \\ 52_{5} \end{gathered}$ | 535 $544_{8}$ 5 | $\begin{aligned} & 492 \\ & 492 \\ & 492 \end{aligned}$ | $\begin{aligned} & 117 \\ & 112 \\ & 112 \end{aligned}$ | $\begin{aligned} & 7 \frac{7}{4} \\ & 8 \end{aligned}$ | $\begin{aligned} & 92 \\ & 9 y_{3} \end{aligned}$ | －82 |  | $\left.{ }_{2}^{1}\right\}^{6}$ |
| $7_{7}{ }_{2}^{1}$ | 478 ${ }_{4}$ | $\begin{aligned} & 288 \\ & 498 \end{aligned}$ | $\begin{gathered} 38 \\ 483 \end{gathered}$ | $\begin{aligned} & 222_{2}^{2} \\ & \hline \end{aligned}$ | ${ }_{42}^{125}$ | $544$ | $\begin{aligned} & 54 \\ & 54 \frac{3}{8} \end{aligned}$ | $\begin{aligned} & 544 \\ & 54_{2} \end{aligned}$ |  | $\begin{aligned} & 518 \\ & 539 \\ & 530 \end{aligned}$ | $\begin{aligned} & 279,9 \\ & 288 \end{aligned}$ | $\begin{aligned} & 159 \\ & 304 \\ & 304 \end{aligned}$ | $\begin{gathered} 219 n_{4}^{2} \end{gathered}$ | $\begin{aligned} & 1477_{8}^{18} \end{aligned}$ | ${ }_{295}^{11}$ | $\left.{ }_{2}^{1}\right\}^{7}$ |

Silicate of Lime were applied per acre，but in 1868，and since， 400 lhs ．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，
$\left.{ }^{7}\right)^{8} 2000 \mathrm{lbs}$ ．Rape－cake per annum for the first six years，and 1000 lbs ．only，each year since．
$\left.{ }^{8}{ }^{8}\right) 300 \mathrm{lbs}$ ．Sulphate of Potash，and $3 \frac{1}{2} \mathrm{cwts}$ ．Superphosphate of Iime，without Nitrate of Soda，the first year（1852）；Nitrate $\left.{ }^{( }{ }^{9}\right) 550 \mathrm{lbs}$ ．Nitrate of Soda for 1853－4－5－6，and 7；and 275 lbs ．only，each year since．
$\left.{ }^{(10}\right)$ 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 foulnes of the plot，from the wet season．
$\left({ }^{15}\right)$ Not recorded．

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 $3-4,5,6,7,8,9,10,1112,13,14,15,16,17,18$, and 19 , each $\frac{7}{2}$ 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 pathe between plot and plot; also a path across the centre of each plot.
[For details of the mrnuring and produce, see pp. 30 and 31.]

## 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 yeare, 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 manuro was more than that by the annual application of Farmyard manure; and in 8 out of the 11 cases in which such miztures 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 jears, 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 plota, see pages 30-31.

Expmrimenta 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, \&e., 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 antumn, 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 ammoniumsalts as a top-dressing in the spring: Plot 15, as already stated, receiving the whol 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 haracters 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 oradicate 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.

|  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |

## FIELD．

## 31 ）

same Land；without Manure，and with different descriptions of Mandre．
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 thiek 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 50 th 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 aince 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．）

| Plots． | Produce per Aore． |  |  |  |  |  |  |  |  |  |  |  |  |  |  | Plote． |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Dressed Grain． |  |  |  |  |  |  |  |  |  | Total Straw． |  |  |  |  |  |
|  | Quantity． |  |  |  |  | Weight per Bushel． |  |  |  |  |  |  |  |  |  |  |
|  | Averages． |  |  | 53rd <br> Year， <br> 1896. | 54th <br> Year， <br> 1897. | Averages． |  |  | 53 rd <br> Year， <br> 1896. | 54th Year， 1897. | Averages． |  |  | 53 rd <br> Year， <br> 1896. | 64th <br> Year， <br> 1897. |  |
|  | $\begin{aligned} & 22 \text { YTA. } \\ & 1852-73 . \end{aligned}$ | $\left\|\begin{array}{c} 22 \mathrm{Yrse} \\ 1874-95 . \end{array}\right\|$ | $\left\lvert\, \begin{gathered} 44 \mathrm{Yrs}, \\ 2852-95 . \end{gathered}\right.$ |  |  | $\begin{gathered} 22 \mathrm{Yrs} ., \\ 1852-73 . \end{gathered}$ | $22 \text { Yrs., }$ $1874-95 .$ | $\left\lvert\, \begin{gathered} 44 \mathrm{Yrg} ., \\ 1852-95 . \end{gathered}\right.$ |  |  | $\begin{aligned} & 22 \text { Yirs., } \\ & 1852-73 . \end{aligned}$ | 22 Yrs．， | $\left\lvert\, \begin{gathered} 44 \mathrm{Yrg}, \\ 1852-95 \end{gathered}\right.$ |  |  |  |
|  | Bush． | Bush． | Bush． | Bush． | Bush． | lbs． | lbs． | lbs． | lbs． | lbs． | Cwts． | Cwts． | Cwts． | Cwts． | Cwts． |  |
| $2\{1$ |  | $\cdots$ |  | 40 | 32 |  |  |  | $63 \frac{3}{4}$ | 613 |  | ．． | 3 | 405 | $29 \frac{1}{2}$ | $\}_{2}\{1$ |
| 22 | $35 \frac{1}{4}$ | 347 | 35 | 44 | $37 \frac{1}{4}$ | 60 | 607 | 608 | 64 | $61 \frac{5}{5}$ | 333 | 32 | $32 \frac{3}{4}$ | 44 $\frac{1}{4}$ | $34 \frac{1}{8}$ | $\}^{2}\{2$ |
| 3 | $14 \frac{1}{4}$ | 112 | 127 | $16 \frac{3}{4}$ | 83 | 575 | $59 \frac{1}{4}$ | $58 \frac{1}{2}$ | 61 管 | $60 \frac{1}{4}$ | 125 | $8 \frac{1}{2}$ | $10 \frac{1}{2}$ | $11 . \frac{3}{4}$ | 78 | 3 |
| 4 | $15 \frac{1}{2}$ | $11 \frac{1}{2}$ | $13 \frac{1}{2}$ | $16 \frac{1}{4}$ | 93 | $58 \frac{1}{4}$ | 591 | $58 \frac{3}{4}$ | 615 | $59 \frac{1}{4}$ | 1338 | $8 \frac{1}{4}$ | 102 | 117 | 83 | 4 |
| 5 | $16 \frac{1}{2}$ | $13 \frac{3}{3}$ | 15 | $\bigcirc 04$ | 127 | $58 \frac{3}{4}$ | $59 \frac{1}{2}$ | 598 | $61 \frac{1}{2}$ | $59 \frac{1}{4}$ | 145 | $9 \frac{3}{4}$ | $12 \frac{1}{1}$ | 15 | $10^{3}$ | 5 |
| 6 | $25 \frac{3}{4}$ | $2 \%$ | $2+\frac{1}{4}$ | 297 | 198 | 594 | $60 \frac{1}{2}$ | $60^{\circ}$ | $62 \frac{1}{4}$ | $60 \%$ | 24 | 1938 | 218 | 247 | 17 | 6 |
| 7 | 341 | $31 \frac{3}{4}$ | 381 | $37 \frac{1}{4}$ | 285 | $59 \frac{1}{4}$ | $60 \frac{3}{4}$ | 60 | 637 | 61 ${ }^{1}$ | $34 \frac{1}{2}$ | 313 | 33 | 333 | $28 \frac{1}{4}$ | 7 |
| 8 | $37 \frac{3}{4}$ | $35 \frac{1}{2}$ | 361 | 44 | 37. | 59 | $60 \frac{1}{2}$ | 593 | $6+\frac{1}{4}$ | $61 \frac{3}{4}$ | $40{ }^{5}$ | $39 \frac{3}{8}$ | $40 \frac{1}{8}$ | $45 \frac{1}{8}$ | 39 | 8 |
| $9\{a$ | 37 | $32 \frac{1}{2}$ | $34 \frac{1}{4}$ | 3012 | 25 星 | $58 \frac{3}{6}$ | $60 \frac{1}{4}$ | $59 \%$ | 62 | 603 | 42 | 34 $\frac{3}{4}$ | 388 | 28. | 26 | ） 9 \｛a |
| $9\{3$ | $25 \frac{8}{4}$ | 191 | 22. | $33 \frac{1}{4}$ | 23 年 | $56 \frac{1}{2}$ | 578 | 57 | $62 \frac{1}{4}$ | $60 \frac{1}{2}$ | 28 | $17 \frac{7}{8}$ | 2.46 | 283 | 288 | $\}^{8} 16$ |
| $10\left\{\begin{array}{l}a \\ \end{array}\right.$ | $22 \frac{1}{4}$ | 17 | 191 | $21 \frac{3}{4}$ | 17\％ | 57 | $57 \frac{8}{4}$ | 573 | $62 \frac{1}{4}$ | $58^{3}$ | 218 | 14 | 178 | $18 \frac{1}{2}$ | 15\％ | $10\left\{\begin{array}{l}a \\ \end{array}\right.$ |
| $10\{b$ | $25 \frac{1}{4}$ | $18 \frac{3}{8}$ | 218 | 227 | $16 \frac{1}{2}$ | $57 \frac{8}{4}$ | $57 \frac{3}{4}$ | $57 \frac{3}{4}$ | $62 \frac{1}{8}$ | $58 \frac{1}{4}$ | $24 \frac{1}{6}$ | $15 \frac{5}{8}$ | 197 | 191 | 163 | $\int^{10} 16$ |
| 11 | 275 | $21 \frac{4}{4}$ | 244 | 24 | $16^{2}$ | $57 \frac{4}{4}$ | $58 \frac{1}{6}$ | 573 | $62 \frac{1}{8}$ | 575 | 36 | $20 \frac{1}{8}$ | 234 | 227 | 181 | 11 |
| 12 | $33 \frac{1}{8}$ | $27 \frac{1}{2}$ | 80. | 34 | 213 | 598 | $59 \frac{1}{2}$ | $59 \frac{1}{4}$ | $62 \frac{3}{4}$ | 59 | 313 | 258 | 281 | 295 | 218 | 12 |
| 13 | $33 \frac{1}{4}$ | 30 | 318 | 34 | $27 \frac{8}{4}$ | $59 \frac{5}{8}$ | $60 \frac{3}{4}$ | $60 \frac{1}{4}$ | $63 \frac{1}{2}$ | 603 | $33 \frac{1}{4}$ | $29 \frac{1}{2}$ | $31{ }^{3}$ | $30 \frac{1}{4}$ | 27） | 13 |
| 14 | $33 \frac{1}{4}$ | $28 \frac{1}{2}$ | $30{ }^{\circ}$ | 293 | 192 | $59 \frac{1}{4}$ | $59 \frac{1}{4}$ | 593 | 63 | $59 \frac{1}{4}$ | $32 \frac{1}{4}$ | $26 \frac{5}{8}$ | 298 | 255 | 201 | 14 |
| $15\left\{\begin{array}{l}a \\ b\end{array}\right.$ | $\left.\begin{array}{l} 32 \frac{3}{4} \\ 33_{\frac{7}{7}}^{7} \end{array}\right\}$ | $28 \frac{3}{4}$ | 31 | $30 \frac{3}{4}$ | 20즐 | 59 598 59 | \} $60 \frac{1}{2}$ | 60 | 621 |  | 323 $33 \frac{3}{4}$ | \} $26 \frac{3}{4}$ | 30 | 265 | 1914． | $15\left\{\begin{array}{l}a \\ b\end{array}\right.$ |
| 16 | $30 \frac{5}{8}$ | $24 \frac{3}{4}$ | $27 \frac{9}{4}$ | $37 \frac{3}{4}$ | $27 \frac{1}{2}$ | $58 \frac{7}{8}$ | $59 \frac{1}{2}$ | 59， | $63 \frac{3}{8}$ | $60 \frac{1}{2}$ | 337 | $24 \frac{3}{4}$ | 298 | $35 \frac{1}{4}$ | 327 | 16 |
| 17 | $30{ }^{\circ}$ | $29 \frac{3}{4}$ | $\left.{ }^{14}\right)^{30} 8$ | 35年 | 11 （16） | $59 \frac{1}{2}$ | 601 $\frac{1}{4}$ | （4） 60 | $63 \frac{8}{4}$ | $595\left({ }^{16}\right)$ | 309 | 271 | （14） $28 \%$ | 313 | 108 （19） | 17 |
| 18 | $17 \frac{1}{4}$ | 13\％ | $\left({ }^{15}\right) 15 \frac{1}{4}$ | 17 | $30 \frac{1}{2}\left({ }^{17}\right)$ | 587 | 543 | （ ${ }^{\text {（15）}} 5841$ | $61 \frac{1}{4}$ | $61_{6}^{\text {bij }}$（ ${ }^{17}$ ） | $15 \frac{3}{4}$ | 11 | （15） 138 | 131 $\frac{1}{4}$ | $29 \frac{1}{4}\left({ }^{17}\right)$ | 18 |
| 19 | $30 \frac{1}{8}$ | $25 \frac{1}{6}$ | 281 | 36 | 22 | $58 \frac{5}{8}$ | 593 | 59 | $61 \frac{1}{2}$ | 00 $\frac{1}{2}$ | 285 | 23 | $25 \frac{8}{4}$ | 327 | 21 | 19 |
| $20(13)$ | 14 $\frac{1}{4}$ | $13 \frac{1}{8}$ | （18） $13 \frac{7}{4}$ | 14 | 8 | $57 \frac{8}{4}$ | $58 \frac{3}{4}$ | ${ }^{18}{ }^{18} 581$ | $61 \frac{1}{4}$ | $61 \frac{1}{8}$ | 135 | 10 | （18） $11 \frac{1}{2}$ | $9 \frac{3}{4}$ | 8 | $20\left({ }^{13}\right)$ |
| 21 | $21 \frac{1}{4}$ | 167 | （19） $19{ }^{4}$ | ．． | 8 | $58{ }^{4}$ | 58 先 | （19） 588 | 4 | \％ | $19 \frac{3}{4}$ | 137 | （19） 168 | ．． | ．． |  |
| 22 | 21. | $17 \frac{3}{4}$ | （ ${ }^{19}$ ） 193 | ． | ．． | $58 \frac{1}{4}$ | $58{ }^{3}$ | $\left({ }^{19}\right) 589$ | ．． | ． | $19 \frac{1}{2}$ | $14 \frac{5}{8}$ | $\left({ }^{19}\right) 17 \frac{1}{6}$ | $\cdots$ | ． | 22 |

（ii）The Manures of Plots 17 and 18 are，year by year，transposed． anmanured for many years；growing wheat up to 1883 inclusive；atd agalu in 1887 and 1891；Potntoes，1889；and left fallow 1884，＇5，＇ 6 ，＇ 8 ＇ 90 ，＇92 and＇ 93 ．
（16）Averases of Ammonium－salts，alternate 1 with Mineral Manures，
（15）Averages of Mineral Manures，alternated with Ammonim－salts．
（t6）Plot 17 had the Mineral Manure 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 he 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 16 ． For the crop of 1880 and since the return of the straw bas been discontinued．
（19）Averages of 16，16，and 32 years，1852－83．

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 acre，on the half acre of wheat after fallow；and in the second column the produce per Rothamsted soil for many years in succession，after bare fallow，compared with that of acre obtained in the adjoining field（Broadbalk），where wheat is grown year after year on 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 expe－ riments 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． 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 strav，per acre per annum，than where the crop is grown continuously．（hen the yield per acre of the whole area，half in crop and half fallow，it gives several 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 sacnfce 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． of the fallow，is lost by drainage during the long period that the land is without a crop．
ment， 1 acre．）

|  | Dressed Grain． |  |  | Weight per Bushel． |  | Total Grain． |  |  | Total Straw． |  |  | Total Produce（Grain and Straw）． |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Wheat after Fillow each year． | $\begin{aligned} & \text { Wheat } \\ & \text { after } \\ & \text { Wheat } \\ & \text { each } \\ & \text { year. } \end{aligned}$ | After Fallow + afrer after Wheat． | Wheat atater Fallow each eacar． | Wheat after Wheat each year． | Wheat after Fallow each year． | Wheat Wheat each year． | After $\begin{aligned} & \text { Fallow } \\ & \text {＋or－} \\ & \text { after } \\ & \text { wheat．}\end{aligned}$ Wheat． | Wheat afat Fallow ealoh year． | Wheat wfter Wheat each year． | $\begin{aligned} & \text { After } \\ & \text { Fallow } \\ & \text { +or } \\ & \text { after } \\ & \text { Wheat. } \end{aligned}$ | Wheat after Fallow Faloh cear． | $\begin{aligned} & \text { Wheat } \\ & \text { after } \\ & \text { wheat } \\ & \text { eacoh } \\ & \text { year. } \end{aligned}$ | $\begin{aligned} & \begin{array}{l} \text { After } \\ \text { Fallow } \\ \text { +or } \\ \text { after } \\ \text { Wheat. } \end{array} \end{aligned}$ |  |
|  | Preliminary Period． |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Bushels． | Buahels． | Bushels． | lbs． | ${ }^{\text {libs．}}$ | 1bs． | lbs． | liss． | 1 lbs ． | 1bs． | libs． | ${ }^{\text {lbs．}}$ | 18s． | lbs． |  |
| 1851 | Fallow | 157 | $-157$ | Fallow | ${ }^{61 \cdot 1}$ | Fallow | 1083 | －1083 | Fallow | 1627 | $-1627$ | Fallow | 2710 | －2710 | 1851 |
| 1852 |  | 13. | ＋234 | 53.0 | $56 \cdot 6$ | 2088 | 860 | ＋1228 | 4934 | 1597 | ＋3337 | 7022 | 2457 | ＋4565 | 1852 |
| 1853 | Fallow | 5 | － 5 | Fallow | $45 \cdot 9$ | Failow | 359 | －359 | Fallow | 1413 | －1413 | Fallow | 1772 | －1772 | 1853 |
| 1854 | 42 | 21 | ＋21 | $60 \cdot 5$ | $60 \cdot 6$ | 2709 | 1359 | ＋1350 | 4545 | 2137 | ＋2408 | 7254 | 3496 | ＋3758 | 1854 |
| 1855 | 173 | 17 | ＋ 0 景 | $54 \cdot 0$ | $59 \cdot 2$ | 1080 | 1072 | ＋ 8 | 1734 | 1787 | － 53 | 2814 | 2859 | － 45 | 1855 |
| Period of Exact Comparison． |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1856 | $21 \frac{18}{4}$ | 1412 | ＋ $7 \frac{1}{4}$ | ${ }^{60 \cdot 0}$ | $54 \cdot 3$ | 1388 | ${ }^{892}$ | ＋496 | 2113 | 1558 | ＋555 | 3501 | 2450 | ＋1051 | 1856 |
| 1857 | 38 | 20 |  | 58.4 | $58 \cdot 3$ | 2299 | 1236 |  |  | 1577 |  |  | ${ }_{2}^{2813}$ | $+2561$ | 1857 |
| 1858 1859 | ${ }_{34}^{253}$ | 18 | ＋ 78 $+15{ }^{\text {a }}$ | $60 \cdot 6$ $55 \cdot 0$ | $60 \cdot 4$ $52 \cdot 5$ | 1630 1976 | 1141 | ＋ 489 <br> $+\quad 925$ | 2468 3686 | 1670 2175 | +798 +1511 | 4098 5662 | 2811 3226 | +1287 +2436 | 1858 1859 |
| 1859 1860 | 124 | 184 <br> 124 | $\begin{array}{r}+153 \\ -\quad 0{ }^{2} \\ \hline\end{array}$ | $55 \cdot 0$ 54.8 | $52 \cdot 5$ $52 \cdot 6$ | 1976 | 1051 738 | ＋ 925 <br> -41 | 3686 1226 | 2175 1459 | +1511 +233 | 5662 1923 | 3226 2197 | +2436 <br> $+\quad 274$ | 1859 |
| 1861 | 17 | 12 星 | ＋6 $\mathbf{6}_{\text {告 }}$ | $58 \cdot 8$ | $57 \cdot 4$ | 1145 | 736 | ＋409 | 2072 | 1254 | ＋ 818 | 3217 | 1990 | ＋1227 | 1861 |
| 1862 | $22^{8}$ | 16 | ＋67 | $57 \cdot 1$ | 57•8 | 1361 | 996 | ＋365 | 2294 | 1713 | ＋581 | 3655 | 2709 | ＋946 | 1862 |
| 1863 | 327 | $17 \frac{1}{2}$ | +15 咅 | $61 \cdot 4$ | $62 \cdot 7$ | 2090 | 1127 | ＋ 963 | 2900 | 1600 | $+1300$ | 4990 | 2727 | ＋2263 | 1863 |
| 1864 | 31 | $16 \frac{1}{2}$ | $+14{ }^{\text {f }}$ | ${ }^{61} \cdot 7$ | $62 \cdot 0$ | 2005 | 1078 | ＋927 | ${ }_{2150}^{2746}$ | ${ }_{1}^{1350}$ |  | 4751 3590 | 2428 | ＋2323 | 1864 |
| 1865 | 24. | $13 \frac{1}{4}$ | ＋11 | $57 \cdot 6$ | $60 \cdot 6$ | 1440 | 828 | +612 | 2150 | 1033 | ＋1117 | 3590 | 1861 | ＋1729 | 1865 |


| 1866 | $10 \frac{3}{4}$ | 121 | －13 | $58 \cdot 5$ | $61 \cdot 3$ | 653 |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1867 | $9{ }^{\text {5 }}$ | 82 | ＋ 0 量 | $58 \cdot 2$ | $56 \cdot 1$ | 616 | 532 | $\begin{array}{r}\text {－} 124 \\ +\quad 84 \\ \hline\end{array}$ | 1146 | 1269 973 | -123 +153 | 1799 | 2046 1505 | -247 +237 | 1866 |
| 1868 | 25 | 16 | ＋838 | $63 \cdot 4$ | $61 \cdot 0$ | 1656 | 1054 | ＋ 602 | 2398 | 973 | ＋1425 | 4054 | 2027 | +237 +2027 | 1867 |
| 1869 | 107 | $14{ }^{\text {全 }}$ | $-4$ | $60 \cdot 1$ | $56 \cdot 1$ | 655 | 848 | －193 | 1019 | 1350 | ＋1425 | 1674 | 2198 | +524 $+\quad 50$ | 1868 |
| 1870 | 174 | 15 | ＋ $2 \frac{1}{4}$ | $62 \cdot 5$ | $61 \cdot 8$ | 1101 | 956 | ＋145 | 1282 | 1046 | ＋ 236 | 2383 | 2002 | +381 +381 | 1870 |
| 1871 | $9 \frac{1}{4}$ | $9{ }^{1}$ | － 0 | $58 \cdot 5$ | $54 \cdot 8$ | 605 | 615 | － 10 | 1287 | 1100 | ＋ 187 | 1892 | 1715 | +177 +1 | 1871 |
| 1872 | $12 \frac{3}{4}$ | $10 \frac{3}{4}$ | $+2$ | $58 \cdot 3$ | $59 \cdot 0$ | 780 | 705 | ＋ 75 | 1307 | 1152 | ＋ 155 | 2087 | 1857 | ＋ 170 +230 | $\begin{aligned} & 1871 \\ & 1872 \end{aligned}$ |
| 1873 | $2 \frac{3}{4}$ | 11妾 | $-9$ | $42 \cdot 0$ | $57 \cdot 0$ | 181 | 701 | － 520 | 875 | 902 | － 27 | 1056 | 1603 | ＋ 230 | $1872$ |
| 1874 | 212 | 113 | $+10$ | $60 \cdot 0$ | $58 \cdot 3$ | 1370 | 694 |  | 2000 |  | ＋1010 | 3370 | $\begin{aligned} & 1684 \\ & 1684 \end{aligned}$ | $\begin{array}{r} 1686 \\ +1686 \end{array}$ | $\begin{aligned} & 1873 \\ & 1874 \end{aligned}$ |
| 1875 | 161 | 8咅 | $+7 \frac{1}{2}$ | $57 \cdot 2$ | $60 \cdot 0$ | ＋993 | 567 | $+\quad 676$ $+\quad 426$ | 1725 | 990 1008 | +1010 $+\quad 717$ | 3370 2718 | $\begin{aligned} & 1684 \\ & 1575 \end{aligned}$ | $\begin{aligned} & +1686 \\ & +1143 \end{aligned}$ | $\begin{aligned} & 1874 \\ & 1875 \end{aligned}$ |
| 1876 | 101 | 81 | $+2 \frac{1}{6}$ | $58 \cdot 7$ | $59 \cdot 0$ | 635 | 500 | ＋ 135 | 790 | 642 | $+148$ | 1425 |  |  |  |
| 1877 | $10 \frac{1}{2}$ | 87 | ＋ 15 | $60 \cdot 5$ | $58 \cdot 9$ | 649 | 543 | ＋ 106 | 829 | 748 | +188 $+\quad 81$ | 1478 | 1291 | +283 +187 | $\begin{aligned} & 1876 \\ & 1877 \end{aligned}$ |
| 1878 | 193 | $12{ }^{\frac{1}{4}}$ | ＋7\％ | $57 \cdot 9$ | $59 \cdot 0$ | 1171 | 776 | ＋ 395 | 1654 | 1081 | +573 | 2825 | 1857 | ＋ 968 | $\begin{aligned} & 1877 \\ & 1878 \end{aligned}$ |
| 1879 | 6 | 4 | ＋ $1 \frac{1}{4}$ | $55 \cdot 6$ | $52 \cdot 5$ | 379 | 330 | ＋ 49 | 808 | 763 | +45 $+\quad 45$ | 1187 | 1093 | $+\quad 94$ $+\quad 94$ | $\begin{aligned} & 1878 \\ & 1879 \end{aligned}$ |
| 1880 | 151 | 113 | ＋3 ${ }_{\text {年 }}$ | $58 \cdot 7$ | $56 \cdot 9$ | 937 | 689 | ＋ 248 | 1665 | 1149 | ＋ 516 | 2602 | 1838 | $+\quad 94$ $+\quad 764$ | $\begin{aligned} & 1879 \\ & 1880 \end{aligned}$ |
| 1881 | 124 | 133 | －1 $1 \frac{1}{2}$ | 54－6 | $58 \cdot 0$ | 748 | 863 | － 115 | 897 | 1146 | ＋ 249 | 1645 | 2009 | ＋ 364 | $\begin{aligned} & 1880 \\ & 1881 \end{aligned}$ |
| 1882 | 119 | 11 | ＋08 | $58 \cdot 6$ | $58 \cdot 7$ | 719 | 679 | ＋ 40 | 1085 | 1095 | － 10 | 1804 | 1774 | +30 $+\quad 30$ | $\begin{aligned} & 1881 \\ & 1882 \end{aligned}$ |
| 1883 | $18 \frac{1}{6}$ | 139 | ＋43 | $61 \cdot 2$ | $61 \cdot 2$ | 1160 | 872 | ＋ 288 | 1301 | 1006 | ＋ 295 | 2461 | 1878 | $+\quad 58$ +583 | $\begin{aligned} & 1882 \\ & 1883 \end{aligned}$ |
| 1884 | $20 \frac{1}{4}$ | 13 | ＋ 71 | $60 \cdot 2$ | $62 \cdot 1$ | 1240 | 824 | ＋ 416 | 1544 | 905 |  | 2784 | 1729 | $\begin{aligned} & +583 \\ & +1055 \end{aligned}$ | $\begin{aligned} & 1883 \\ & 1884 \end{aligned}$ |
| 1885 | 23 | 158 | $\begin{array}{r}+78 \\ +\quad 78 \\ \hline\end{array}$ | $57 \cdot 9$ | $59 \cdot 0$ | 1351 | 925 | +488 <br> +426 | 1812 | 19 | $+\quad 639$ <br> $+\quad 675$ | 2784 3163 | 1729 2062 | $\begin{aligned} & +1055 \\ & +1101 \end{aligned}$ | $\begin{aligned} & 1884 \\ & 1885 \end{aligned}$ |
| 1886 | $9{ }^{1}$ | 9 | $+0 \frac{1}{4}$ | $62 \cdot 2$ | 61.5 | 588 | 564 | ＋ 24 | 657 | 570 |  | 1245 |  |  |  |
| 1887 | 19 | 147 | ＋ $4{ }^{1}$ | $59 \cdot 9$ | $59 \cdot 8$ | 1153 | 906 | ＋ 247 | 1212 | 895 | +317 +31 | 2365 | 1801 | +111 +564 | $\begin{aligned} & 1886 \\ & 1887 \end{aligned}$ |
| 1888 | 123 | 10 | ＋ 2 委 | $56 \cdot 1$ | $58 \cdot 8$ | 735 | 614 | ＋ 121 | 1239 | 901 | ＋317 | 1974 |  | +564 +459 | $\begin{aligned} & 1887 \\ & 1888 \end{aligned}$ |
| 1889 | 13 | 122 | ＋03 | $59 \cdot 5$ | $59 \cdot 8$ | 796 | 743 | $+\quad 51$ $+\quad 53$ | 1216 | 902 | $+\quad 317$ $+\quad 14$ | 1712 | 1645 | $+\quad 459$ $+\quad 67$ | $\begin{aligned} & 1888 \\ & 1889 \end{aligned}$ |
| 1890 | $17 \frac{3}{4}$ | 14 | ＋33 | $59 \cdot 8$ | $59 \cdot 4$ | 1088 | 849 | $+\quad 53$ $+\quad 239$ | 1657 | 1004 | +114 +653 | 2745 | 1853 | $+\quad 69$ $+\quad 89$ | $\begin{aligned} & 1889 \\ & 1890 \end{aligned}$ |
| 1891 | 231 | 13，${ }^{\frac{8}{4}}$ | ＋ $9_{8}^{8}$ | $58 \cdot 9$ | $57 \cdot 4$ | 1404 | 828 | +576 $+\quad 57$ | 2241 | 1314 | +685 +927 | 3645 | 2142 | +892 +1503 | $1890$ |
| 1892 | 113 | $9{ }^{9}$ | －${ }^{\text {a }}$ | $60 \cdot 2$ | $59 \cdot 6$ | 731 | 589 | +186 $+\quad 142$ | 1108 | 1314 836 | $+\quad 927$ $+\quad 272$ | 3645 1839 | 1425 | +1503 +414 | $\begin{aligned} & 1891 \\ & 1892 \end{aligned}$ |
| 1893 | 132 | 98 | ＋ 38 | $62 \cdot 4$ | $62 \cdot 7$ | 870 | 642 | +142 +228 | 854 | 609 | +272 +245 | 1839 1724 | 1251 | +414 +473 | $1892$ |
| 1894 | $15 \frac{1}{2}$ | 18 | － $2 \frac{3}{2}$ | $59 \cdot 7$ | $60 \cdot 2$ | 953 | 1121 | ＋ 168 | 1483 | 1487 | $+\quad 245$ $+\quad 4$ | 1724 2436 | 12508 | $+\quad 473$ +172 | $\begin{aligned} & 1893 \\ & 1894 \end{aligned}$ |
| 1895 | $15 \frac{1}{2}$ | 10 | ＋ 5 2 | $62 \cdot 2$ | $62 \cdot 5$ | 978 | 664 | +168 +314 | 1151 | 1487 720 | －${ }^{4}$ | $\begin{aligned} & 2436 \\ & 2129 \end{aligned}$ | $\begin{aligned} & 2608 \\ & 1384 \end{aligned}$ | $\begin{array}{r}+172 \\ +745 \\ \hline\end{array}$ | $\begin{aligned} & 1894 \\ & 1895 \end{aligned}$ |
| 1896 | 161 | 16 ${ }^{\frac{9}{4}}$ | － 08 | $60 \cdot 7$ 50.5 | 61.4 | 1020 | 1087 | － 67 | 1312 | 1309 | ＋ 3 | 2332 | 2896 |  |  |
|  | 7 | 87 | －17 | 59.5 | $60 \cdot 3$ | 460 | 592 | － 132 | 710 | 867 | － 157 | 1170 | 1459 | － 289 | 1897 |
| Averages－Produce after F＇allow reckoned at the yleld per Acre of the half in Crop each year． |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5 yrs．1851－＇55 | 191 | 143 ${ }^{4}$ | ＋41 | 55•8 | 56.7 | 1175 | 947 | ＋ 228 | 2243 | 1712 |  | 3418 | 2659 |  |  |
| 10 yrs．1856－＇65 | $26 \frac{1}{8}$ | 157 | ＋1014 | $58 \cdot 5$ | $57 \cdot 9$ | 1603 | 982 | $+621$ | 2473 | 1539 |  |  |  |  |  |
| 10 yrs．1866－75 | $13 \frac{1}{2}$ | $11{ }^{7}$ | ＋ $1{ }^{5}$ | 57－9 | $58 \cdot 5$ | 861 | 745 | $+116$ | 1417 |  | $\bigcirc$ | 4076 | 2521 | ＋1555 | 10 yrs 1856－＇65 |
| $10 \mathrm{yrs}$.1876 －＇85 | 143 | 111 | ＋ $3 \frac{1}{2}$ | $58 \cdot 4$ | $58 \cdot 5$ | 899 | 700 | +116 +199 | 1417 | 1076 | ＋ 341 | 2278 | 1821 | ＋ 457 | 10 yrs．1866－＇75 |
| $10 \mathrm{yrs}$.1886 －＇95 | $15 \frac{1}{1}$ | 121 | $+3$ | $60 \cdot 1$ | $60 \cdot 2$ | 930 | 752 | +1169 +178 +1 | 1238 | 967 | ＋ 271 | 2137 | 1667 | $+470$ | 10 yrs．1876－＇85 |
| 40 yrs．1856－＇95 | 173 | 123 |  |  |  |  |  |  | 1252 | 924 | ＋ | 2182 | 1.676 | ＋ 506 | 10 yrs 1886－＇95 |
| 40 yrs．1856－95 | 17 B | 12 |  | $58 \cdot 7$ | $58 \cdot 8$ | 1073 | 795 | ＋ 278 | 1595 | 1127 | $+468$ | 2668 | 1921 | $+747$ | 40 yrs．1856－＇95 |
| averages－Pboduce after F＇allow regoned at the field per Acre of the whole Area，half in Crop and half F |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5 yrs．1851－＇55 | 98 | $14 \frac{3}{4}$ | － $5^{\frac{1}{8}}$ |  |  | 587 | 947 | － 360 | 1122 | 1712 | － 590 | 1709 | 2659 | － 950 | 5 yrs．1851－＇55 |
| 10 yrs 1856－＇65 | 13 | 152 | － $2^{7}$ |  |  | 802 | 982 |  |  | 1539 |  |  |  |  |  |
| $\bigcirc 10 \mathrm{yrs} 1866-$. | $6{ }^{3}$ | 112 | － $5 \frac{8}{8}$ |  |  | 430 | 745 | － 315 | 709 | 1076 | － 367 | 1139 | － 1821 | － 488 |  |
| $10 \mathrm{yrs}$. 1876－＇85 | 78 | $11 \frac{1}{4}$ | － 37 |  |  | 449 | 700 | － 251 | 619 | 967 | － 348 | 1068 | 1667 | － 599 | $10 \text { yrs. 1876-' } 85$ |
| 10 yrs．1886－＇95 | 712 | 12 l | －45 |  |  | 465 | 752 | － 287 | 626 | 924 | $\begin{array}{r}\text {－} 298 \\ \hline\end{array}$ | 1091 | 1676 | － 585 | $10 \text { yss. } 1886 \text { - } 95$ |
| 40 yrs．1856－＇95 | $8{ }^{5}$ | 123 | －41 |  |  | 536 | 795 | － 259 | 798 | 1127 | － 329 | 1334 | 1921 | － 587 | 40 yrs．1856－＇95 |

Experiments on the Growth of OATS year after year on the samit
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 AORE, PER ANNUM. | Produol per Adre. |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 1st Season, 1869. |  |  | 2nd Season, 1870. |  |  |
|  |  | Dressed Grain. |  | Total Straw. | Dressed Grain. |  | Total Straw. |
|  |  | Quantity | Weight per Bushel |  | Quantity. | Weight per Bushel. |  |
| 1 | Unmanured | $\begin{gathered} \text { Bushels. } \\ \mathbf{3 6} \frac{5}{8} \end{gathered}$ | $\begin{aligned} & \text { lbs. } \\ & 36{ }_{9}^{8} \end{aligned}$ | cwts. 197 | Bushels. $16 \frac{9}{6}$ | $\begin{aligned} & \text { lbs. } \\ & \mathbf{3 5} \end{aligned}$ | cwts. $\boldsymbol{9}_{\mathrm{b}}^{1}$ |
| 2 | $\left\{\begin{array}{c} 200 \text { lbs. Sulphate Potash, } 100 \mathrm{lbs} \text {. Sulphàte Soda, } \\ 100 \text { lbs. Sulphate Magnesia, and } 3 \frac{1}{2} \\ \text { cvts. } \end{array}\right\}$ | 45 | $38 \frac{1}{2}$ | 241 | 19! | 351 | 95 |
| 3 | 400 lbs. Ammonium-salts ${ }^{(2)}$.. .. .. .. | 561 | $37 \frac{1}{2}$ | 367 | 30 | 347 | 173 |
| 4 | $\left\{\begin{array}{c} 400 \mathrm{lbs} \text {. Ammonium-salts, } 200 \mathrm{lbs} \text {. Sulphate Pot-- } \\ \text { ash, } 100 \mathrm{lbs} \text { Sulphate Soda, } 100 \mathrm{llbs} \text { Sulphate } \\ \text { Magnesia, and } 3 \frac{1}{2} \text { ewts. Superphosphate } \end{array}\right\}$ | 751 | 397 | 54 | 505 | 36 | 285 |
| 5 | 550 lbs . Nitrate of Soda ${ }^{(3)}{ }^{(9)}$.. .. .. .. | 624 | 381 | 423 | 361 $\frac{1}{2}$ | 351 | 23 |
| 6 | $\left\{\begin{array}{c} 550 \mathrm{lbs} \text {. Nitrate of Soda, } 200 \mathrm{lbs} \text {. Sulphate Potash, } \\ 100 \mathrm{lbs} \text { Sulphate Soda, } 100 \text { lbs. Sulphate } \\ \text { Magnesie, and } 8 \frac{1}{2} \text { owts. Superphosphate } \end{array}\right\}$ | 693 | $38 \frac{1}{2}$ | 497 | 50 | $35 \frac{3}{4}$ | $28 \frac{3}{4}$ |

Sigond 5 Yifars ; Mineral Mandres as before,

|  |  | 6th Season, 1874. |  |  | 7 th Stagon, 1875. |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | Unmanured | Bushels. 12 | $\begin{aligned} & \text { lbs. } \\ & \text { 311 } \end{aligned}$ | ${ }_{7}^{\text {cwts. }}$ | Busbels. 121 | $\begin{aligned} & \text { lbs. } \\ & 293 \end{aligned}$ | cwts. $57$ |
| 2 | $\left\{\begin{array}{c} 200 \text { lbs. Sulphate Potash, } 100 \text { lbs. Sulphate Soda, } \\ 100 \text { lbs. Sulphate Magnesia, and 3⿺辶 } \\ \text { Superphosphate of Lime }{ }^{(1)} \text {.. } \\ \text {.. } \end{array}\right\}$ | $13^{5}$ | 311 | $6 \frac{1}{2}$ | 131 | $29 \frac{9}{4}$ | 67 |
| 3 | 200 lbs, Ammonium-salts ( ${ }^{2}$ ) .. .. .. .. | $37 \frac{1}{4}$ | 33 | 227 | 309 | 327 | 159 |
| 4 | $\left\{\begin{array}{c} 200 \mathrm{lbs} . \text { Ammonium-salts, } 200 \mathrm{lbs} \text {. Sulphate Pot- } \\ \text { ash, } 100 \mathrm{lbs} \text {. Sulphate Soda, } 100 \text { lbs. Sulphate } \\ \text { Magnesia, and 3. cwts. Superphosphate .. } \end{array}\right\}$ | 469 | 345 | 245 | 305 | 347 | 201 |
| 5 | 275 lbs. Nitrate of Soda ( ${ }^{3}$ ) .. .. .. .. .. | $351{ }^{(4)}$ | 30 ( ${ }^{(1)}$ | $16 \frac{1}{2}\left({ }^{4}\right)$ | $23 \frac{1}{2}\left({ }^{4}\right)$ | $\left.311{ }_{4}{ }^{4}\right)$ | $113{ }^{(4)}$ |
| 6 | $\left\{\begin{array}{c} 275 \text { lbs. Nitrate of Soda, } 200 \text { lbs. Sulphate Potash, } \\ 100 \text { lbs. Sulphate Soda, } 100 \text { lbs. Sulphate } \\ \text { Magnesia, aud } 8 \frac{1}{2} \text { ewts. Superphosphate } . . \end{array}\right\}$ | $28 \frac{1}{2}\left({ }^{4}\right)$ | $33 \frac{1}{2}\left({ }^{4}\right)$ | $16 \frac{5}{6}\left({ }^{4}\right)$ | $28{ }^{\text {a }}$ ( ${ }^{4}$ ) | $335{ }^{(4)}$ | 141 ${ }^{(4)}$ |

(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.
${ }^{(3)} 550 \mathrm{lbs}$. 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.

## FIELD.

Land; without Manubi, and wity different debdhiftions of Manube.
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.
${ }_{4}{ }^{3}$ acre.)


Ammonidm-salta and Nitrate of Soda only half as muof as previously.

| 8th Season, $1876{ }^{(5)}$. |  |  | 9 th Seabon, 1877 ( ${ }^{6}$ ). Fallow. |  |  | 10th Season, 1878. |  |  | Average per Annom 4 Years, 1874, '5, '6, and '8. |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{array}{\|c} \text { 'Bushels, } \\ 8 \frac{1}{6} \end{array}$ | $\begin{gathered} \text { lbs. } \\ 32 \end{gathered}$ | $\begin{gathered} \text { cwts. } \\ 2 \text { 2. } \end{gathered}$ | Bushels. <br> * | lbs. | cwts, | Bushels. 224 | $\begin{aligned} & \text { lbs. } \\ & 32 \end{aligned}$ | cwts. 83 | Bushels. $13 \frac{3}{4}$ | $\begin{aligned} & { }^{\mathrm{lbs}} \\ & 31 \frac{1}{4} \end{aligned}$ | $\begin{gathered} \text { cwts. } \\ 6 \end{gathered}$ |
| $7{ }^{3}$ | 30 | $2{ }^{5}$ | .. | * | * | $17 \frac{3}{4}$ | $35 \frac{1}{4}$ | $8 \frac{1}{4}$ | $13^{\frac{1}{8}}$ | 315 | 61 |
| $17 \frac{5}{8}$ | 341 | . 6 | * | * | * | 30 | 32 $\frac{8}{4}$ | 123 | 287 | 334 | 14! |
| 293 | $35 \frac{1}{2}$ | $12 \frac{1}{2}$ | . | .. | - | 458 | 37 | 221 | 38 | $35 \frac{1}{2}$ | 20 |
| 129 ${ }^{\frac{9}{4}}$ | 307 | 37 | -• | . | -• | $34 \frac{1}{8}$ | 344 | 122 $\frac{1}{2}$ | 269 | 31需 | $11 \frac{1}{8}$ |
| 195 | 334 | 8 | * | * | $\cdots$ | 37 | $36 \frac{1}{4}$ | 171 | 283 | 344 | 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, ete.
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.

## RESULTS OF EXPERIMENTS MADE IN HOOS FTELD 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 powerfullyrooting 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 surfacesoils 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 mantures; notwithstanding that Beans, like other Leguminous crops, contain a much higher percentage of nitrogen, and gield much more nitrogen per acre, than grain crops. Further, on the growth of Beans thus year after yoar 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 mach 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 cousiderable 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 Clcver, 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.

## EXPERIMENTS ON THE GROWTH OF LEGUMINOUS CROPS.

I.-Beans, Praf, and Tares-Gemboroft 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 60 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 wenness of the land in the first instance, and the subsequent hindrance by other spring sowing, they were not putt 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 $18 \dot{7} 6$, winter Beans were put in (drilled), without further manuring.
In 1878 the ustual 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 barrowed, 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.

## Experiments on the Growth of Leguminous Crops-continued.

In April 1888, 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 scuffleharrowed, 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 ewts. 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 28, 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.

# Experimentis on the Growth of Leguminous Crops-continued. 

## II.-Rend Clover (Trifolium praterse).

## 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. Ammoniumsalts 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 coujunction 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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## Experiments on the Growth of Lequminous Crops-continued.

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 $\times 2$, were arranged on the previously ummanured 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 imporfect, 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 1888, 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 topdressing. 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 $(=86 \mathrm{lbs}$. 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 footnote, 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-amile 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 Leguminods 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 seedweeds; the beds were therefore dug up, later in the autumn, left fallow during the winter, and

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## Experiments on the Growie of Legominous Crops-continued.

 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 in 1895.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; butit 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 surfacesoil 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 45 th 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, dec.

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 "cloversickness," 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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## Experiments on the Growth of Lequminous Crops-continued.

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 exelude 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 nitrogencompounds 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.
( 46 )

Experments with various LEGUIMINOUS PLANTS.-HOOS FIELD.

| frequent succession since 1849 , was devoted to experiments with various Leguminous Plants in | Nos. 11 and 12, Trifolium pratense (Red Clover). |
| :--- | :--- | :--- |
| 1878 ; so that the present season, 1898, is the twenty | Nos. 13 and 14, Vicia sativa (Common Tare or Vetch). | The object was to ascertain whether, among a selection of plants all belonging to the to the different plots. Up to 1897 inclusive there were 3 " Scries" : Series the manures applied 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 Sories:-Series 1, mineral manures only; Series 2, the same mineral or rape-cake, or cows' urine, in addition. The manures have been applied in the quantities 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 an average of only 14 lbs , of nitrogen. Against this, Melilotus leucantha yielded in 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 340 lbs ., in 1885 about 270 lbs ., and over the 6 years (1880-85), an average of in 1884 nearly 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. 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, (White or Dutch Clover). (Area under Experiment, about 3 acres; and soil history is substantially continued. (See Plan and footnotes thereto at p. 36 .)

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 June '88; April' 's9; Melilotus leucan. -May'90.



[^0]\[

$$
\begin{aligned}
& 5 \text { Lands (1) ; } \\
& \text { Each Plot as }
\end{aligned}
$$
\]

Nitrate of Soda,
550 lbs.
in $1878, \quad 82$, s.nd 84 ;
275 lbs.

 .

$$
\begin{aligned}
& \text { SERIES I, } \\
& \text { and- }
\end{aligned}
$$


 more, of soluble phosphate.




## ( 48 )

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 Jand about 8 acres.
$1,2,5,6,7$, and 8 , of each Series, rather over $\frac{1}{7}$ acre ( $0 \cdot 14598$ acre)
$\left\{\begin{array}{l}3 \text {, of each Series about } \frac{1}{3} \text { acre ( } 0.03649 \text { acre). } \\ 4,\end{array}\right.$
4 , of each Series about $\frac{1}{3}$ aere ( $0 \cdot 20074$ acre).
(9, rather over $\frac{4}{10}$ acre ( $0 \cdot 42$ acre).
The double lines indicate division paths between plot and plot.
[For particulars of manuring and produce, etc., see pp. 50-75.]

## 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-manuro, and with varions artificial manures-commencing in 1843 ;

Norfolk White Turnips, 6 years, 1843-48;
Swedish Turnips, 4 yenrs, 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-beetSee 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 generully 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 aetual 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 leafsurface.

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.
(50)

## Experiments on ROOT-CROPS.-BARN FIELD.

 numerous Plots, were set apart for the purpose, and ene crop 18as and "Swedes" 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 in order to test the comparative corn-growing condition the equalise their condition, as far as possible, by the exhan of some of the most active and immediately available constituents supplied by the previou 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 see pp.
also p. 73.)
(Area under experiment about 8 acres; quantities, average per acre, per annum.)

Swedisi Turnips; Fodr Seasons, 1849-1852; Roots and Leaves carted off the Land (excepting 1849, when the Leaves were too small to weigh or remove).



| Swedish Turnips; Fifteen Seasons, 1856-1870.(1) |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Standard Manureg. | Series 1. Standard Manures only. |  | Sertrs 2. <br> Standard Manures and Cross-dressed with5 years, 1856-1860, 3000 lbs. Saw-dust, and 328 lbs . Nitric Acld. 10 years, 1861-1870, 550 lbs. Nitrate Soda. |  | Series 3. <br> Standard Manures, and Cross-dressed with - <br> 5 years, 1856-1860, 200 lbs. Ammonium-8alts. <br> 10 years, 1861-1870, 400 lbs. Ammonium-salts. |  | Series 4. <br> Standard Manures, and Cross-dressed with- <br> 5 years, 1856-1860, 200 lbs. Ammonium-salts, and 3000 lbs. Sawdast. <br> 10 years, 1861-1870, 400 lbs . Ammonium-salts, and 2000 lbs . Rape-cake. |  | Sertes 5. Standard Manures, and Cross-dressed with5 years, 1856-1860, 3000 lbs . Sawdust. 10 years, 3861-1870, 2000 ibs. Hape-cake. |  |
|  |  | Roots. | Leaves. | Roots. | Leaves. | Ruots. | Leaves. | Roots. | Leaves. | Roots. | Leaves. |
| © Lorss. |  | Tons. cwts. | Tons. cwts. $0 \quad 17$ | Tons. cwts. <br> 7 <br> 9 | Tons. cwts. 12 | $\begin{gathered} \text { Tons. cwts. } \\ 0 \end{gathered}$ | Tons. cwts. <br> Tons. | Tons. cwts. 816 | Tons. cwts. <br> 19 | Tons. cwts. <br> 80 | Tons. cwts. |
| 2 | Farmyard Manure, 14 tons, and Superphosphate | $6 \quad 7$ | 016 | 713 | 13 | $8 \quad 5$ | 15 | 814 | 19 | 7 16 | 12 |
| 3 | Without Manure, 1846, and since ... ... .. ... .. ... .. | $0 \quad 11$ | 03 | 019 | 04 | $0 \quad 13$ | 03 | 36 | $0 \quad 14$ | 38 | 0 0 13 |
| 4 | Superphosph., each year; Sulph. Potash, Soda, and Magnesia, 1856-60 | $2 \quad 16$ | 08 | $5 \quad 2$ | 016 | 412 | $\begin{array}{ll}0 & 14\end{array}$ | $\begin{array}{ll}6 & 12\end{array}$ | 15 | 58 | $\begin{array}{ll}0 & 17\end{array}$ |
| 5 |  | $\begin{array}{ll}2 & 12 \\ 2\end{array}$ | $0 \quad 9$ | 413 | 018 | 316 | 015 | 516 | 17 | 50 | 019 |
| 6 | Superphosphate, each year; Sulphate Potash, 1856-1860 ... $\quad \ddot{\text { ar }}$ | $\begin{array}{ll}2 & 7\end{array}$ | 07 | $4 \quad 11$ | 0 | $4{ }^{4} 5$ | 0 | 6 6 6 | 12 | 53 | $\begin{array}{ll}0 & 16\end{array}$ |
| 7 | Superphosph., each year ; Sulph. Potash, and 361 Amm.-salts, 1856-60 | $2 \quad 12$ | 07 | 413 | $0 \quad 14$ | $4 \quad 12$ | 014 | $6 \quad 15$ | 14 | $5 \quad 9$ | $0 \quad 17$ |
| 8 | Unman. 1853, and since: previously part Unman.; part Superphosph. |  | $0 \quad 4$ | 113 | $0 \quad 5$ | 12 |  |  |  | 314 |  |

E 2
52 )
Experiments on sugar beet (Vilmorin's Green-tor White Silesiak).—BARN FiELD.

Grown year after fear on the same Land, without Manure, and with different descriptions of Manure, 5 years, 18 gecond and subsequent Cropping:-1843-48 (6 Seasons), experiments on years of Sugar Beet slight alterations in the 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 in the rows; plants moulded up afterwards. Roots all carted off, Leaves weighed, spread on the respective Plots, and ploughed in. weighed, spread aren the Manures and Produce for the 5 Seasons, 1871-75.
Below

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

| Plots. | Manures, per Acre, per Annum. |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Standard Manures. | $\begin{gathered} \text { SERIEs } 1 . \\ \text { Standard Manures } \\ \text { only. } \end{gathered}$ |  | Series 2. <br> Stanäard Manures, and Cross-dressed with 550 lbs . Nitrate Soda. |  | Sertes 3. Standard Manures, and Cross-dressed with 400 lbs." Ammoniamsalts." |  | Sertes 4. <br> Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake, and 400 lbs . "Am-monium-salts." |  | Serues 5. Stanüard Manures, and Cross-dressed wit 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. | Leaves. | Roots. | Leaves. | Roots. | Leaves. | Roots. | Leaves. | Roots. | Leaves. |
| 2 |  | Tons. cwts. 188 1413 | $\begin{array}{\|c\|c\|} \text { Tous. cwts. } \\ 3 & 5 \\ 2 & 14 \end{array}$ | $\left\lvert\, \begin{gathered} \text { Tons. ewts. } \\ 2713 \\ 2516 \end{gathered}\right.$ | $\begin{gathered} \text { Tons. cwts. } \\ 619 \\ 515 \end{gathered}$ | [Tons. cw ts. 22 21 21 15 | $\begin{array}{cc} \text { Tons. } & \text { cwts. } \\ 5 & 6 \\ 4 & 6 \end{array}$ | $\left\lvert\, \begin{array}{cc} \text { Tons. owts. } \\ 26 & 4 \\ 25 & 2 \end{array}\right.$ | $\begin{array}{cc}\text { Tons. } & \text { awts. } \\ 6 & 14 \\ 6 & 7\end{array}$ |  | Tons, cwts. |
| 2 3 | Farmyard Manure ( 14 tons), and $3 \frac{1}{4}$ ewts. Superphosphate (1) .. .. | 1413 711 | [ $\begin{aligned} & 214 \\ & 200\end{aligned}$ | 2516 223 | 515 512 | $\begin{gathered} 21 \\ 15 \end{gathered} 15$ | 4 416 | 1918 | 6 <br> 7 | 20 20 16 | 412 |
| 3 | Soda, 100 lbs. Sulphate Magnesia <br> $\left\{3 \frac{1}{2}\right.$ ewts. Superphosphate, 300 lbs . Sulphate Potash, $\ddot{00} \ddot{\mathrm{lbs} .}$ Sulphate $\}$ | 711 | 15 | 2215 | 48 | 1710 |  | 2215 | 63 | 217 | 319 |
| 5 | Soda, 100 lbs. Sulphate Magnesia .. .. .. .. .. .. .. <br> 33 owts. Superphosphate .. | 512 | 18 |  | 314 |  |  |  | 712 | 1819 |  |
| 7 |  | 5 5 5 5 | 1 8 <br> 1 4 | 21 20 20 | $\begin{array}{llll}3 & 14 \\ 3 & 13 \\ 3 & 18\end{array}$ | 17 18 18 18 | 3 3 3 4 4 4 | ${ }_{21} 2311$ | 611 5 5 | $\begin{array}{ll}21 & 0 \\ 21\end{array}$ | $\begin{array}{lll}3 & 11 \\ 3 & 17\end{array}$ |
| 7 |  | 518 710 | $\begin{array}{ll}1 & 5 \\ 1 & 5 \\ 1 & 14\end{array}$ | 2019 2113 | 3118 316 | 18 <br> 16 | 4 <br> 4 <br> 4 | 21 <br> 17 <br> 19 | $5{ }^{5} 110$ | 21 20 20 | 317 4 4 | Second Season, 1872. Seed dibbled May 1-3; Crop taken up November 12-28. .


|  | Farmyard Manure (14 tons) | 1513 | ${ }_{4}^{4}{ }^{2}$ | 23 | 9 | 719 | 2214 | ${ }_{9}^{9} 16$ |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\frac{1}{3}$ | Farmyard Manure (14 tons), and 313 cwts. Superphosphate ( ${ }^{1}$ ) | $\begin{array}{rrr}16 & 0 \\ 7 & 17\end{array}$ | 318 1 |  |  | 816 $6 \quad 6$ | $\begin{array}{ll}22 & 0 \\ 15 & 3\end{array}$ | 716 413 | 2 | ${ }_{8}^{9}$ | 914 101 | 2015 163 | 5 3 3 111 |
| 3 | Without Manure ( 1846 , and since) <br> (31 wwts Superphole 500 lbs Sulphate $\ddot{\text { Potash }} 2 \ddot{0} 0 \mathrm{lbs}$. Chloride | 717 | 113 1 | 21 | 2 | $\begin{array}{ll}6 & 6 \\ 5 & 19\end{array}$ | 15 15 10 |  |  |  |  |  | 315 |
| 4 | $\left\{\begin{array}{l}3 \frac{1}{2} \text { cwts. Superphosphate, } \\ \text { Sodium (common salt), } 200 \text { lbs. Sulphate Magnesia }\end{array}\right.$.. .. .. | 614 | 110 |  | 2 | 519 $6 \quad 4$ | 1510 145 |  | 18 | 11 | 713 10 | 1718 1518 | 316 |
| 5 6 |  | 617 6 6 |  |  |  | $\begin{array}{ll}6 & 4 \\ 5 & 14\end{array}$ |  | 413 319 |  |  |  | 1517 | 314 |
| 7 |  | 615 |  |  | 0 | 61 |  | 319 |  | 9 | 910 | 1510 | 315 |
| 8 | Unmanured, 1853, and since; previously part Unman., part Superphos. |  |  | 15 | 6 | 519 | 1310 |  | 19 | 12 | 917 |  |  |

## 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, termed "colloid water," as distinguished from the water of the juice. In the Rothamsted and different seasons, on the composition of Sugar-beet, is given below. In interpreting the " Memoranda" for 1881, attention was called to Scheibler's new results and conclusions, and it
figures it wust be bornc in mind that with forty different experiments each year, and in each was pointed out that if they were confirmed the percentages of sugar annually recorded in the year four, or five, or more times as much produce on some Plots as on others, it would be impossible Tables of the Rothamsted ressults should be reduced by about to or $\frac{1}{2}$. 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, 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 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 percentag
of nitrogen, yet the larger crops yielded very much more sugar per acre.

## Manures, per Acre, per annum, unless otherwise stated (see beiow).

| Plots. | Manures, per Acre, per annum, unless otherwise stated (see beiow). |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Abbreviated Description of Standard Manures. <br> For details, see pp. 52-3. | Sertes 1. <br> Standard Manures only. |  |  |  | Series 2. <br> Standard Manures, and Cross-dressed with 550 lbs . Nitrate Soda. |  |  |  | Series 3. <br> Standard Manures, and Cross-dressed with 400 lbs. "Ammonium-salts." |  |  |  | Series 4. <br> Standard Manures, and Cross-dressed with 2000 ibs. Rape-cake, and 400 lbs. "Ammonium-salts." |  |  |  | Series 5. <br> 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 | Sugar. | Ash. | Nitrogen. | $\begin{gathered} \text { Dry } \\ \text { Matier. } \end{gathered}$ | Sugar. | Asb. | $\begin{gathered} \text { Nitro- } \\ \text { gen. } \end{gathered}$ | $\left\lvert\, \begin{gathered} \mathrm{Dry} \\ \text { Matter. } \end{gathered}\right.$ | Sugar. | Ash. | Nitrogen. | $\\| \begin{aligned} & \text { Dry } \\ & \text { Matter. } \end{aligned}$ | Sugar. | Ash. | $\begin{gathered} \text { Nitro- } \\ \text { gen. } \end{gathered}$ | $\operatorname{liry}_{\text {Dry }} \text { Matter. }$ | Sugar. | Ash. | Nitrogen. |
|  |  | $\begin{gathered} \text { Percent. } \\ 17 \cdot 04 \end{gathered}$ | Perent. | Per cent. <br> 0.821 | Percent. <br> $0 \cdot 142$ | Percent $14 \cdot 83$ | Percent, <br> $9 \cdot 25$ | Percent <br> 0.945 | Percent. <br> 0.184 | Per cent <br> 16.07 | Percent $10 \cdot 46$ | $\xrightarrow{\text { Percents }}$ | Percant. 0.199 | percent. $14 \cdot 73$ | ercent. $8 \cdot 87$ | $\xrightarrow{\text { Percent. }}$ | Percent. 0.271 | Percent. $15 \cdot 44$ | Percent. | Percent. 0.892 | $\begin{gathered} \text { Percent. } \\ 0 \cdot 191 \end{gathered}$ |
| 2 |  | 17.24 | 11-29 | $0 \cdot 826$ | $0 \cdot 146$ | $15 \cdot 03$ | $9 \cdot 28$ | $0 \cdot 970$ | $0 \cdot 199$ | $15 \cdot 12$ | $9 \cdot 43$ | $0 \cdot 977$ | $0 \cdot 212$ | 14.80 | $8 \cdot 75$ | 0.988 | $0 \cdot 249$ | 16.11 | $10 \cdot 24$ | $0 \cdot 909$ |  |
| 3 |  | 17.47 | 11.86 | 0.771 |  | $15 \cdot 36$ | 9.82 | 0.861 |  | 17.75 | $10 \cdot 40$ | $0 \cdot 901$ |  | 16.71 | $9 \cdot 15$ | 0.915 |  | 1695 | 11.10 | $0 \cdot 758$ |  |
| ${ }_{5}^{4}$ |  | 18.07 | 12.31 | 0.738 0 | $0 \cdot 100$ $0 \cdot 101$ | $15 \cdot 72$ | $10 \cdot 24$ | 0.828 0.787 | $0 \cdot 157$ 0.130 | 18.68 | 11.74 | ${ }^{0} 0.907$ | $0 \cdot 170$ | 16.87 | $9 \cdot 38$ | 1.002 | $0 \cdot 244$ | 16.61 | $11 \cdot 08$ | ${ }^{0.767}$ | 0.138 0.155 |
| 5 |  | 17.89 18.09 | 12.32 | 0.768 0.778 | 0.101 0.098 | $15 \cdot 93$ 15.29 | 10.49 9 | 0.787 0.856 | $0 \cdot 130$ $0 \cdot 137$ | $16 \cdot 36$ 16.33 | 10.83 10.91 | 0.754 0.843 | 0.176 0.148 | 14.63 15.28 | $8 \cdot 79$ $9 \cdot 20$ | 0.843 0.956 | - $0 \cdot 273$ | 16.84 17.05 | 111-22 | $0 \cdot 722$ 0.812 | $0 \cdot 155$ 0.146 |
| 7 |  | 17.97 | $12 \cdot 47$ | $0 \cdot 762$ |  | $15 \cdot 86$ | 9-98 | 0.901 |  | 16.71 | $10 \cdot 89$ | 0.826 |  | $15 \cdot 99$ | $9 \cdot 69$ | 0.904 |  | 17.57 | $11 \cdot 65$ | 0.782 |  |
| 8 |  | 18.32 | $12 \cdot 33$ | 0•791 |  | 15.98 | $10 \cdot 48$ | 0.856 |  | 16.08 | $10 \cdot 30$ | $0 \cdot 764$ |  | $14 \cdot 90$ | $8 \cdot 84$ | 0.806 |  | 16.73 | $11 \cdot 29$ | 0.747 |  |


( 56
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 Swedes, is now added as a manured Plot. With this exception, the manures are also tinuation, see pp. 60-1, 64-5, 68-9, and $72-73$. excepting that Plot 9 , which was unmanured for Sugar-beet, and also previously for $\begin{aligned} & \text { for }\end{aligned}$ (Area under experiment about 8 acres.)

| Plots. | Manures per Agre prr annum. |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Standard Manures. | SERIES 1. Standard Manures only. |  | Serides 2. Standard Manures, and Cross-dressed with 550 lbs. Nitrate Soda. |  | Series 5. Standard Manures, and Cross-dressed with 400 lbs. "Ammoniumsalts." |  | Sertes 4. <br> Standard Manures, and Cross-diessed with 2000 lbs. Rape-cake and 400 lbs ." Am-monium-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. | Leaves. | Roots. | Leaves. | Roots. | Leaves. | Roots. | eav | Roots. | Leave |
|  | Farmyard Manure (14 tons) .. .. .. .. .. .. .. .. | $\begin{gathered} \text { Tons cwts. } \\ 19 \\ 12 \end{gathered}$ | $\begin{gathered} \text { Tons. cwts. } \\ 4 \end{gathered}{ }_{9}$ | $\underset{25}{\text { Tons. cwts. }} \underset{2}{ }$ | $\begin{gathered} \text { Tons. cwts. } \\ 7 \\ 5 \end{gathered}$ | $\begin{gathered} \text { Tons. cwts } \\ 29 \end{gathered}$ | $\begin{gathered} \text { Tons. cwts. } \\ 712 \end{gathered}$ | Tons. cwts. | $\frac{\text { Tons. cwts. }}{10}$ | $\xrightarrow[\text { Tons. cwts. }]{24}$ | Tons. cwts. |
| 2 |  | 1913 | 4 4 | $\begin{array}{ll}27 & 13\end{array}$ | $\begin{array}{ll}7 & 3 \\ 7 & 3\end{array}$ |  | 712 7 7 | $\begin{array}{rr} 31 & 9 \\ 30 & 18 \end{array}$ | $\begin{array}{rr}10 \\ 9 & 16\end{array}$ | $\begin{array}{ll}29 & 19 \\ 29 & 19\end{array}$ |  |
| 3 | Without Manure (1846, and since) <br> (32 $\frac{1}{2}$ cwts. Superphosphate, 500 lbs , Sulphate Potash, $2 \ddot{00} \mathrm{lbs}$. Chioride $)$ | $6 \quad 10$ | $1 \begin{array}{ll}1 & 14\end{array}$ | 20 | $\begin{array}{ll}5 & 12\end{array}$ | $14 \quad 3$ | 410 | $\begin{array}{ll} 10 \\ 19 & 19 \end{array}$ | $7 \quad 7$ | $\begin{array}{ll}17 & 4\end{array}$ |  |
| 4 | $\left\{\begin{array}{l}\frac{1}{2} \text { ewts. Superphosphate, } 500 \mathrm{lbs} \text {. Sulphate Potash, } 200 \mathrm{lbs} \text {. Chloride } \\ \text { Sodium (common salt), } 200 \mathrm{lbs} \text {. Sulphate Magnesia .. .. .. }\end{array}\right\}$ | 88 |  | 25 | 60 | $\begin{array}{ll}19 & 19\end{array}$ | 4 | 30 |  | 25 | 510 |
|  |  | $\begin{array}{ll}7 & 10 \\ 6 & 16\end{array}$ |  | $\begin{array}{ll}21 & 0 \\ 21\end{array}$ | $\begin{array}{lll}5 & 14 \\ 5 & 8\end{array}$ |  |  |  |  |  |  |
| ${ }^{6}$ |  | 6 8 8 18 |  | $\begin{array}{ll}21 & 2 \\ 22\end{array}$ |  | $\begin{array}{rrr}17 & 15 \\ 19\end{array}$ |  | $\begin{array}{ll}26 & 8 \\ 27 & 8 \\ 27\end{array}$ |  | $\begin{array}{ll}20 & 10 \\ 20 & 12\end{array}$ | $\begin{array}{lr}5 & 4 \\ 5 & 15 \\ 5\end{array}$ |
| 8 | Unmanured, 1853, and since; previously part Unman., part Superphos. | $5 \quad 9$ | 110 | 1516 |  |  |  | 18 |  |  | $\begin{array}{lll}5 & 15 \\ 4 & 18\end{array}$ |
| 9 | Farmyard Manure ( 14 tons), $3 \frac{1}{2}$ ewts. Superphosphate ( ${ }^{3}$ ) .. .. |  |  | 15 | -.. |  | 4 <br> 7 | 18 | 711 | 1512 |  |

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Third Season, 1878. Seed dibbled, June 8-9 (Plot 9, June 11th). Crop taken up, Nov. 7-20.

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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
 95 per cent. We are not aware of any published resuits or the determinations of sigar in Mangel-roots
extraction with alcohol; but until dirrect evidence on the point is available, it is assumed that the amouit of Juice in Mangels, like that in Sugar-beet, will probably average about 90 per cent.; and having in 1895 to re
 that sami roots varying so much in character of growth, size, and ripeness, the percentage of juice would not bo
the same in all. Nevertheless, it was considered that thie results calculated on the assumption of 96 per cent. of
fuice now that only 90 per cent. of juice is asssumed it may be supposed that the results will be actually yearer the
truath

 samples were as a rule taken within a period of from one to two weeks; as far as practicable begining with the
ripest. It it obvious , however, that the smaller crops would be much riper than the larger ones; but, although
the langer MANURES, PER ACRE, PER ANNUM.

| Series 4. | Series 5. |
| :---: | :---: |
| Standard Manures, and Cross- | Standard Manures, |

Series 5.
Standard Manures, and Cross-dressed with
2000 lbs. Rape-calke.

 dressed with 2000 lbs . Rape-
cake and 400 lbs . Am,-salts. 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 publishied results

(
1 SERIES 3.
Standard Manures,
and Cross-dressel with
400 lbs. Ammonium-salts.
 be new one sbowed only about 90 per cent. Scheibler concluded that water egual to the difference (about 5 per pointed out, that supposing the same applied to Mangels, and that the amount of true juite in the

$$
\begin{aligned}
& \text { First SEason, } 187 \\
& \begin{array}{c}
\text { SERILES } 2 . \\
\text { Standard Manures, } \\
\text { and Cross-dressed with } \\
550
\end{array} \\
& \text { First Seas }
\end{aligned}
$$

(59)

| 1 | Farmyard Manure .. .. .. | $12 \cdot 26$ | 6.87 | 0.995 | $0 \cdot 170$ | $11 \cdot 47$ | $5 \cdot 97$ | 1-036 | $0 \cdot 218$ | $11 \cdot 17$ | 5.88 | 1.013 | 0.206 | $10 \cdot 83$ | $5 \cdot 30$ | $1 \cdot 046$ | $0 \cdot 241$ | 11.98 | $6 \cdot 47$ | 0.985 | 0-186 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 2 | Farmyard Manure, \& Super. .. | 11.51 | $6 \cdot 53$ | $0 \cdot 981$ | $0 \cdot 182$ | $10 \cdot 05$ | $4 \cdot 89$ | 1-072 | $0 \cdot 216$ | $11 \cdot 00$ | $5 \cdot 70$ | 1.034 | 0-206 | $10 \cdot 50$ | $5 \cdot 57$ | $0 \cdot 987$ | $0 \cdot 217$ | $10 \cdot 66$ | $5 \cdot 76$ | $0 \cdot 948$ | $0 \cdot 17 \mathrm{a}$ |
| 3 | Unmanured (1846, \& since) ... | 15.25 | $9 \cdot 56$ | $0 \cdot 824$ | $0 \cdot 186$ | $12 \cdot 02$ | $6 \cdot 64$ | 0908 | $0 \cdot 211$ | 13.47 | $7 \cdot 59$ | $0 \cdot 811$ | $0 \cdot 261$ | $12 \cdot 86$ | $7 \cdot 14$ | 0.802 | $0 \cdot 247$ | $14 \cdot 10$ | $8 \cdot 27$ | 0.846 | 0.240 |
| 4 | Super., \& Pot., Sod., \& Mag. .. | 13.56 | 8.45 | $0 \cdot 928$ | $0 \cdot 129$ | 11.03 | $5 \cdot 85$ | $1 \cdot 084$ | $0 \cdot 188$ | $11 \cdot 90$ | $6 \cdot 81$ | 0.975 | $0 \cdot 144$ | 10-33 | $5 \cdot 51$ | 1.027 | $0 \cdot 181$ | $11 \cdot 22$ | $6 \cdot 12$ | 1-044 | $0 \cdot 171$ |
| 5 | Superphosphate .. .. | $13 \cdot 91$ | $8 \cdot 60$ | $0 \cdot 810$ | $0 \cdot 144$ | 11.61 | $6 \cdot 47$ | 0.873 | $0 \cdot 188$ | $13 \cdot 00$ | $7 \cdot 63$ | 0.845 | 0.187 | $12 \cdot 69$ | $7 \cdot 20$ | $0 \cdot 739$ | 0.244 | 13.87 | $8 \cdot 12$ 6.90 | 0.786 0.940 | 0.211 0.197 |
| 6 | Super., \& Potash | $14 \cdot 23$ | $8 \cdot 55$ | $0 \cdot 989$ | $0 \cdot 173$ | 11.04 | 5.84 | 0.986 | 0.193 | $13 \cdot 55$ | $8 \cdot 13$ | 0.988 | 0-184 | $12 \cdot 09$ | $6 \cdot 53$ | 1.016 | 0.235 | $12 \cdot 18$ | 6.90 | $0 \cdot 940$ | 0-197 |
| 7 | Super., Pot., \& $36 \frac{1}{2} \mathrm{lb}$. Am.-slts. | 13.42 | .. | 0.976 | .. | 11•26 | . | $0 \cdot 982$ | .. | 11.92 | .. | 0.932 |  | $12 \cdot 03$ | .. | 0.986 | .. | $12 \cdot 05$ | .. | 0.977 | .. |
| 8 | Unmanured (1853, \& since) .. | 14.50 | .. | $0 \cdot 903$ | .. | 11-10 | .. | 0.937 | .. | $12 \cdot 81$ | .. | 0.869 | . | $11 \cdot 93$ | .. | $0 \cdot 879$ | .. | $12 \cdot 52$ | .. | 0.863 |  |
| 9 | Farmyard Manure, \& Super. .. | .. | .. | .. | .. |  |  | . | . | 10•77 | . | 0.939 |  |  | . | .. |  |  | . | . |  |
| Fourth Season, 1879. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1 | Farmyard Manure | $14 \cdot 91$ | $9 \cdot 02$ | 1.007 | $0 \cdot 175$ | 13.18 | $7 \cdot 47$ | $1 \cdot 010$ | 0.196 | $13 \cdot 86$ | 8.13 | 1.025 | $0 \cdot 193$ | 13•34 | $7 \cdot 51$ | 1-025 | $0 \cdot 186$ | 14.62 | $8 \cdot 61$ | 1.022 | $0 \cdot 177$ |
| 2 | Farmyard Manure, \& Super. .'. | $14 \cdot 78$ | $8 \cdot 90$ | 1.012 | $0 \cdot 185$ | $13 \cdot 43$ | $7 \cdot 58$ | 1.016 | $0 \cdot 184$ | $13 \cdot 14$ | $7 \cdot 57$ | $1 \cdot 051$ | $0 \cdot 181$ | $13 \cdot 54$ | $7 \cdot 80$ | 1.064 | $0 \cdot 186$ | $14 \cdot 40$ | 8.67 | 0.995 | 0.219 |
| 3 | Unmanured (1846, \& since) .. | 18.81 | $11 \cdot 72$ | $0 \cdot 861$ | $0 \cdot 205$ | $16 \cdot 01$ | $9 \cdot 38$ | $0 \cdot 955$ | $0 \cdot 226$ | $17 \cdot 18$ | $10 \cdot 39$ | $0 \cdot 834$ | 0.252 | 16.27 | 9.79 | 0.831 1.086 | $0 \cdot 260$ 0.171 | $16 \cdot 16$ | 9.81 8.08 | 0.842 0.938 | 0.203 0.136 |
| 4 | Super., \& Pot., Sod., \& Mag. .. | $15 \cdot 56$ | $9 \cdot 78$ | $0 \cdot 980$ | $0 \cdot 151$ | $12 \cdot 83$ | $7 \cdot 60$ | $1 \cdot 010$ | $0 \cdot 156$ | 14.03 | $8 \cdot 70$ | $0 \cdot 962$ | $0 \cdot 134$ | 13.67 | 7.84 | ${ }^{\text {L }} \cdot 086$ | $0 \cdot 171$ | $13 \cdot 51$ | 8.08 9.75 | 0.938 0.840 | $0 \cdot 136$ 0.182 |
| 5 | Superphosphate .. .. | 16.53 | $10 \cdot 58$ | 0.848 | $0 \cdot 159$ | $12 \cdot 60$ | $7 \cdot 34$ | $0 \cdot 951$ | 0-180 | $15 \cdot 61$ | $9 \cdot 77$ | $0 \cdot 814$ | $0 \cdot 202$ | 14.84 | $8 \cdot 68$ | 0.810 | 0-220 | $15 \cdot 57$ | $\stackrel{9}{ } \cdot 75$ | $0 \cdot 840$ | $0 \cdot 182$ |
| 6 | Super., \& Potash .. .. | $16 \cdot 34$ | 10.29 | 1.008 | 0.156 | $13 \cdot 75$ | $8 \cdot 21$ | $0 \cdot 972$ | 0•180 | $14 \cdot 50$ | 9•00 | $0 \cdot 998$ | 0•162 | $13 \cdot 49$ | 7•94 | 1.038 | 0.214 | $14 \cdot 42$ | $8 \cdot 77$ | $0 \cdot .949$ | $0 \cdot 157$ |
| 7 | Super., Pot., \& $36 \frac{1}{2} \mathrm{lb}$. Am.-slts. | $16 \cdot 33$ | .. | 0.895 | .. | $12 \cdot 97$ | .. | $0 \cdot 997$ |  | 14.48 | .. | 0.946 | .. | $14 \cdot 18$ | .. | $0 \cdot 947$ |  | 15.35 | .. | $0 \cdot 947$ | .. |
| 8 | Unmanured (1853, \& since) .. | 18.46 | .. | $0 \cdot 903$ | .. | 13.78 | .. | $0 \cdot 963$ | .. | $15 \cdot 44$ | .. | 0.812 | .. | 14•13 | .. | 0.853 | . | $15 \cdot 58$ | .. | $0 \cdot 852$ | .. |
| 9 | Farmyard Manure, \& Saper. .. |  | .. |  |  |  |  |  |  | 14-52 |  | 0.930 | . |  |  |  | .. |  | .. |  | . |
| Fiffth Season, 1880. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1 | Farmyard Manure | 12.65 | $7 \cdot 79$ | $0 \cdot 841$ | $0 \cdot 126$ | $10 \cdot 72$ | $5 \cdot 63$ | 0.942 | $0 \cdot 186$ | 11.23 | $6 \cdot 39$ | 0.871 | $0 \cdot 172$ | 11.26 | $6 \cdot 35$ | $0 \cdot 877$ | $0 \cdot 212$ | 12.08 | 6.72 | 0.877 | $0 \cdot 176$ |
| 2 | Farmyard Manure, \& Super. .. | 12.87 | $7 \cdot 56$ | $0 \cdot 850$ | $0 \cdot 136$ | $10 \cdot 44$ | $5 \cdot 52$ | $0 \cdot 986$ | $0 \cdot 188$ | 11.68 | $6 \cdot 59$ | 0.891 | 0-189 | $10 \cdot 47$ | $5 \cdot 94$ | 0.948 | $0 \cdot 220$ | $11 \cdot 66$ | 6.69 | 0.855 | $0 \cdot 171$ |
| 3 | Unmanured (1846, \& since) .. | $17 \cdot 02$ | 11.04 | $0 \cdot 739$ | $0 \cdot 142$ | $12 \cdot 18$ | $6 \cdot 90$ | 0-874 | $0 \cdot 217$ | $14 \cdot 48$ | $8 \cdot 63$ | 0.746 | 0.272 | 11.75 | $6 \cdot 66$ | $0 \cdot 716$ | $0 \cdot 225$ | $12 \cdot 95$ | $7 \cdot 80$ | 0.690 | 0.203 |
| 4 | Super., \& Pot., Sod., \& Mag. .. | 14.05 | 9.25 | $0 \cdot 756$ | 0.082 | $12 \cdot 36$ | $7 \cdot 61$ | $0 \cdot 847$ | $0 \cdot 136$ | $12 \cdot 23$ | $7 \cdot 71$ | $0 \cdot 849$ | $0 \cdot 119$ | $10 \cdot 77$ | $6 \cdot 12$ | 0.883 0.679 | 0.151 0.192 | $11 \cdot 18$ | 6.74 | 0.869 | $0 \cdot 123$ |
| 5 | Superphosphate .. ... .. | $13 \cdot 72$ | $8 \cdot 85$ | 0.709 | $0 \cdot 100$ | $11 \cdot 50$ | $6 \cdot 47$ | 0.819 | $0 \cdot 173$ | $12 \cdot 84$ | $7 \cdot 94$ | 0.709 | $0 \cdot 158$ | $10 \cdot 72$ | $6 \cdot 20$ | 0.679 | $0 \cdot 192$ | $12 \cdot 27$ | $7 \cdot 35$ | 0.676 | $0 \cdot 165$ |
| 6 | Super., \& Potash .. .. .. | 14.04 | $8 \cdot 99$ | 0.761 | $0 \cdot 097$ | $11 \cdot 86$ | $7 \cdot 00$ | 0.807 | $0 \cdot 153$ | $12 \cdot 40$ | $7 \cdot 46$ | 0.878 | 0.123 | $12 \cdot 16$ | $7 \cdot 00$ | 0.837 | $0 \cdot 188$ | $13 \cdot 17$ | $8 \cdot 14$ | $0 \cdot 745$ | $0 \cdot 151$ |
| 7 | Super., Pot., \& 36⿺ $\frac{1}{1 \mathrm{lb}}$. Am.-slts. | 13.63 | .. | 0.798 | .. | $11 \cdot 64$ | .. | 0.862 | $0 \cdot 154$ | $12 \cdot 14$ | .. | $0 \cdot 863$ | .. | $11 \cdot 68$ | .. | $0 \cdot 906$ | .. | $12 \cdot 79$ | .. | $0 \cdot 742$ | .. |
| 8 | Unmanured (1853, \& since) .. | 14-26 | .. | 0•776 | .. | $12 \cdot 61$ | .. | $0 \cdot 863$ | .. | 14.08 | .. | 0.772 | . | 11-29 | .. | $0 \cdot 693$ | .. | $12 \cdot 91$ | .. | 0.672 | .. |
| 9 | Farmyard Manure, \& Super. .. |  |  |  |  |  | .. | .. |  | 11.32 | .. | $0 \cdot 801$ |  |  | .. |  |  |  | . | .. | .. |
| Average of $5\left({ }^{1}\right)$ Seasons, $1876,{ }^{\prime} 77,{ }^{\prime} 78, ~$ '79, and 1880. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1 | Farmyard Manure | $13 \cdot 29$ | $8 \cdot 04$ | 0.960 | $0 \cdot 157$ | 11.58 | 6.69 | 1.028 | 0.200 | 11.97 | $7 \cdot 20$ | 1.017 | 0.190 | $11 \cdot 37$ | $6 \cdot 66$ | 1-025 | $0 \cdot 213$ | $12 \cdot 66$ | $7 \cdot 28$ | $0 \cdot 977$ | 0-180 |
| 2 | Farmyard Manure, \& Super. .. | 13.08 | $8 \cdot 10$ | $0 \cdot 949$ | $0 \cdot 168$ | $11 \cdot 24$ | 6.42 | 1.040 | $0 \cdot 196$ | $11 \cdot 74$ | $6 \cdot 80$ | 1.017 | $0 \cdot 192$ | 11.04 | 6.63 | 1.032 | $0 \cdot 208$ | $12 \cdot 26$ | $7 \cdot 27$ | $0 \cdot 961$ | 0.188 |
| 3 | Unmanured (1846, \& since) .. | 16.56 | $10 \cdot 70$ | 0.816 | 0.1.78 | 13.24 | $7 \cdot 78$ | $0 \cdot 942$ | $0 \cdot 218$ | $14 \cdot 88$ | $9 \cdot 03$ | 0.837 | 0. 262 | $13 \cdot 38$ | $8 \cdot 20$ | 0.799 | $0 \cdot 244$ | 14.41 | $8 \cdot 87$ | 0.790 | $0 \cdot 215$ |
| 4 | Super., \& Pot., Sod., \& Mag. .. | 14.52 | 9-23 | 0.903 | $0 \cdot 121$ | 11.97 | 6.76 | $1 \cdot 015$ | 0.160 | $12 \cdot 70$ | $7 \cdot 74$ | $0 \cdot 972$ | $0 \cdot 132$ | $11 \cdot 47$ | $6 \cdot 36$ | 1.057 | $0 \cdot 168$ | $12 \cdot 13$ | $7 \cdot 33$ | 0.980 | $0 \cdot 143$ 0.186 |
| 5 | Superphosphate .. .. | $14 \cdot 70$ | $9 \cdot 57$ | $0 \cdot 796$ | $0 \cdot 134$ | $11 \cdot 92$ | $6 \cdot 85$ | $0 \cdot 890$ | $0 \cdot 180$ | $13 \cdot 76$ | $8 \cdot 31$ | $0 \cdot 788$ | $0 \cdot 182$ | $12 \cdot 71$ | $7 \cdot 09$ | 0.766 | $0 \cdot 219$ | 13.54 | $8 \cdot 33$ | 0.766 0.905 | $0 \cdot 186$ 0.168 |
| 6 | Super., \& Potash .. .. .. | 14.89 | $9 \cdot 32$ | 0.915 | $0 \cdot 142$ | $12 \cdot 08$ | $7 \cdot 35$ | $0 \cdot 966$ | $0 \cdot 175$ | $13 \cdot 30$ | $8 \cdot 08$ | $0 \cdot 990$ | $0 \cdot 156$ | $12 \cdot 51$ | $6 \cdot 98$ | 0.998 | 0.212 | $13 \cdot 08$ | 7-99 | 0.905 | 0-168 |
| 7 | Super., Pot., \& $36 \frac{1}{1 \mathrm{lb}} \mathrm{lb}$ Am.-slts. | 14.58 | .. | $0 \cdot 899$ | .. | 12.04 | .. | $0 \cdot 959$ | .. | $12 \cdot 62$ | .. | $0 \cdot 962$ | .. | $12 \cdot 23$ | .. | 0.998 | .. | 13•12 | .. | $0 \cdot 928$ | .. |
| 8 | Unmanured (1853, \& since) .. | $15 \cdot 30$ | .- | $0 \cdot 883$ | .. | 12.55 | .. | $0 \cdot 946$ | . | 13.74 | . | $0 \cdot 858$ | .. | 12-41 | $\cdots$ | $0 \cdot 818$ | $\cdots$ | 13.50 | .. | 0.790 | $\cdots$ |
| 9 | Farmyard Manure, \& Super. .. | .. | . | .. | . | .. | .. | .. | . | 12.61 | . | 0-911 | . | . | . | . |  | . | . | . | .. |

Experiments on mangel wurzel.-BARN FIELD (after Sugar-beet) ; commencing 1876—continued.


[^2](61)

| Stison |  | Crop taken up Nov. 2-10. ${ }^{4}$ ) |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | Farmyard Manure (14 tons) | $22 \quad 12$ | $\begin{array}{ll}3 & 16\end{array}$ | $27 \quad 5$ |  | 246 | 63 |  |  | 33 |  |  |
| 2 | Farmyard Manure (14 tons), and $3 \frac{1}{2}$ cwts. Superphosphate ( ${ }^{1}$ ) | 1819 | 216 | 2815 |  | 23 | $6 \quad 10$ | 3214 |  |  |  |  |
| 3 | Without Manure (1846, and since) ... .. .... |  | 1 | $18 \quad 14$ | 4 | 86 |  | 13 | 418 | 1313 | 2 | 19 |
| 4 | $\left\{\begin{array}{l}3 \frac{1}{2} \text { cwts. Superphosphate, } 500 \mathrm{lbs} \text {. Sulphate Potash, } 200 \mathrm{lbs} \text {. Chloride } \\ \text { Sodicher }\end{array}\right.$ | 515 |  | 2315 | 316 | $19 \quad 18$ | 3 | 3312 | $5 \quad 15$ | 2310 | 3 |  |
| 5 |  |  |  | $21 \quad 12$ |  | 1015 | 39 |  | 53 |  | 3 |  |
| 6 | $3 \frac{1}{2} \mathrm{cwts}$. Superphosphate, 500 libs . Sulphate Potash | 46 | $\begin{array}{ll}0 & 16\end{array}$ |  | $2 \quad 14$ | 194 | 217 | 33 | $6 \quad 9$ | $23 \quad 9$ |  | 13 |
| 7 | $3 \frac{1}{3}$ cwts. Superphos., 500 lbs . Sulphate Potash, $36 \frac{1}{2} \mathrm{lbs}$. Am.-salts ( ${ }^{2}$ ) | $6 \quad 4$ | 11 | $22 \quad 14$ | $2 \quad 19$ | $20 \quad 12$ | $\begin{array}{ll}2 & 17\end{array}$ | 33 | 68 | $\begin{array}{ll}24 & 17\end{array}$ | 3 |  |
| 8 | Unmanured, 1853, and since; previously part Unman., part Superphos. | 46 | $0 \quad 18$ | 170 | $3 \quad 19$ | 711 | 30 | 13 | $4 \quad 15$ | 1310 | 4 |  |
| 9 |  |  |  |  |  | $20 \quad 11$ | 5 ¢ | .. | .. | .. |  |  |
| Ninth Season, 1884. Seed drilled April 10-11. Plot 9 dibbled April 12. Crop taken up Oct. 29-31. |  |  |  |  |  |  |  |  |  |  |  |  |
| 1 | armyard Manure ( 14 tons) | 1519 |  | $26 \quad 14$ | $\begin{array}{ll}3 & 12\end{array}$ | $22 \quad 3$ | $4 \quad 13$ | 25 | 4 |  | 3 |  |
|  | Farmyard Manure ( 14 tons), and $3 \frac{1}{2}$ cwts. Superphosphate ( ${ }^{1}$ ) |  |  | 2613 |  | $22 \quad 14$ | $4 \quad 14$ | $23 \quad 3$ |  |  | 3 |  |
| 3 | Without Manure (1846, and since) .. . . . . . . |  |  |  |  | $\begin{array}{ll}5 & 15\end{array}$ | 29 | 716 | 215 |  | 2 |  |
| 4 | $\left\{\begin{array}{l}3 \frac{1}{2} \text { cwts. Superphosphate, } 500 \mathrm{lbs} \text {. Sulphate Potash, } 200 \mathrm{lbs} \text {. Chloride } \\ \text { Sodium (common salt), } 200 \mathrm{lbs} \text {. Sulphate Magnesia } \\ \text {. }\end{array}\right.$ |  |  | 12 | 219 | 1318 | 3 | 2319 |  | 19 | 2 | 6 |
| 5 | $3 \frac{3}{3}$ cwts. Superphosphate $\quad . . \quad . \quad . . \quad . . .$. | $5 \quad 19$ | 018 | 517 |  | 14 | 212 |  |  |  | 3 |  |
| 6 | $3 \frac{1}{2}$ cwts. Superphosphate, 500 lbs . Sulphate Potash .. .. ... .. |  | 015 | 419 |  | $9 \quad 15$ | 31 |  | $4 \quad 19$ | $17 \quad 15$ | 2 |  |
| 7 | $3 \frac{1}{2} \mathrm{cwts}$. Superphos., 500 lbs . Sulphate Potash, $36 \frac{1}{2} \mathrm{lbs}$. Am.-salts ( ${ }^{2}$ ) |  |  |  | 0 | 80 | 22 |  | 4 |  | 2 | 12 |
| 8 | Unmanured, 1853, and since; previously part Unman., part Superphos. | 415 | $\begin{array}{ll}0 & 16\end{array}$ |  | $0 \quad 13$ | 32 |  | 78 | 212 |  | 2 | g |
| 9 | Farmyard Manure (14 tons), 31 ewts. Superphosphate ( ${ }^{3}$ ) .. .. |  | .. |  | .. | 148 | 3 | .. | .. | .. |  |  |
| Ievth Season, 188j. Mineral Manures and Rape-cake sown April 13; seed drilled April 14 and 15; Nitrate Soda aud Ammonium-salts not sown (see note 5 Crop taken up Oct. 26-Nov. 2. |  |  |  |  |  |  |  |  |  |  |  |  |
| 1 | Farmyard Manure ( 14 tons) | 36 | 0 | 215 | 015 |  | $0 \begin{array}{ll}0 & 18\end{array}$ | 1115 | 29 | 158 | 2 |  |
| 2 | Farmyard Manure (14 tons), and $3 \frac{1}{2}$ ewts. Superphosphate ( ${ }^{1}$ ) |  | 0 0 10 |  | 012 | $2 \quad 14$ | 014 |  | 2 | 1310 | 2 |  |
| 3 | Without Manure (1846, and since) .. ${ }^{\text {a }}$ ) . |  |  |  |  | 01 | 0 |  |  |  | 1 | 10 |
| 4 | $\left\{3 \frac{1}{2}\right.$ cwts. Superphosphate, 500 lbs . Sulphate Potash, 200 lbs . Chloride $\}$ |  |  |  |  | 19 | 06 | 1415 |  |  | 1 |  |
| $\pm$ | \ Sodium (common salt), 200 lbs . Sulphate Magnesia . .. ${ }^{\frac{3}{2} \text { ewts. Superphosphate .. .. }}$ | 03 |  |  |  |  | 0 - |  |  |  |  |  |
| 6 | $3 \frac{1}{2}$ cwts. Superphosphate, 500 lbs . Sulphate Potash .. .. .. .. | $0 \quad 10$ |  | $0 \quad 10$ |  | 25 | 0 |  |  | 714 |  |  |
| 7 | $3 \frac{1}{2}$ ewts. Superphos., 500 lbs. Sulphate Potash, $36 \frac{1}{2} \mathrm{lbs}$. Am.-salts ( ${ }^{2}$ ) | $0 \quad 10$ |  | 014 |  | 116 | 010 |  | $2 \quad 2$ |  |  | 12 |
| 8 | Unmanured, 1853, and since; previously part Unman., part Superphos. |  |  | - 0 |  | 04 | $0 \quad 2$ |  | $0 \quad 17$ | $0 \quad 12$ | 0 | 13 |
| 8 | Farmyard Manure (14 tons), $3 \frac{1}{2}$ cwts. Superphosphate ( ${ }^{3}$ ) .. .. |  | .. | .. |  |  | $0 \quad 19$ | .. | .. | .. |  | . |
| Average of 4 Seasons, 1881, '82, '83 and 1884. ( ${ }^{6}$ ) |  |  |  |  |  |  |  |  |  |  |  |  |
| 1 | Farmyard Manure (14 tons) | $16 \quad 15$ |  | 239 | 319 | $\underline{21}$ | 5 | $25 \quad 3$ | 514 | 25 |  |  |
| 2 | Farmyard Manure ( 14 tons), and $3 \frac{1}{2}$ cwts. Superphosphate ( ${ }^{1}$ ) |  | 2.9 |  | 413 |  | $5 \quad 9$ | $24 \quad 18$ |  | 248 | 3 |  |
| 3 | Without Manure (1846, and since) $\quad . \quad \ddot{\sim} \quad \ddot{0}$ |  | 0 |  | 219 | , | 218 | $9 \quad 19$ |  | 11 : 3 | 2 |  |
| 4 | $\left\{\begin{array}{l}3 \frac{1}{2} \text { ewts. Superphosphate, } 500 \mathrm{lbs} \text {. Sulphate Potash, } 200 \mathrm{lbs} \text {. Chloride) } \\ \text { Sodium (common salt), } 200 \mathrm{lbs} \text {. Sulphate Magnesia }\end{array}\right\}$ | 516 |  | $17 \quad 14$ |  |  | 17 | 2618 |  | 20 | 2 |  |
| 5 | $3 \frac{1}{2}$ cwts. Superphosphate $\quad \ddot{\text { a }}$, | $5 \quad 7$ | 0. 17 | $14 \quad 13$ | 218 | 8 | $3 \quad 4$ | 11 |  |  | 3 |  |
| 6 | $3 \frac{2}{2}$ ewts. Superphosphate, 500 lbs. Sulphate Potash .. .. .. .. | $4 \quad 15$ | 015 | $14 \quad 11$ |  | 148 | 216 |  | 510 |  |  |  |
| 7 | $3 \frac{2}{2}$ cwts. Superphos., 500 lbs . Sulphate Potash, $36 \frac{1}{2} \mathrm{lbs}$. Am.salts ( ${ }^{2}$ ) | $6 \quad 12$ |  | 1416 | 211 | 1413 | $2 \quad 14$ | $23 \quad 12$ |  | 2015 |  |  |
| 8 | Unmanured, 1853, and since; previously part Unman., part Superphos. |  | $\begin{array}{ll}0 & 16\end{array}$ | 103 | $2 \quad 19$ | 5 | 212 |  |  |  | 3 |  |
| 9 | Farmyard Manure (14 tons), $3 \frac{1}{2}$ cwts. Superphosphate ( ${ }^{3}$ ) .. .. | .. | .. | .. | .. | $18 \quad 10$ | 419 | .. |  | .. |  |  |
| (1) "Superphosphate of Lime" - in all cases made from 200 lbs . Bone ash, 150 lbs . Sulphuric acid, $\mathrm{sp} . \mathrm{gr} . \mathrm{I}^{17}$ (and water). <br> (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. <br> (4) Owing to dry weather much seed failed, especially on some Ammonia and Nitrate plots, and the blanks were filled up by transplanting. <br> ${ }^{(2}$ ) "Ammonium-salts"--in each case equal parts Sulphate and Muriate of <br> (5) In order to lessen possible loss by drainage, or injury to the seed or young plants, it was decided to top-dress the Nifrate of Soda and Ammonium-salts after the plant was well up, and for greater con sown on the flat; but owing to unfavourable weather, and to the unsatisfactory condition of the land where these manures had been applied withont any organic matter for so many years, the plant almost |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| 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 ${ }^{(8)}$ Owing to the |  |  |  |  |  |  |  |  |  |  |  |  |



$\begin{array}{ll}\text { Below are given the particulars of the Manures and Produce，of the Eleventh，Twelfth，} & \text { Sugar－beet（see pp．} 52-3 \text { ）；excepting that Plot } 9 \text { ，which was unmanured for Sugar－beet，}\end{array}$ Thirteenth，Fourteenth，and Fifteenth seasons，1886，1887，1888，1889，and 1890．For and also previously for Swedes，was brought in as a manured plot for Mangels．Wron the in
 The arrangement of the plots，and of the Manures，is precisely the same as it was for the dibbled on ridges；rows 26 inches apart；plants 11 inches apart in the rows．（ ${ }^{3}$ ）Roots ten preceding years of Mangels（see pp．56－7 and 60－1），and also the same as previously for 1 all carted off；leaves weighed，spread on the respective plots，and ploughed in． （Area under experiment，about 8 acres．）

| Manures per Acre per Annum． |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Plots． | Standard Manures． | $\begin{gathered} \text { SERIES } 1 . \\ \text { Standard Manures } \\ \text { only. } \end{gathered}$ | Series 2 nd Cuard Manures 550 lbs ．Nitrate Soda． | Series 3. <br> Standard Manures， and Cross－dressed with 400 lbs．＂Ammonium－ Salts．＂（ ${ }^{4}$ ） | Series 4. <br> Standard Manures， and Cross－dressed with 2000 lbs．Rape－cake and 400 lbs ．＂Am－ monium－Salts．＂（ ${ }^{4}$ ） | Series 5. <br> Standard Manures， and Cross－dressed with 2000 lbs．Rape－cake． |

（64）


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|  －NO 00000 |
|  <br>  |
|  |

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Thirteenth Season, 1888. Seed dibbled April 16; Plot 9 April 25.



|  |  |
| :---: | :---: |


| Fifteenth Season, 1890. Seed dibbled April 23 and 24. Crop taken up, October 17-23. |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | Farmyard Manure ( 14 tons) .. .. .. .. .. .. .. .. .. | $22 \quad 19$ | 33 | $\begin{array}{ll}31 & 17\end{array}$ | 415 | 3018 | 69 | 3017 | 6 | $32 \quad 18$ | 57 |
| 2 | Farmyard Manure ( 14 tons), and $3 \frac{1}{2}$ cwts, Superphosphate .. .. | 23.9 | 39 | 3313 | 5111 | $30 \quad 2$ | 60 | 30 |  | 334 |  |
| 3 | Without Manure (1846, and since) .. $\quad .0 \quad .0$ |  | 10 | 1616 | 33 | $8 \quad 19$ | 3 | 1515 |  | 1519 |  |
| 4 | $\left\{3 \frac{1}{2} \mathrm{cwts}\right.$. Superphosphate, 500 lbs . Sulphate Potash, 200 lbs . Chloride $\}$ Sodium (common salt), 200 lbs . Sulphate Magnesia | 7 | 1 | 271 |  | 2116 | 37 | 335 | $5 \quad 14$ | 29 | 42 |
| 5 | $3 \frac{3}{2}$ cwts. Superphosphate.. .. .. .. .. .. .. .. .. .. | 6 |  | 2118 |  | $10 \quad 4$ | 34 | 15 | 4 |  | 3 |
| 6 | $3 \frac{1}{2} \mathrm{cwts}$. Superphosphate, 500 lbs . Sulphate Potash .. .. | $5 \quad 13$ | 018 | $21 \quad 12$ | 216 | 1911 | $2-17$ | 3019 | 56 | $26 \quad 2$ | 3 |
| 7 | $3 \frac{1}{2} \mathrm{cwts}$. Superphos., 500 lbs . Sulphate Potash, $36 \frac{1}{2} \mathrm{lbs}$. Am.-salts ( ${ }^{2}$ ) | $7 \quad 4$ | 12 | 225 | 218 | 227 | 37 | 3312 | $6 \quad 7$ | 2711 | 39 |
| 8 | Unmanured, 1853, and since; previously part Unman., part Superphos. | 55 | 10 | 15 5 | 313 | 109 | 315 | $13 \quad 14$ | 47 | $18 \quad 5$ | 37 |
| 9 | Farmyard Manure (14 tons), $3 \frac{2}{2} \mathrm{cwts}$. Superphosphate (3) | .. | .. | .. | .. | $28 \quad 11$ | $5 \quad 14$ | .. |  | .. | .. |
| Average of 5 Seasons, 1886, '87, '88, '89, and 1890. |  |  |  |  |  |  |  |  |  |  |  |
| 1 | Farmyard Manure (14 tons) .. .. .. ${ }^{\text {a }}$.. .. .. .. | $15 \quad 15$ | 218 | $20 \quad 19$ | 42 | $20 \quad 2$ | 51 | 21.9 | 56 | 2111 | 411 |
| 2 | Farmyard Manure ( 14 tons), and 31 $\frac{1}{\text { cwts. Superphosphate .. }}$ | 16 - 7 |  | $22 \quad 11$ | 46 | $19 \quad 15$ | $4 \quad 18$ | $21 \quad 11$ | $5 \quad 15$ | 218 |  |
| 3 | Without Manure (1846, and since) .. $\quad . \quad \because \quad .$. | 43 | 1 | 1313 | $2 \quad 17$ | 67 | $2 \quad 12$ | 108 | 313 | 1015 |  |
| 4 | \{31 cwts. Superphosphate, 500 lbs . Sulphate Potash, 200 lbs . Chloride \} Sodium (common salt), 200 lbs . Sulphate Magnesia | 415 |  | 18 8 | 39 | $14 \quad 16$ | 211 | 227 | $4 \quad 19$ | 197 |  |
| 5 | 32 $\frac{2}{2}$ cwts. Superphosphate.. .. .. .. .. .. .. .. |  |  | 1512 | 215 | $8 \quad 2$ | 214 | $10 \quad 10$ |  | 1110 |  |
| 6 | $3 \frac{1}{2}$ cwts. Superphosphate, 500 lbs . Sulphate Potash | $4 \quad 4$ | 10 | 154 | 29 | $13 \quad 13$ | 27 | $19 \quad 13$ | 414 | 166 |  |
| 7 | $3 \frac{1}{2} \mathrm{cwts}$. Superphos,, 500 lbs . Sulphate Potash, $36 \frac{1}{2} \mathrm{lbs}$. Am.-salts ( ${ }^{2}$ ) | 51 | 14 | 15.16 | 212 | $14 \quad 14$ | 211 | 2010 |  | $17 \quad 3$ |  |
| 8 | Unmanured, 1853, and since; previously part Unman., part Superphos. | 310 | $0 \quad 19$ | $10 \quad 18$ | $2 \quad 19$ | $6 \quad 3$ | 213 |  | $3 \quad 17$ |  |  |
| 9 | Farmyard Manure (14 tons), $3 \frac{3}{2}$ cwts. Superphosphate ( ${ }^{3}$ ) .. .. | .. | .. | .. | .. | 1611 | 419 | .. | .. | .. | .. |


Experiments on mangel wurzel.-BARN FIELD-continued.-Sumarary of the Composimon of the Maneel Roots, in the Eleventh, Twelfth, Thirteenth, Fourteenth, and For 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 $\begin{gathered}\text { In interpreting the figures, it must be borne in mind, that, with forty different experiments each } \\ \text { vear and in each vear four, five, or more, times, as much produce on some plots as on others, }\end{gathered}$ Ain ass seasons, on the composition of Mangels, is given below. The dry matter, ash, and nitrogen, are of year, and in each year four, five, or more, times, as much prose same condition of ripeness. Each in many cases, been determined in the expressed juice. In many cases also, the amount of the nitrogen year the seed was sown on all the plots at the same time. The sample analysed was as a rule taken mixture of vertical sections of ten or fifteen roots, and an a 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
per acre.
Mantres, per acre, per annum.

| Plots. | Mantres, per acre, per Annum. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Abbreviated Description of Standard Manures. <br> For details, see pp. 64-5. | Series 1. <br> Standard Manures only. |  |  |  | Series 2. <br> Standard Mancies, and Cross-dressed with 5.50 lbs. Nitrate Soda. |  |  |  | Series 3. <br> Standard Manures, and Cross-dressed with 400 lbs. Ammonium-salts. (1) |  |  |  | Series 4. <br> Standard Manures, and Cross-dressed with 2000 lbs . Rape-cake and 400 lbs . Ammonium-salts. (²) |  |  |  | Series 5 <br> Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake. |  |  |  |
| Eleventh Season, 1886. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Mean Per Cent. Total Dry Matter, Mineral Matter (Crude Ash), and Nitrogen in the Roots. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | $\mathrm{c}_{\text {Dry }}^{\text {Drater. }}$ | Sugar. | sh. | $\begin{gathered} \text { Nitro- } \\ \text { gen. } \end{gathered}$ | $\stackrel{\text { Dry }}{\text { Matter. }}$ | Sugar. | Ash. | $\begin{gathered} \substack{\text { Nirro- } \\ \text { gen. }} \end{gathered}$ | $\begin{aligned} & \text { Dry } \\ & \text { Matter. } \end{aligned}$ | Sugar. | Asl | $\begin{gathered} \begin{array}{c} \text { Nitro- } \\ \text { gen. } \end{array} \end{gathered}$ | Mry | Sugar. | Asb. | $\begin{gathered} \text { Nitro- } \\ \text { gen. } \end{gathered}$ | Dry | Sugar. | Ast. | $\begin{gathered} \text { Nitro- } \\ \text { gen. } \end{gathered}$ |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  | Percent. | Percent. | ercent | Percent. | Percent. | ercent. |  |  |
|  | Farmyard Manure .. .. | Per cent, | Percent, | Per cent, 0.851 0.908 |  | Percent 12.28 11.80 |  | Percent 0.950 0.951 |  | (er |  | 0.888 0.941 |  | $11 \cdot 92$ 11.93 |  | 0.854 0.900 |  | $12 \cdot 69$ 13.18 |  | 0.845 <br> 0.834 <br> 0.85 |  |
| 2 | Farmyard Manure, \& Super. .. | $12 \cdot 96$ |  | 0.908 0.750 |  | ${ }_{12}^{11 \cdot 80}$ |  | 0.951 0.953 |  | 14.93 |  | ${ }_{0} \cdot 799$ |  | $13 \cdot 76$ |  | $0 \cdot 734$ |  | 14.08 |  | 0.687 <br> 0.885 <br> 0. |  |
| 3 | Unmanured (1846, \& since) .. | $16^{\circ} 07$ |  | 0.750 0.878 | $0 \cdot 135$ | +12.02 |  | ${ }_{0}^{0} 966$ | $0 \cdot 168$ | 13.77 |  | 0.909 | $0 \cdot 154$ | 13.00 |  | 0.947 | ${ }^{0} \cdot 176$ | 12.50 |  | 0.885 0.702 0 | 0.150 0.224 |
| 4 | Super., \& Pot, Sol., \& Mag. .. Superphosphate . | 14.72 14.38 |  | 0.745 | $0 \cdot 133$ | 12.27 |  | 0.790 | $0 \cdot 180$ | 14.29 |  | 0.697 | 0.235 | $12 \cdot 47$ |  | 0.750 0.847 | 0.256 0.189 | - $13 \cdot 59$ |  | ${ }_{0} \cdot 850$ | 0.168 |
| 5 6 | Superphosphate Super., $\&$ Potash S | 14.52 |  | 0.813 | $0 \cdot 132$ | 12.02 |  | 0.878 | $0 \cdot 180$ | 14.18 |  | 0.924 0.886 | 0•171 | ${ }_{12}^{12 \cdot 72}$ |  | 0.847 0.997 |  | ${ }_{14}$ |  | $0 \cdot 888$ |  |
| 7 |  | 14.45 |  | 0.847 0.814 |  | $12 \cdot 74$ 11 |  | 0.920 0.921 |  | 13.82 14.29 |  | 0.886 0.783 |  | ${ }_{13} 12.58$ |  | ${ }_{0} \cdot 734$ |  | $14 \cdot 22$ |  | $0 \cdot 669$ |  |
| 8 | Unmanured (1855, \& since) ${ }^{\text {U }}$.. | $15 \cdot 44$ |  | 0.814 |  | $11 \cdot 26$ |  |  |  | 11195 |  | $0 \cdot 930$ |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Farmyard Manure | $15 \cdot 21$ |  | 1.042 |  | 13.66 |  | 1.066 |  | 14.56 |  | 1.040 |  | 14.95 |  | 0.953 0.944 |  | 15.00 14.79 |  | 0.943 |  |
| 2 | Farmyard Manure, \& Super. .. | 14.47 |  | 1.044 |  | $15 \cdot 39$ 17.03 |  | ${ }_{1}^{1.118}$ |  | $14 \cdot 82$ $20 \cdot 26$ |  | 1.051 |  | 17.41 |  | $0 \cdot 917$ |  | $17 \cdot 14$ |  | 0.822 |  |
|  | Unmanured (1846, \& since) .. |  |  |  |  |  |  | 1.201 |  | ${ }_{15} \cdot 11$ |  | $1 \cdot 217$ | 0.329 | 14.56 |  | 1-146 | 0.283 | 14.60 |  | $1 \cdot 154$ | $0 \cdot 260$ |
| 4 | Super., \& Pot., Sod., \& Mag. .. | $17 \cdot 11$ |  | 1.219 0.946 | 0.283 0.245 | 16.41 15.60 |  | ${ }_{1}^{1.056}$ | 0.359 | $19 \cdot 00$ |  | $0 \cdot 952$ | $0 \cdot 399$ | $17 \cdot 44$ |  | $0 \cdot 868$ | $0 \cdot 370$ | 17.34 |  | $0 \cdot 810$ | 0.314 |
| 5 | Superphosphate .. .. .. |  |  |  |  |  |  | 1.286 | ${ }^{-} \cdot 350$ | $15 \cdot 69$ |  | $1 \cdot 230$ | $0 \cdot 286$ | 15.50 |  | $1 \cdot 102$ | $0 \cdot 315$ | 14.77 |  |  | $0 \cdot 263$ |
| 6 7 | Super., \& Potash Super., Pot, \& $36 \frac{1}{2} \mathrm{lb} . \mathrm{Am}$.-slts. | 16.92 16.76 |  | 1.093 1.143 | $0 \cdot 236$ | 15.98 |  | $1 \cdot 167$ | 0 | 15.64 |  | $1 \cdot 281$ |  | 15.86 |  | 1.144 0.861 |  | 15.31 18.32 |  | 1.088 0.823 |  |
| 7 | Super., Pot., \& $36 \frac{1}{2} \mathrm{lb}$. Am. Unmanured $(1853, ~ \& ~ s i n c e) ~$ .. | $16 \cdot 76$ 17.74 |  | ${ }_{1}^{1 \cdot 077}$ |  | 18.13 |  | $1 \cdot 134$ |  | 19.24 15.28 |  | 1.004 0.982 |  | $17 \cdot 88$ |  | 0.861 | .. | 18.32 |  | 0.823 | .. |
| ${ }_{9}$ | Farmyard Manure, \& Super. .. | , |  | .. |  | .. |  | .. | .. | $15 \cdot 28$ |  |  |  |  |  |  |  |  |  |  |  |

( 67.)


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，Sugar－beet，and also previously for Swedes，was brought in as a manured plot for Mangels－ 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． $72-3$ ．Globe；dibbled on ridges；rows 26 inches apart；plants 11 inches apart in the rows．（ ${ }^{3}$ ） | The arrangement of the plots，and of the manures，is precisely the same as it was for the | Roots all carted off；leaves weighed，spread on the respective plots，and ploughed in |
| :---: | :---: | :---: |
| fifteen preceding years of Mangels（see pp． $56-7,60-1$ ，and $64-5$ ），and also the same as | In the spring of 1894 permanent division paths were laid out between plot and plot． |

| Manures per Acre per Annum． |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Series 2. | Series 3. | Series 4. |  |
| Plots． | Standard Manures． | Series 1. Standard Manures only． | Standard Manures， and Cross－dressed with 550 lbs ．Nitrate Soda． （ ${ }^{4}$ ） | Standard Manures， and Cross－dressed with 400 lbs．＂Ammonium－ Salts．＂ <br> $\left({ }^{4}\right)$ | Standard Manures， and Cross－dressed with 2000 lbs．Rape－cake and 400 lbs．＂Am－ monium－Salts．＂（4） | Standard Manures， and Cross－dressed with 2000 lbs ．Rape－cake． |

Suxteenth Season，1891．Seed dibbled April 16 and 17．Crop taken up，November 2－7．
（． 68 ）


$$
\left.\begin{array}{l|l|lllll|rrrrrr}
\hline 1 & \text { Farmyard Manure (14 tons) } & & & & & & \\
2
\end{array}\right)
$$

Crop taken up，October 26 to November 14.

$$
\sin _{\substack{\infty}}^{\infty} \operatorname{cosec}_{\sim}^{\infty}+\infty
$$

$$
\underset{\sim}{\infty}
$$ （Area under experiment，about 8 acres．）

net H Horto 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

$$
\text { Seventeenth Season, 1892. Seed dibbled April } 7 \text { and }
$$

$$
\begin{aligned}
& \text { moon N Nたが }
\end{aligned}
$$

( 69 )

Expertments on malgel WURZeL.-BARN FIELD-continued.-Summary of the Compostion of the Mangel Roots in the Sixteente, Si 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 aqueous, and in an alcoholic extract of the pulp, and the results given in the Table are the means of course determined in the roots themselves. The amounts of dry matter, ash, and nitrogen, have also, 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 practicabler it is obvious, however, that the smaller crops would be much riper the larger ones ;
ripest. but, although the larger crops generally contain a lower percentage of sugar, they yield very
Mandres, per Acre, per Annum.


| Seventeenth Season, 1892. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | Farmyard Manure | $14 \cdot 07$ | 0.774 |  | $13 \cdot 25$ | 0.831 |  | $12 \cdot 49$ | 0.886 |  | $13 \cdot 13$ | 0.778 |  | 14.19 | 0.821 |  |
| 2 | Farmyard Manure, \& Super. .. | $13 \cdot 53$ | $0 \cdot 753$ |  | $1.2 \cdot 78$ | 0.855 |  | $12 \cdot 77$ | $0 \cdot 815$ |  | $12 \cdot 94$ | 0.872 |  | $13 \cdot 25$ | 0.829 |  |
| 3 | Unmanured (1846, \& since) .. | $15 \cdot 80$ | 0.666 |  | $13 \cdot 25$ | 0.841 |  | $14 \cdot 70$ | 0.678 |  | 12.89 | 0.708 0.997 |  | 14.48 $13 \cdot 03$ | 0.658 0.854 |  |
| 4 | Super., \& Pot., Sod., \& Mag. .. | $15 \cdot 22$ | 0.793 | $0 \cdot 124$ | $13 \cdot 99$ | $0 \cdot 904$ | 0.158 0.182 | 14.06 | 0.843 0.639 | $0 \cdot 137$ $0 \cdot 185$ | $11 \cdot 26$ $13 \cdot 48$ | 0.997 0.683 | 0.206 0.251 | 13.03 13.43 | 0.854 0.620 | $0 \cdot 148$ 0.214 |
| 5 | Superphosphate.. .. .. .. | 15.03 14.70 | 0.625 0.757 | 0.122 0.120 | $12 \cdot 18$ 13.78 | 0.741 0.866 |  | $14 \cdot 31$ $14 \cdot 35$ | 0.639 0.819 | $0 \cdot 185$ $0 \cdot 126$ | $13 \cdot 48$ $13 \cdot 35$ | 0.633 0.905 | 0.251 0.206 | 13.43 13.85 | 0.620 0.784 | $0 \cdot 114$ $0 \cdot 172$ |
| 6 7 | Super., \& Potash Super., Pot., $\& 36 \frac{1}{2} \mathrm{Ib}$. Am.-slts. | $14 \cdot 70$ $14 \cdot 94$ | 0.757 0.779 | $0 \cdot 120$ | $13 \cdot 78$ .. | 0.866 .. | $0 \cdot 161$ | $14 \cdot 35$ .. | 0.819 .. | $0 \cdot 126$ | $13 \cdot 35$ .. | $0 \cdot 905$ .. | $0 \cdot 206$ | $13 \cdot 85$ .. | 0.784 |  |
| 8 | Unmanured (1853, \& since) .. | .. | .. |  | .. | .. |  | .. | .. |  | .. | .. |  | . | . |  |
| 9 | Farmyard Manure, \& Super. .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | . | . |


(1) The plant failed on these plots, owing to dronght, 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 IMANGEL 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 Twentyfirst 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. <br> 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 |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Manures per Acre per Annum. |  |  |  |  |  |  |  |  |  |  |  |
| Piots. | M | only. <br> SERIES 1. Standard Manures |  | Series 2. <br> Standard Manures, and Cross-dressed with 550 lbs. Nitrate Soda |  | Sertes 3. <br> Standard Manures, and Cross-dressed with 400 lbs." AmmoniumSalts." |  | Series 4. <br> Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake and 400 lbs. "Am-monium-Salts." |  | Series 5. <br> 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. |  |  |  |  |  |  |  |  |  |  |  |
|  | Farmyard Manure (14 tons) <br> Farmyard Manure (14 tons), $4 \stackrel{50}{ } \mathrm{lbs}$. Basic Siag, and 500 lbs . Süi. Pot. Without Manure (1846, and since) | Produce per Acre. |  |  |  |  |  |  |  |  |  |
|  |  | Roots. | Leaves. | Roots. | Leares. | Roots. | Leaves. | Roots. | Leaves. | Roots. | Lea |
| $\frac{2}{2}$ |  | $\begin{array}{\|cc\|} \hline \text { Tons. cwts. } \\ 18 & 11 \\ 21 & 7 \\ (7 & \left.12^{3}\right) \end{array}$ |  | Tons. <br> 27 <br> cwts. <br> 31 <br> 20 <br> 20 | $\begin{array}{cc} \text { Tons. cwts. } \\ 6 & 2 \\ 7 & 0 \\ 5 & 18 \\ 5 \end{array}$ | Tons. cwts.  <br> 19 3 <br> 24 4 <br> 6 3 |  | $\left\lvert\, \begin{array}{rr} \text { Tons. cwts. } \\ 19 & 13 \\ 23 & 18 \\ 6 & 17 \end{array}\right.$ | $\begin{array}{\|cc\|} \hline \text { Tons. cwts. } \\ 5 & 4 \\ 6 & 5 \\ 2 & 13 \end{array}$ | $\left\lvert\, \begin{array}{rr} \text { Tong. cwte. } \\ 19 & 3 \\ 22 & 5 \\ 6 & 11 \end{array}\right.$ | $\left\lvert\, \begin{array}{cc} \text { Tons. cwts. } \\ 4 & 10 \\ 4 & 17 \\ 2 & 6 \end{array}\right.$ |
|  | $\left\{\begin{array}{l}\text { Sodium (common salt), } 200 \mathrm{lbs} \text {. Sulphate Magnesia } \\ 400 \mathrm{lbs} \text { Basic Slag } \\ \text {. }\end{array}\right.$ |  | $1 \begin{array}{ll}1 & 9\end{array}$ |  | 15 | 1619 | 30 | 2312 |  | 2013 | 16 |
|  |  |  | 18 |  |  | $5 \quad 2$ | 2 |  |  |  |  |
| 7 |  |  | $\begin{array}{ll}1 & 3 \\ 1 & \\ 1\end{array}$ |  | 8 | 15 |  |  |  |  | 7 |
| 8 | Unmanured, 1853, and since; previously part Unman., part Superphos. |  |  |  |  |  |  |  | $\begin{array}{lll}4 & 18 \\ 2 & 14\end{array}$ |  |  |
| 8 |  | 312 | 4 | 119 | 4 | $\begin{array}{rr}5 & 0 \\ 17 & 19\end{array}$ | $\begin{array}{ll}2 & 15 \\ 4 & 19\end{array}$ | 619 | 214 |  |  |
| Twenty-second Season, 1897. Seed drilled May 4 and 5; Plot 9, dibbled May 5 and 6. Crop taken up, October 11-23. |  |  |  |  |  |  |  |  |  |  |  |
|  | Farmyard Manure ( 14 tons) |  |  |  |  |  |  |  |  |  |  |
| 2 | Farmyard Manure ( 14 tons), $40 \ddot{0} \mathrm{l} \ddot{\mathrm{bs}}$. Basic Slag, and $\ddot{0} 00 \mathrm{l} \ddot{\mathrm{bs}}$. Suil. Pöt. |  | 4 | ${ }_{27}^{25} 1$ | 88 | ${ }_{23}^{19}$ |  |  |  |  |  |
| 3 | Without Manure (1846, and since) $\quad \because \quad \because \because \quad \ddot{*}$ | $\left(\begin{array}{ll}5 & 8\end{array}\right)$ | 112 |  | 8 |  |  | 817 |  |  |  |
| 4 | $\{400$ lbs. Basic Slag, 500 lbs. Sulphate Potash, 200 lbs . Chloride Sodium (common salt), 200 lbs . Sulphate Magnesia .. .. .. | 45 | 16 | 17. | 712 |  |  |  |  |  | 13 |
|  |  |  | , |  |  | 8 | 417 |  |  |  | $4 \quad 9$ |
| 7 |  |  | $1{ }^{1} \quad 3$ |  |  | 11 | 44 14 | 1816 |  |  |  |
| 8 | Unmanured, 1853, and since; previously part Unman., part Superphos. | $\begin{array}{ll}3 & 17 \\ 1 & 13\end{array}$ |  |  |  |  |  |  |  |  |  |
| 9 | Farmyard Manure ( 14 tons), 400 lbs . Basic Slag $\left({ }^{2}\right)$.. ${ }^{\text {a }}$.. ${ }^{\text {a }}$.. ${ }^{\text {a }}$.. |  |  |  |  |  |  |  |  |  |  |

 | 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. |  |


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ixpertments on MANGEL WURZEL_-BARN FLELD_-continued_-_Sumary of the Composition of the Mangel Roots in the Twenty-first, and Twenty-gecond 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 the expressed juice as formerly, but in both an aqueous, and in an alcoholic extract of the pulp, and 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 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.
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 amides and as nitric acid. It may be observed that by far the larger proportion of both the minerai 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 as albuminoids. In former years when sugar has been estimated, it has been determined by more detail in the letterpress above the Table on p. 58 . In selected cases of the crops of the Mantere in

[^3]| Plots. | Abbreviated Description of <br> Standard Manures. $\qquad$ For details, see pp. 72-3. | Series 1. <br> Standard Manures only. | SERIES 2. <br> Standard Manures, and Cross-dressed with 550 lbs . Nitrate Soda. | Series 3. <br> Standard Manures, and Cross-dressed with 400 lbs. Ammonium-salts. | SERIES 4. <br> Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake and 400 lbs . Ammonium-salts. | Series 5. <br> Standard Manures, and Cross-dressed with 2000 lbs. Rape-cake. |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |


| 'I'wenty-first Season, 1896. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Per Cent. Total Dry Matter, Sugar, Mineral Matter (Crude Ash), and Nitrogen in the Roots. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| y ${ }^{\text {y }}$ Sugar. | Asb. | Nitrogen. | Dry Matter. | Sugar. | Ash. | Nitrogen. | $\begin{gathered} \text { Dry } \\ \text { Matter. } \end{gathered}$ | Sugar. | Ash. | Nitrogen. | Dry Matter. | Sugar. | Ash. | Nitrogen. |
| ent. Percent. | Per cent. | Percent. | Percent. | Percent. | Percent. | Percent. | Per cent. | Percent. | Percent. | Percent. | Percent. | Percent. | Percent. | Percent. |
| . 69 | I.029 |  | 9-61 |  | 0.908 |  | 9.56 |  | $0 \cdot 901$ |  | $10 \cdot 36$ |  | 0.944 |  |
| . 03 | 1.033 |  | $10 \cdot 66$ |  | 1.026 |  | 10.46 |  | 1.033 |  | 10.10 |  | 1.012 |  |
| . 70 | 0.892 |  | $13 \cdot 63$ |  | 0.789 |  | $12 \cdot 29$ |  | 0.731 |  | 11.77 |  | 0.755 |  |
| 52 | 1.066 | 0.169 | 11.02 |  | $1 \cdot 005$ | $0 \cdot 160$ | $9 \cdot 38$ |  | 1.056 | $0 \cdot 200$ | 10-15 |  | 0986 | $0 \cdot 165$ |
| 29 | $0 \cdot 797$ | $0 \cdot 185$ | $12 \cdot 84$ |  | $0 \cdot 780$ | 0.289 | $11 \cdot 77$ |  | $0 \cdot 803$ | $0 \cdot 285$ | $12 \cdot 30$ |  | $0 \cdot 755$ | $0 \cdot 260$ |
| 22 | $0 \cdot 940$ | $0 \cdot 182$ | $11 \cdot 40$ |  | $0 \cdot 938$ | $0 \cdot 186$ | $10 \cdot 78$ |  | 1.018 | 0.237 | $10 \cdot 36$ |  | $0 \cdot 919$ | $0 \cdot 200$ |
|  | . |  | . | $\cdots$ | -. |  | .. |  | - |  | * |  | $\cdots$ |  |
|  | $\cdots$ |  | . | * | $\cdots$ |  | * |  | - |  | $\cdots$ |  | . |  |
|  | . |  | .. | * | .. |  | .. |  | *- |  | .. |  | . |  |


| 1 | Farmyard Manure . | $14 \cdot 91$ |  | 0.884 | $0 \cdot 187$ | $13 \cdot 79$ | 8.87 | 0.886 | 0.222 | $12 \cdot 98$ |  | $0 \cdot 819$ | 0.227 | $18 \cdot 64$ |  | 0.821 | $0 \cdot 259$ | $13 \cdot 29$ | $8 \cdot 19$ | $0 \cdot 850$ | $0 \cdot 25$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 2 | Farmyard Manure, Slag, \& Pot. | $14 \cdot 80$ |  | 0.873 | $0 \cdot 185$ | $12 \cdot 99$ | $8 \cdot 03$ | $0 \cdot 934$ | 0.217 | $13 \cdot 47$ |  | 0.953 | $0 \cdot 229$ | $12 \cdot 92$ |  | $0 \cdot 967$ | 0.249 | 13.85 | $8 \cdot 52$ | 0.812 | 0.229 |
| 3 | Unmanured (1846, \& since) .. | 16.65 |  | $0 \cdot 670$ |  | $14 \cdot 32$ |  | 0.793 |  | $15 \cdot 48$ |  | 0.589 |  | $14 \cdot 26$ |  | $0 \cdot 634$ |  | 14.54 |  | 0.609 |  |
| 4 | Basic Slag, \& Pot., Sod., \& Mag. | 15.89 | $10 \cdot 11$ | $0 \cdot 865$ | $0 \cdot 147$ | $13 \cdot 76$ | $8 \cdot 53$ | 0.976 | $0 \cdot 201$ | $14 \cdot 86$ | 9-23 | 0.996 | $0 \cdot 196$ | $13 \cdot 32$ | 8-10 | $0 \cdot 944$ | 0.212 | $13 \cdot 46$ | 8•32 | 0.901 | $0 \cdot 18$ |
| 5 | Basic Slag .. .. .. .. | $15 \cdot 91$ | $10 \cdot 08$ | $0 \cdot 671$ | 0-142 | $14 \cdot 23$ | 9.03 | 0.826 | $0 \cdot 214$ | 14.76 | 8.88 | 0.606 | $0 \cdot 254$ | 14.03 | $8 \cdot 10$ | 0.608 | $0 \cdot 299$ | $14 \cdot 51$ | 8-77 | 0.629 | $0 \cdot 26$ |
| 6 | Basic Slag, \& Potash .. .. | $15 \cdot 28$ | $9 \cdot 56$ | 0.785 | $0 \cdot 132$ | $13 \cdot 17$ | $8 \cdot 05$ | 0.952 | 0.191 | $14 \cdot 94$ | $9 \cdot 12$ | $0 \cdot 958$ | 0.179 | $13 \cdot 47$ | 8-22 | $0 \cdot 947$ | 0. 227 | 14.72 | 9•37 | 0.834 | $0 \cdot 20$ |
| 7 | Slag, Pot., \& 36 $\frac{1}{2} \mathrm{lb}$. Am.-slts. | $15 \cdot 95$ |  | $0 \cdot 856$ |  | .. |  | .. |  | .. |  | .. |  | , |  | .. |  | 13.82 |  | 0.838 |  |
| 8 | Unmanured (1853, \& since) ... | .. |  | .. |  | . |  | .. |  | $\because$ |  | - 0 |  | .. |  | .. |  | .. |  | .. |  |
| 9 | Farmyard Manure, \& Basio Slag | .. |  | .. |  | .. |  | .. |  | 13.61 |  | $0 \cdot 795$ |  | .. |  | . |  | .. |  | .. |  |

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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 briof aummary 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 23 rd year of their continuance. The descriptions grown were "Rock," 4 years, "Champion," 11 years, "Sutton's Abundance," 5 years, "Bruce," 1 year, and " White Beanty 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, $11 \frac{1}{2}$ owt.; with ammoniumsalts alone, 1 ton, $18 \frac{1}{2} \mathrm{ewt}$. ; with nitraie of soda alone, 2 tons, 8 cwt ; with superphosphate alone, 3 tons, $2 \frac{1}{4} \mathrm{cwt}$. with mixed mineral manure, including potash, 3 tons, $6 \frac{3}{4}$ 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 tho 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 leas produce than the mixture of mineral manure and ammonium-salts, or nitrate of aoda, 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 manule 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. ; whilat 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 ashconstituents, 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 $1 \frac{1}{2}$ ton. In othor 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 nonnitrogenous 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 highor, and sometimes a much higher, percentage of nitrogen in the dry substance of the discased than in that of the sound tubors, indicating a loss of non-nitrogenous constituents. In many cases the still white, and also the soparated 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 "Mare" 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 moresugar (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 tho 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 readyformed 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 manuro 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 particnlars of the manuring and produce, and to some extent of the composition of the differently grown tubers, see pages 78-97.

## Experiments on potatoes.-HOOS FIELD; commencing 1876.

Below are given the particulars of the Manures and Produce of each of the now receives for potatoes; and Plot 8 now receives the same complex mineral first 5 Seasons, 1876 - 1880 ; also the average Produce of those first 5 Seasons. manures, and the same amount of nitrogen, but as Nitrate of Soda instead of 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.)

| Lots. | Mandres per acre per annux. | Produce per acre. |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Tubers. |  |  |  | Tops. |
|  |  | Good. | Small. | Diseased. | Total. |  |
| First Season, 1876. Potatoes planted, June 10-13; Crop taken up, Oct. 30-31. |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| $\begin{aligned} & 1 \\ & 2 \\ & 3 \end{aligned}$ |  |  | $\begin{array}{cc} 0 & 5 \\ 0 & 5 \\ 0 & 4 \\ 0 & 6 \\ \hline \end{array}$ |  |  | Withered, oot weighed, |
| $4$ |  |  | 0 0 | $\begin{array}{ll} 0 & 5 \text { 娄 } \\ 0 & 198 \end{array}$ | $\begin{array}{rl} 5 & 6 \frac{7}{7} \\ 6 & 6412 \end{array}$ | not weighed, each lot |
| 5 |  | ${ }^{5}$ |  | [ ${ }_{0}$ |  |  |
|  |  |  |  |  | $\begin{array}{lll}3 & 178 \\ 8 & 2 \\ 8\end{array}$ |  |
|  | 550 lbs. Nitrate of Soda, 32 ¢wts. Superphos, 300 lbs . Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs. Sulph. Mag. | ${ }_{6}{ }^{17}$ | 010 |  |  |  |
| $\text { (5) }\left\{\begin{array}{l} 0 \\ 9 \\ 9 \end{array}\right.$ | $3_{\frac{1}{2}}^{2}$ ewts. Superphosphate |  |  |  |  | in. |
|  |  | 53 | 066 |  | ${ }_{6}{ }^{8} 38$ |  |

Secosd Season, 1877. Potatoes planted, April 27-28; Crop taken up, Oct. 8-10.

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| 1 | Unmanured | 266 | $08^{8} 8$ | 0 | 2 | 2 | 1712 | 0 | $3 \frac{1}{4}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 2 | Farmyard Manure (14 tons) | 411 | 0 0 121 | 0 | $8 \frac{1}{2}$ | 5 | 11 妥 | 0 | $6{ }^{6}$ |
| 3 | Farmyard Manure (14 tons), and $3 \frac{1}{\frac{1}{2}}$ cwts. Superphosphate ( ${ }^{1}$ ) .. .. .. .. .. .. .. | 51818 | $0{ }_{0}^{0} 14 \frac{1}{2}$ | 0 | $13 \frac{1}{4}$ | 7 | 6 | 0 | 11 |
| 4 | Farmyard Manure ( 14 tons), $3 \frac{1}{2}$ cwts. Superphosphate, and 550 lbs. Nitrate of Soda .f .. .. | $\begin{array}{ll}6 & 113 \\ 2\end{array}$ | $\begin{array}{ll}0 & 111 \\ 0 & 81\end{array}$ | 1 | ${ }^{6 \frac{1}{4}}$ | 8 | 92 ${ }^{92}$ | 1 | 6 |
| 5 6 | 400 lbs . Ammonium-salts ( ${ }^{2}$ ) <br> 550 lbs. Nitrate of Soda | 2 $16 \frac{1}{4}$ <br> 3 $16 \frac{3}{4}$ <br>   | $\begin{array}{ll}0 & 8 \frac{8}{2} \\ 0 & \end{array}$ | 0 | 53 ${ }^{\frac{3}{2}}$ | 3 4 | 132 | 0 | $\begin{array}{r} 7 \\ 11 \end{array}$ |
| 7 |  | $7{ }^{7}$ 63 | 0093 | 1 | ${ }^{2}$ | 8 | 172 | 0 | 139 |
| 8 | 550 lbs . Nitrate of Soda, $3 \frac{3}{2}$ cwts. Superphos., 300 lbs . Sulph. Potash, 100 lbs . Sulph. Soda, 100 lbs . Sulph. Mag. | $\begin{array}{ll}7 & 11 \frac{1}{2} \\ 3\end{array}$ | $\begin{array}{ll}0 & 9 \\ 0\end{array}$ | 1 | $3{ }^{3}$ | 9 | 42 | 1. | 0 $4 \frac{3}{3}$ |
| 9 10 |  | 3 5 <br> 3 8 | $\begin{array}{ll}0 & 9 \\ 0 & 9\end{array}$ | 0 | 4 $4 \frac{1}{2}$ | 3 4 | 183 18 | 0 | 43 <br> 48 <br> 4 |

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

Experiments on POTATOES.-HOOS FTELD-continued.-Stumary of the Composition of the "Good" Tubers, in each of the first 5 Seasone,
An abstract of the analytical results obtained, illustrating the influence of different manures, "mare" of the white portion, contained very little nitrogen, whilst that of the discoloured portion contained very, much more. 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 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 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 aterwards, 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

| Plots. | Mandres per Acre, per Annum. <br> (For Produce, see pp. 78-9.) | Specific Grarity of the Tubers. |  | Compositi | the " G | " Tube |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | $\begin{gathered} \text { Dry } \\ \text { Matter. } \end{gathered}$ | Mineral Matter (Ash) . |  | Nitrogen. |  |
|  |  |  |  | In Fresh Tubers. | In Dry Matter. | In Fresh Tubers. | In Dry Matter. |
| Frrst Season, 1876. |  |  |  |  |  |  |  |
| 1 | Unmanured .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. | 1.097 | Per cent. $23 \cdot 9$ | $\begin{gathered} \text { Per cent. } \\ 0.84 \end{gathered}$ | Per cent. $3 \cdot 53$ | $\begin{gathered} \text { Per cent. } \\ 0 \cdot 269 \end{gathered}$ | $\begin{gathered} \text { Per cent. } \\ 1 \cdot 13 \end{gathered}$ |
| 2 |  | 1.091 | $23 \cdot 4$ | $0 \cdot 96$ | $4 \cdot 11$ | $0 \cdot 223$ | $0 \cdot 95$ |
| 3 |  | 1.097 | $23 \cdot 5$ | $1 \cdot 00$ | $4 \cdot 27$ | $0 \cdot 191$ | $0 \cdot 81$ |
| 4 | Farmyard Manure (14 tons), $3 \frac{1}{2}$ ewts. Superphosphate, and 550 lbs . Nitrate of Soda .. .. .. .. .. .. | 1.085 | $21 \cdot 2$ | $0 \cdot 83$ | $3 \cdot 92$ | $0 \cdot 295$ | 1.39 |
| 5 | 400 lbs. Ammonium-salts ( ${ }^{2}$ ) .. .. .. .. .. .. ${ }^{\text {a }}$ (. ${ }^{\text {a }}$ | 1.087 | $22 \cdot 1$ | $0 \cdot 81$ | 3.67 | 0.332 | $1 \cdot 50$ |
| 6 |  | 1.091 | $22 \cdot 0$ | $0 \cdot 79$ | $3 \cdot 59$ | $0 \cdot 327$ | $1 \cdot 49$ |
| 7 | 400 lbs . Ammonium-salts, $3 \frac{1}{2} \mathrm{cwts}$. Superphos., 300 lbs . Sulph. Potash, 100 lbs . Sulph. Soda, 100 lbs . Sulph. Mag. | 1.090 | $20 \cdot 9$ | 0.98 | $4 \cdot 71$ | 0.266 | $1 \cdot 27$ |
| 8 | 550 lbs . Nitrate of Soda, $3_{\frac{1}{2}} \mathrm{cwts}$. Superphos., 300 lbs . Sulph. Potash, 100 lbs . Sulph. Soda, 100 lbs . Sulph. Mag. | 1.088 | $21 \cdot 9$ | $0 \cdot 98$ | $4 \cdot 46$ | 0.292 | $1 \cdot 33$ |
| 9 |  | $1 \cdot 103$ | $23 \cdot 5$ | $1 \cdot 10$ | $4 \cdot 72$ | 0.199 | 0.84 |
| 10 | $3 \frac{1}{2} \mathrm{cwts}$. Superphosphate, 300 lbs . Sulphate Potesh, 100 lbs . Sulphate Soda, and 100 lbs . Sulphate Magnesia .. | 1-102 | $22 \cdot 9$ | $1 \cdot 06$ | 4.64 | $0 \cdot 171$ | $0 \cdot 74$ |
| Second Season, 1877. |  |  |  |  |  |  |  |
| 1 | Unmanured .. .. .. .. .. .. .. .. .. .. .. | $1 \cdot 119$ | $33 \cdot 0$ | 1.05 | $3 \cdot 17$ | $0 \cdot 302$ | $0 \cdot 91$ |
| 2 | Farmyard Manure (14 tons) . . . . . . . . . 14 .. .. .. .. .. .. .. .. .. .. .. .. | $1 \cdot 109$ | 26.5 | $1 \cdot 06$ | $4 \cdot 00$ | $0 \cdot 212$ | $0 \cdot 80$ |
| 3 | Farmyard Manure (14 tons), and $3 \frac{1}{2}$ cwts. Superphosphate ( ${ }^{1}$ ) $\quad . \quad \ddot{ }$ | $1 \cdot 103$ | $26^{\circ} 0$ | $1 \cdot 11$ | $4 \cdot 26$ | $0 \cdot 207$ | $0 \cdot 80$ |
| 4 | Farmyard Manure (14 tons), $3 \frac{1}{2}$ cwts. Superphosphate, and 550 lbs. Nitrate of Soda .. .. .. .. .. .. | 1-112 | $27 \cdot 2$ | $1 \cdot 06$ | $3 \cdot 90$ | $0 \cdot 301$ | $1 \cdot 11$ |
| 5 | 400 lbs. Ammonium-salts ( ${ }^{2}$ ) .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. .. | 1-107 | $22 \cdot 0$ | $0 \cdot 67$ | $3 \cdot 07$ | $0 \cdot 281$ | $1 \cdot 28$ |
| 6 | 550 lbs . Nitrate of Soda $\quad .0$ | 1-116 | $25 \cdot 9$ | $0 \cdot 74$ | $2 \cdot 85$ | $0 \cdot 301$ | $1 \cdot 16$ |
| 7 | 400 lbs . Ammoniom-salts, $3 \frac{1}{2}$ cwts. Superphos., 300 lbs . Sulph. Potash, 100 lbs . Sulph. Soda, 100 lbs . Sulph. Mag. | 1-103 | 28.4 | $1 \cdot 23$ | $4 \cdot 33$ | $0 \cdot 270$ | $0 \cdot 95$ |
| 8 | 550 lbs . Nitrate of Soda, $3 \frac{1}{2} \mathrm{cwts}$. Superphos., 300 lbs . Sulph. Potash, 100 lbs . Sulph. Soda, 100 lbs . Sulph. Mag. | 1-112 | ${ }^{27 \cdot 3}$ | $1 \cdot 16$ | $4 \cdot 26$ | $0 \cdot 268$ | $0 \cdot 98$ |
| 9 10 |  | 1-109 | $26 \cdot 5$ | $1 \cdot 18$ | 4.44 | 0.203 | $0 \cdot 76$ |
| 10 | $3 \frac{1}{2}$ cwts. Superphosphate, 300 lbs . Sulphate Potash, 100 lbs . Sulphate Soda, and 100 lbs . Sulphate Magnesia .. | 1-109 | $26 \cdot 8$ | 1-21 | $4 \cdot 52$ | 0.208 | $0 \cdot 78$ |

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| 1 | Unmanured .. .. .. .. | $1 \cdot 107$ | $26 \cdot 0$ | $0 \cdot 85$ | $3 \cdot 26$ | $0 \cdot 228$ | 0.88 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 2 | Farmyard Manure (14 tons) ... .. .. | $1 \cdot 100$ | $24 \cdot 4$ | $1 \cdot 02$ | $4 \cdot 20$ | $0 \cdot 209$ | 0.86 |
| 3 |  | $1 \cdot 090$ | $23 \cdot 8$ | 1.03 | $4 \cdot 35$ | 0.205 | $0 \cdot 86$ |
| 4 | Farmyard Manure ( 14 tons), $3 \frac{1}{2} \mathrm{cwts}$. Superphosphate, and 550 lbs . Nitrate of Soda .. .. .. .. .. .. | 1.078 | $21: 9$ | 0.97 0.78 | $4 \cdot 45$ $3 \cdot 12$ | $0 \cdot 269$ $0 \cdot 310$ | $\begin{aligned} & 1 \cdot 23 \\ & 1 \cdot 25 \end{aligned}$ |
| 5 | 400 lbs. Ammonium-salts ( ${ }^{2}$ ) $\quad .0$ | 1-099 | $24 \cdot 9$ | 0.78 0.67 | $3 \cdot 12$ $2 \cdot 64$ | $\begin{aligned} & 0 \cdot 310 \\ & 0 \cdot 326 \end{aligned}$ | $\begin{aligned} & 1 \cdot 25 \\ & 1 \cdot 28 \end{aligned}$ |
| 6 |  | f. 105 $1 \cdot 093$ | $25 \cdot 5$ | 0.67 1.08 | $2 \cdot 64$ $4 \cdot 57$ | $\begin{aligned} & 0 \cdot 326 \\ & 0 \cdot 223 \end{aligned}$ | $\begin{aligned} & 1.28 \\ & 0.95 \end{aligned}$ |
| 7 | 400 lbs. Ammonium-salts, $3 \frac{1}{2} \mathrm{cwts}$. Superphos., 300 lbs . Sulph. Potash, 100 lbs . Sulph. Soda, 100 lbs . Sulph. Mag. | $1 \cdot 093$ $1 \cdot 097$ | $23 \cdot 6$ $24 \cdot 4$ | 1.08 1.08 | 4.57 4.41 | $\begin{aligned} & 0 \cdot 223 \\ & 0 \cdot 228 \end{aligned}$ | $\begin{aligned} & 0.95 \\ & 0.94 \end{aligned}$ |
| 8 | 550 lbs . Nitrate of Soda, $3 \frac{1}{2}$ cwts. Superphos., 300 lbs . Sulph. Potash, 100 lbs . Sulph. Soda, 100 lbs . Sulph. Mag. $3 \frac{1}{2}$ ewts. Superphosphate | $1 \cdot 097$ | $24 \cdot 1$ | $1 \cdot 14$ | $4 \cdot 74$ | 0.165 | $0 \cdot 68$ |
| 10 |  | $1 \cdot 098$ | $23 \cdot 7$ | $1 \cdot 16$ | $4 \cdot 90$ | 0.167 | $0 \cdot 71$ |
| Fourth Season, 1879. |  |  |  |  |  |  |  |
| 1 | Unmanured | $1 \cdot 103$ | $24 \cdot 3$ | 0.96 | $3 \cdot 95$ | $0 \cdot 242$ | $1 \cdot 00$ |
| 2 | Farmyard Manure ( 14 tons) .. .. .. .. .. .. .. .. .. .. .. .. .. .. | 1-103 | $23 \cdot 7$ | 0.99 | $4 \cdot 16$ | $0 \cdot 220$ | 0.93 |
| 3 | Farmyard Manure ( 14 tons), and $3 \frac{3}{2}$ ewts. Superphosphate ( ${ }^{1}$ ) | 1-099 | 24.0 | 1.02 0.91 | $4 \cdot 26$ 3.69 | 0.218 | $0 \cdot 91$ |
| 4 | Farmyard Manure ( 14 tons), 31 cwts. Superphosphate, and 550 lbs . Nitrate of Soda .. .. .. .. .. | 1-102 | $24 \cdot 6$ 24.6 | 0.91 0.76 | 3.69 3.06 | 0.224 0.270 | 1.04 |
| 5 |  | -103 | $24 \cdot 6$ $25 \cdot 0$ | 0.76 0.76 | 3.06 3.05 | 0.300 | $1 \cdot 10$ $1 \cdot 20$ |
| 6 |  | 1.104 1.098 | $23 \cdot 1$ | 0.95 | 4 | $0 \cdot 241$ | 1.05 |
| 7 8 | 400 lbs . Ammonium-salts, $3 \frac{1}{2}$ cwts. Superphos, 300 lbs . Sulph. Potash, 100 lbs . Sulph. Soda, 100 lbs . Sulph. Mag. | 1-102 | $23 \cdot 9$ | $1 \cdot 04$ | $4 \cdot 36$ | $0 \cdot 272$ | $1 \cdot 14$ |
| 9 | 550 lbs. Nitrate of Soda, $3 \frac{1}{2}$ cwts. Superphos., 300 lbs. Sulph. Potash, $100 \mathrm{los}$. Sulph. Soda, 100 lbs. Sulph. Kag. $3 \frac{1}{2}$ cwts. Superphosphate | $1 \cdot 099$ | $23 \cdot 6$ | $1 \cdot 10$ | 4.65 | $0 \cdot 219$ | $0 \cdot 93$ |
| 10 | $3 \frac{1}{2}$ cwts. Superphosphate, 300 lbs. Sulphate Potash, 100 lbs . Sulphate Soda, and 100 lbs . Sulphate Magnesia .. | 1.099 | $23 \cdot 5$ | $1 \cdot 15$ | $4 \cdot 89$ | $0 \cdot 211$ | $0 \cdot 90$ |
| Fifth Season, 1880. |  |  |  |  |  |  |  |
| 1 | Unmanured | $1 \cdot 123$ | $28 \cdot 8$ | 0.77 | $2 \cdot 66$ | 0.382 | $1 \cdot 33$ |
| 2 |  | $1 \cdot 114$ | $27 \cdot 6$ | $0 \cdot 98$ | 3.56 | $0 \cdot 287$ | $1 \cdot 04$ |
| 3 | Farmyard Manure ( 14 tons), and $3 \frac{1}{2}$ ewts. Superphosphate ( ${ }^{1}$ ) $\quad . \quad . \quad \ddot{0}$ | $1 \cdot 117$ | $27 \cdot 8$ | $0 \cdot 98$ | $3 \cdot 52$ | $0 \cdot 275$ | $0 \cdot 99$ |
| 4 | Farmyard Manure ( 14 tons), $3 \frac{1}{\frac{1}{2}} \mathrm{cwts}$. Superphosphate, and 550 lbs . Nitrate of Soda .. .. .. .. .. | $1 \cdot 102$ | $25 \cdot 2$ | $0 \cdot 88$ | $3 \cdot 48$ | $0 \cdot 357$ | 1.41 |
| 5 | 400 lbs. Ammonium-salts ( ${ }^{2}$ ) .. .. .. .. .. .. .. .. .. .. .. .. | 1•114 | $28 \cdot 5$ | $0 \cdot 84$ | $2 \cdot 95$ | $0 \cdot 430$ | 1.51 |
| 6 | 550 lbs. Nitrate of Soda $\quad . .10$ | 1-117 | $28 \cdot 8$ | $0 \cdot 88$ | $3 \cdot 06$ | $0 \cdot 415$ | $1 \cdot 44$ |
| 7 | 400 lbs Ammonium-salts, $3 \frac{1}{2}$ ewts. Superphos., 300 lbs . Sulph. Potash, 100 lbs . Sulph. Soda, 100 lbs . Sulph. Mag. | 1.097 | $25 \cdot 9$ | $0 \cdot 97$ | $3 \cdot 73$ | $0 \cdot 327$ | $1 \cdot 06$ |
| 8 | 550 lbs . Nitrate of Soda, $3 \frac{1}{4}$ cwts. Superphos., 300 lbs . Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs . Sulph. Mag. | 1.118 | $26 \cdot 7$ | 0.96 1.03 | 3.59 3.81 | 0.318 | $1 \cdot 19$ |
| 9 10 |  | $1 \cdot 114$ $1 \cdot 116$ | $27 \cdot 2$ $27 \cdot 3$ | 1.03 1.06 | 3.81 3.86 | 0.247 0.236 | 0.91 0.87 |
| 10 | $3 \frac{1}{2} \mathrm{cwts}$. Superphosphate, 300 lbs . Sulphate Potash, 100 lbs . Sulphate Soda, and 100 lbs . Sulphate Magnesia.. | $1 \cdot 116$ | 27.3 | $1 \cdot 0$ | 3.86 | $0 \cdot 236$ | 0.87 |
| Average of 5 Seasons, 1876 '77, '78, '79, and 1880. |  |  |  |  |  |  |  |
| 1 | Unmanured .. .. Un $^{\text {a }}$ | 1.110 | $27 \cdot 2$ | $0 \cdot 89$ | $3 \cdot 31$ | $0 \cdot 285$ | $1 \cdot 05$ |
| 2 |  | $1 \cdot 103$ | $25 \cdot 1$ | $1 \cdot 00$ | $4 \cdot 01$ | $0 \cdot 231$ | 0.92 |
| 3 |  | $1 \cdot 101$ 1.096 | $\stackrel{25 \cdot 0}{ }{ }^{2} \cdot 0$ | 1.03 0.93 | $4 \cdot 13$ $3 \cdot 89$ | 0.220 0.296 | 0.88 1.24 |
| 4 | Farmyard Manure (14 tons), $3 \frac{1}{2}$ cwts. Superphospliate, and 550 lbs . Nitrate of Soda .. .. .. .. .. | 1-096 $\mathrm{r} \cdot 102$ | $24 \cdot 0$ 24 | 0.93 0.77 | $3 \cdot 89$ $3 \cdot 17$ | 0.296 0.326 | $1 \cdot 24$ |
| 5 |  | 1.107 | $25 \cdot 4$ | $0 \cdot 77$ | $3 \cdot 04$ | $0 \cdot 335$ | $1 \cdot 32$ |
| 6 |  | 1.096 | $24 \cdot 4$ | 1.04 | $\pm \cdot 29$ | $0 \cdot 266$ | $1 \cdot 10$ |
| 7 | 500 lbs. Nitrate of Soda, $3 \frac{1}{2}$ cwts. Superphos., 300 lbs . Sulph. Potash, 100 lbs . Sulph. Soda, 100 lbs . Sulph. Mag. | $1 \cdot 103$ | $24 \cdot 8$ | $1 \cdot 04$ | $4 \cdot 22$ | $0 \cdot 276$ | 1-12 |
| 9 |  | $1 \cdot 104$ | $25^{\circ} \mathrm{O}$ | $1 \cdot 11$ | $4 \cdot 47$ $4 \cdot 56$ | 0.207 0.199 | 0.83 0.80 |
| 10 | $3 \frac{1}{2}$ ewts. Superphosphate, 300 lbs . Sulphate Potash, 100 lbs . Sulphate Soda, and 100 lbs . Sulphate Magresia .. | $1 \cdot 105$ | $24 \cdot 8$ | $1 \cdot 13$ | $4 \cdot 56$ | $0 \cdot 199$ | $0 \cdot 80$ |

[^4]G
Below are given the particulars of the Manures and Produce of the Sixth, Seventh, same amount of complex mineral manure, and Ammonium-salts, for the Wheat, as Eighth, Ninth, and Tenth Seasons, 1881, 1882, 1883, 1884, and 1885. For the Plut 7 now receives for potatoes; and Plot 8 now receives the same complex mineral Manures and Produce of the 5 preceding years, see $\mathrm{pp} .78-9$, and of succeeding manures, and the same amount of nitrogen, but as Nitrate of Soda instead of years, 1886 and since, see pp. 86-7, 90-1, and 94-5. Ammonium-salts. Plots 9 and 10 received the same complex mineral manures alone The Land had been under experiments with Wheat, differently manured, from 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, 8 received the with 14 inches from plant to plant in the rows.
(Area under experiment, 2 acres.)

| Plots. | Manures per Agre per annum. | Producle per Acre. |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Tubers. |  |  |  | Tops. |
|  |  | Good. | Small. | Diseased. | Total. |  |
| Sixth Season, 1881. Potatoes planted, March 31; Crop taken up, October 5, 6 and 7. |  |  |  |  |  |  |
| 1 | Unmanured, in 1876, and each year since | Tons. cwts. | Tons. cwhs. | Tons. cwts. | Tons. cwts. |  |
| 2 | Farmyard Manure (14 tons) | ${ }_{7}^{1} 114 \frac{1}{4}$ | 0 0 | 0 0 <br> 0 $1{ }^{3}$ | $8{ }^{2} 0^{\frac{3}{4}}$ | Withered, |
| 3 | Farmyard Manure ( 14 tons), and $3 \frac{1}{2}$ ewts. Superphosphate ( ${ }^{1}$ ) .. .. .. .. .. .. .. .. .. .. .. |  |  |  | 6 193 | not weighed, |
| 4 |  | $8{ }^{8}$ 6 ${ }^{14}$ | $0 \quad 5 \frac{1}{4}$ | ${ }_{0}{ }^{1} 9$ | 9 112 | each lot |
| 5 |  | $2{ }^{2}$ | 0 - $4 \frac{1}{2}$ | 0 0 | ${ }_{2} 10 \frac{1}{2}$ | spread on |
| 6 | 550 lbs . Nitrate of Soda $\quad \ddot{5}$ | ${ }^{2} 1193$ | 0 0 | $\begin{array}{ll}0 & 03 \\ 0 & \\ 0\end{array}$ | ${ }^{3} \underbrace{3 \frac{3}{4}}$ | its own Plot |
| 7 |  | 10 10 <br> 9 $12 \frac{7}{3}$ | $\begin{array}{ll}0 & 3 \frac{1}{2} \\ 0 & 4\end{array}$ |  | $\begin{array}{cc}10 & 16 \\ 10 & 0\end{array}$ | $\underset{\text { ploughed }}{\text { and }}$ |
| 10 |  |  |  | $\begin{array}{ll}0 & 0 \frac{1}{2} \\ 0 & 1\end{array}$ |  | in. |
| 10 | $3 \frac{1}{2} \mathrm{cwts}$. Superphosphate, 300 lbs . Sulphate Potash, 100 lbs . Sulphate Soda, and 100 lbs . Sulphate Magnesia .. | $5 \quad 14$ 嵒 |  |  | $518 \frac{1}{2}$ |  |


| Seventh Season, 1882. Potatoes planted, March 21. Crop taken up, September 25-27. |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | Uumanured, in 1876, and each year since |  |  |  | 119 |  |
| 2 |  | 315 |  | $0{ }^{0} \quad 2$ |  |  |
| 3 |  | 58 |  | $0{ }^{0}$ 31 | ${ }^{5} \quad 1 \begin{aligned} & 153 \\ & 4\end{aligned}$ | ot weighed, |
| $\stackrel{4}{5}$ | Farmyard Mauure (14 tons), $3 \frac{1}{3}$ ewts. Superphosphate. In 1881, and previously, 550 lbs. Nitrate of Soda also .. | ${ }^{4} \begin{aligned} & 4 \\ & 1\end{aligned} 7^{7 \frac{1}{4}}$ | $\begin{array}{ll}0 & 3 \frac{3}{2} \\ 0 & 3 \\ 0\end{array}$ | $\begin{array}{ll} 0 & 1 \frac{1}{4} \\ 0 & 0 \frac{1}{4} \end{array}$ |  | spread |
| 6 | 550 lbs . Nitrate of Soda | 1 188 | 0 | $0{ }^{0}$ |  | its own Plot |
| 7 |  | $715 \frac{1}{3}$ | 0 3劲 |  |  | and |
| 8 | 550 lbs . Nitrate of Soda, 31 ${ }^{\frac{1}{2}} \mathrm{cwts}$. Superphos., 300 lbs . Sulph. Potash, 100 lbs . Sulph. Soda, 100 lbs . Sulph. Mag. |  |  | $0{ }^{0} 2$ | $7 \quad 2 \begin{aligned} & \text { 23 } \\ & 4\end{aligned}$ | oughed |
| 10 |  |  | - ${ }_{0}^{0}$ - 2 2 $2 \frac{1}{4}$ | $\begin{array}{ll}0 \\ 0 & 1 \\ 0 & 1 \frac{1}{2} \\ \end{array}$ | $\begin{array}{ll}4 & 153 \\ 4 & 10\end{array}$ |  |
|  |  |  |  |  |  |  |

（ 83 ）

| Eightif Season，1883．Potatoes planted，March 22．Crop taken up October 22－25． |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | Unmanured，in 1876，and each year since | $2{ }^{4} 4$ | $0{ }^{6}$ 6 | $\frac{1}{4}$ |  |  |
| 2 | Unmanured in 1882，and since．Previously Farmyard Manure（ 14 tons）．．．．． | 45 | $1{ }^{1}$ | 0 | $\begin{array}{ll}5 & 93 \\ 6\end{array}$ |  |
| 3 | Farmyard Manure（14 tons）alone 1883；previously $3 \frac{7}{2}$ cwts．Superphosphate also（ ${ }^{1}$ ） | 5 6 ${ }^{\frac{1}{2}}$ | 0 9 ${ }^{\frac{1}{2}}$ | $4 \frac{3}{4}$ | 60 |  |
| 4 | $\left\{\begin{array}{c}\text { Farmyard Manure（ } 14 \text { tons）alone 1883．In 1882，and previously，} 3 \frac{1}{2} \text { owts．Superphosphate，and in } 1881 \text { ，and } \\ \text { previously，} 550 \mathrm{lbs} \text { ．Nitrate of Soda also ．．．．．．．．．．}\end{array}\right.$ | 40 年 | 0 111 $\frac{1}{4}$ | $0 \quad 1{ }^{3}$ | $4 \quad 13{ }^{4}$ |  |
| 5 |  | $13 \frac{1}{4}$ | 82 |  |  |  |
| 6 | 550 lbs ．Nitrate of Soda | $2{ }^{2} 13 \frac{1}{2}$ | $0{ }^{0} \quad 7 \frac{3}{4}$ | $1 \frac{1}{4}$ | $3 \quad 2 \frac{1}{2}$ |  |
| 7 | 400 lbs ．Ammonium－salts， $3 \frac{1}{2}$ cwts．Superphos．， 300 lbs ．Sulph．Potash， 100 lbs ．Sulph．Soda， 100 lbs ．Suiph．Mag． | $716 \frac{3}{4}$ | $0{ }_{0} 14$ | $8 \frac{4}{4}$ | $8 \quad 19$ |  |
| 8 | 550 lbs ．Nitrate of Soda， $3 \frac{1}{3}$ cwts．Superphos．， 300 llss ．Sulph．Potash， 100 lbs ．Sulph．Soda， 100 lbs ．Sulph．Mag． | $7 \quad 9 \frac{1}{2}$ | $\begin{array}{ll}0 & 93 \\ 0\end{array}$ | ${ }_{0}^{0} 3$ 32 | $8 \quad 23$ | ploughed in． |
| 10 | $3 \frac{1}{2}$ cwts．Superphosphate | 4 $8 \frac{1}{2}$ <br> 4 $9 \frac{1}{2}$ | $\begin{array}{ll}0 & 7 \frac{3}{4} \\ 0 & 7 \frac{1}{2}\end{array}$ | $\begin{array}{ll}0 & 3 \frac{1}{4} \\ 0 & 1 \frac{1}{4}\end{array}$ | $\begin{array}{ll}4 & 19 \frac{1}{2} \\ 4 & 18\end{array}$ |  |
| Ninth Season，1884．Potatoes planted，March 21．Crop taken up，September 24－26． |  |  |  |  |  |  |
| 1 | Unmanured，in 1876，and each year since | $20 \frac{1}{4}$ | $4 \frac{3}{4}$ | 1 | 2 |  |
| 2 | Unmanured in 1882，and since．Previously Farmyard Manure（14 tons） | $25^{1}$ | $0 \quad 4 \frac{1}{4}$ | $0 \quad 2$ | 2 111 ${ }^{\frac{1}{2}}$ |  |
| 3 |  | $3 \quad 10 \frac{3}{4}$ | $0{ }^{5}$ | $0 \quad 2 \frac{1}{4}$ | $\begin{array}{ll}3 & 188\end{array}$ |  |
| 4 | $\left\{\begin{array}{c}\text { Farmyard Manure（ } 14 \text { tons）alone } 1883-4 \text { ．In 1882，and previously，} 3 \frac{1}{2} \text { ewts．Superphosphate，and in 1881，and } \\ \text { previously，} 550 \mathrm{lbs} \text { ．Nitrate of Soda also }\end{array}\right.$ | 3 121 ${ }^{\frac{1}{2}}$ | $0 \quad 6 \frac{1}{4}$ | 0 2 ${ }^{\frac{1}{2}}$ | 4 1爯 | not weighed， |
| 5 | 400 lbs．Ammonium－salts（ $\left.{ }^{( }\right) \quad . . \quad .$. | $0 \frac{1}{2}$ | $7 \frac{1}{2}$ | $0 \frac{3}{4}$ | $2 \quad 8 \frac{3}{4}$ | spread on its own Plot |
| 6 | 550 lbs ．Nitrate of Soda | $16 \frac{1}{4}$ | $3 \frac{1}{4}$ | $0 \frac{1}{2}$ |  | its own Plot <br> and |
| 7 | 400 lbs ．Ammonium－salts， $3 \frac{1}{2}$ cwts．Superphos．， 300 lbs ．Sulph．Potash， 100 lbs ．Sulph．Soda， 100 lbs. Sulph．Mag． | $4 \quad 19 \frac{1}{4}$ | 10 $\frac{1}{4}$ | 24 | 12 | and ploughed |
| 8 | 550 lbs ．Nitrate of Soda， $3 \frac{1}{2}$ cwts．Superphos， 300 lbs. Sulph．Potash， 100 lbs. Sulph．Soda， 100 lbs. Sulph．Mag． | $4 \quad 10 \frac{1}{4}$ | 07 | $2 \frac{1}{2}$ | $19 \frac{3}{1}$ | in． <br> ploughed |
| 10 |  | $13{ }^{13}$ | 0 | 1 | 19를 | in． |
| Tentr Season，1885．Potatoes planted，March 17 and 18．Crop taken up，September 24－26． |  |  |  |  |  |  |
| 1 | Unmanured in 1876，and each year since | 0 163 | 0 47 | 0 0 | 11 |  |
| 2 | Unmanured in 1882，and since，Previously Farmyard Manure（14 tons）．．．．．．．．．． | 113 | $0{ }^{0} 3 \frac{3}{4}$ | $\begin{array}{ll}0 & 1\end{array}$ | $1{ }^{1} \quad 178$ |  |
| 3 | Farmyard Manure（ 14 tons）alone 1883 and since；previously $3 \frac{1}{2}$ ewts．Superphosphate also（ ${ }^{1}$ ）．．．．${ }^{\text {a }}$ ．．$\quad .$. | $26^{5}$ | 0 5 ${ }^{\frac{1}{8}}$ | $0 \quad 0{ }^{5}$ | $2122^{3}$ | Withered， not weighed |
| 4 | $\left\{\begin{array}{c}\text { Farmyard Manure（ } 14 \text { tons）a ane } 1883 \text { and since．In } 1882 \text { ，and previously，} 3 \frac{1}{2} \text { ewts．Superphosphate，and in } \\ 1881 \text { ，and previously，} 550 \text { lbs．Nitrate of Soda also } \\ \text { ．．}\end{array}\right.$ ．．．．．．．．．．．．．．．．．．．．．．．．$\}$ | 211 | $4 \frac{1}{6}$ | 05 | $2 \quad 15 \frac{8}{4}$ |  |
| 5 |  | $6 \frac{1}{2}$ | $5 \frac{1}{2}$ | 0 0 | 12 | pread on |
| 6 |  | 74 | 5 | $0 \quad 0 \frac{1}{4}$ | 1 121 ${ }^{\frac{1}{2}}$ | own Plot |
| 7 | 400 lbs ．Ammonium－salts， $3 \frac{1}{2}$ cwts．Superphos．， 300 lbs ．Sulph．Potash， 100 lbs ．Sulph．Soda， 100 lbs ．Sulph．Mag． | 42 | $6 \frac{1}{2}$ | 0 13 | 4 97 | ploughed |
| 8 | 550 lbs ．Nitrate of Soda， $3 \frac{1}{2}$ ewts．Superphos．， 300 lbs ．Sulph．Potash， 100 lbs ．Sulph．Soda， 100 lbs ．Sulph．Mag． | 3 16 ${ }^{3}$ | 4 | $\begin{array}{ll}0 & 1 \frac{1}{8} \\ 0 & 0\end{array}$ | $4 \quad 2{ }^{4}$ | oughed in． |
| $\begin{array}{r}9 \\ 10 \\ \hline\end{array}$ |  | $\begin{array}{ll}2 & 1 \\ 2 & 1 \frac{1}{81} \\ \end{array}$ | $\begin{array}{ll}0 & 3 \text { 3 } \\ 0 & 2 \text { 亲 }\end{array}$ | $\begin{array}{ll}0 & 0 \\ 0 & 0 \frac{1}{2} \\ \end{array}$ |  |  |
| Average of 5 Seasons，1881，＇82，＇83，＇84，and 1885. |  |  |  |  |  |  |
| 1 | Unmanured in 1876，and each year since | 143 | $0{ }^{0} 43$ | 009 |  |  |
| 2 | Unmanured in 1882，and since．Previously Farmyard Manure（14 tons）．．．．．．．．．．．．．．．．．． | 318 | $0{ }^{0} 6$ | ${ }_{0}^{0} 21$ |  |  |
| 3 | Farmyard Manure（ 14 tons）alone 1883 and since；previously $3 \frac{1}{2}$ cwts．Superphosphate also（ ${ }^{1}$ ）．． <br> （Farmyard Manure（ 14 tons）alone 1883 and since．In 1882，and previously， $3 \frac{1}{6}$ ewts．Superphosphate，and in | $4 \quad 13 \frac{1}{1}$ | 5 觪 | 0 2 2 |  | Withered， ot weighed， |
| 4 | $\left\{\begin{array}{c}\text { Farmyard Manure（ } 14 \text { tons）alone } 1883 \text { and since．In 1882，and previously，} 3 \frac{1}{2} \text { ewts．Superphosphate，and in } \\ \text { 1881，and previously，} 550 \text { lbs．Nitrate of Soda also ．．．．．．}\end{array}\right.$ | $4 \quad 11 \frac{5}{6}$ | $6 \frac{1}{8}$ | $3 \frac{1}{8}$ | $5 \quad 0 \frac{7}{8}$ |  |
| 5 | 400 lbs．Ammonium－salts（ ${ }^{2}$ ）．．．．．．． | $0{ }_{8}$ | 4 | $0 \frac{3}{4}$ | $2{ }^{2} 78$ | spread on its own Plot |
| 6 | 550 lbs．Nitrate of Soda | 23 | 43 | $0{ }_{8}^{5}$ | 288 | its own Plot and |
| 7 | 400 lbs ．Ammonium－salts， $3 \frac{1}{2}$ ewts．Superphos．， 300 lbs ．Sulph．Potash， 100 lbs. Sūlph．Soda， 100 lbs ．Suilph．Mrag． | 07 | 7 | 5 | 7 1331 | and |
| 8 | 550 lbs ．Nitrate of Soda， $3 \frac{1}{2}$ ewts．Superphos．， 300 lbs. Sulph．Potash， 100 lbs ．Sulph．Soda， 100 lbs ．Sulph．Mag． | 1 | 5 | ${ }_{0}^{0} \quad 25$ | $\begin{array}{ll}6 & 17 \frac{1}{2} \\ 4\end{array}$ | ploughed in． |
| 10 |  | 4 $0 \frac{1}{2}$ <br> 4 08 | $\begin{array}{ll}0 \\ 0 & 4 \\ 4\end{array}$ | $\begin{array}{ll}0 & 1 \frac{1}{2} \\ 0 & 1\end{array}$ | $\begin{array}{ll}4 & 61 \\ 4 & 6\end{array}$ | in． |

Experiments on POTATOES.-HOOS FIELD-continued.-Sumimary of the Composition of the "Good" Tubers, in the Sixth, Seventh, Eighth, North, and Tenth Seasons, 1881 , 188 and since, see pp. 88-9, 92-3, and 96-7.

| An abstract of the analytical results obtained, illustrating the influence of different manures, | other hand, the washed, or exhausted "mare" of the white portion, contained very little nitrogen, |
| :--- | :--- | :--- |
| whilst that of the discoloured portion |  | of the tubers is also given. In the tubers the dry matter, nitrogen, and ash have been 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. 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
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 performeen 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 resalts, 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.

| Specific Gravity Tubers. | Composition of the " Good " Tubers. |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{gathered} \text { Dry } \\ \text { Matter. } \end{gathered}$ | Mineral Matter (Ash). |  | Nitrogen. |  |
|  |  | $\begin{aligned} & \text { In Fresh } \\ & \text { Tubers. } \end{aligned}$ | $\begin{aligned} & \text { In Dry } \\ & \text { Matter. } \end{aligned}$ | In Fresh Tubers. | $\begin{aligned} & \text { In Dry } \\ & \text { Matter. } \end{aligned}$ |



| Seventi Season, 1882. |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| ${ }_{2}^{1}$ | Unmanured, in 1876, and each year since $\stackrel{\text { Unmanured in }}{ }$ | ${ }_{1} \cdot 131$ | ${ }_{30} \cdot 3$ | 0.91 | 3.01 | $0 \cdot 260$ | 0.86 |
| ${ }_{3}$ | Farmyard Manure (14 tons), and $3 \frac{1}{\frac{1}{2}}$ ewts. Superphosphate (1) | 1.122 | $28 \cdot 7$ | $0 \cdot 97$ | $3 \cdot 39$ | $0 \cdot 261$ | 0.91 |
| 4 | Farmyard Manure ( 14 tons), $3 \frac{1}{2}$ ewts. Superphosphate. In 1881, and previously, 550 lbs . Nitrate of Soda also.. | 1.116 | $26 \cdot 6$ | 0.93 | 3.48 | 0.313 | $1 \cdot 18$ |
| 5 | 400 lbs Ammonium-salts ( ${ }^{2}$ ) .. .. .. | 1.119 | $27 \cdot 9$ 27.9 | 0.77 0.79 | $2 \cdot 78$ 2.82 | 0.372 0.408 | 1.34 1.46 |
| 6 | 550 lbs. Nitrate of Soda $\ddot{\sim}$ | ${ }_{1}^{1 \cdot 119}$ | ${ }_{27 \cdot 9}^{27.9}$ | 0.79 0.96 | $2 \cdot 82$ $3 \cdot 49$ | $0 \cdot 408$ $0 \cdot 305$ | ${ }_{1}^{1 \cdot 46}$ |
| 7 | 400 lbs. Ammonium-salts, $3 \frac{1}{2}$ cwts. Superphos., 300 lbs . Sulph. Potash, 100 lbs . Sulph. Soda, 100 lbs . Sulph. Mag. | ${ }_{1}^{1 \cdot 120}$ | $27 \cdot 5$ $28 \cdot 2$ | 0.96 0.98 | $\stackrel{3}{3 \cdot 46}$ | 0.336 | $1 \cdot 19$ |
| 8 | 550 lbs . Nitrate of Soda, $3 \frac{1}{2}$ ewts. Superphos., 300 lbs . Sulph. Potash, 100 lbs Sulph. Soda, 100 lbs . Sulph. Mag. | ${ }_{1} \cdot 128$ | $29 \cdot 3$ | 1.03 | $3 \cdot 53$ | $0 \cdot 209$ | $0 \cdot 71$ |
| 10 | ${ }_{3}^{3 \frac{1}{2}} \begin{aligned} & \text { owts. Superphosphate } \\ & 3\end{aligned}$ | $1 \cdot 125$ | $29 \cdot 1$ | $1 \cdot 08$ | $3 \cdot 71$ | $0 \cdot 229$ | 0.79 |



Experivents on POTATOES.-HOOS FIELD-continued.
Below are given the particulars of the Manures and Produce, of the Eleventh, crops. The manures are the same as for the crops of 1883 , 1884 and 1885 , exceptTwelfth, Thirteenth, Fourteenth, and Fifteenth Seasons, 1886, 1887, 1888, 1889, ing that for the crop of 1887 Sulphate Ammonia was applied instead of equal parts and 1890. For the Manures, description of Potatoes grown, and the Produce, in the of Sulphate and Muriate Ammonia, as in former years and since (see foot-note 10 preceding years, see pp. 78-9, and 82-3, and in succeeding years, pp. 90-1, and 94-5. No. 2). Description of Potato, "The Champion" (White). Rows 25 inches apart; preceding potato 14 inches from plant to plant in the rows.
(Area under experiment, 2 acres.)

| Plots. | Mantures per agre per Annum. | Produce per Acre. |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Tubers. |  |  |  | Tops. |
|  |  | Good. | Small. | Diseased. | Total. |  |
| Eleventh Season, 1886. Potatoes planted, April 10. Crop taken up, September 30, and October 1 and 2. |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| 1 <br> 2 |  | $\begin{array}{ll}0 & 13{ }^{\text {a }} \\ 1 & 17\end{array}$ | $\begin{array}{ll}0 \\ 0 & 4 \\ 0\end{array}$ | $\begin{array}{ll} 0 & 0 \text { an } \\ 0 & 1 \end{array}$ | $\left\lvert\, \begin{array}{cc} 0 & 18 \\ 2 & 1 \end{array}\right.$ |  |
| 3 |  | $\begin{array}{ll}1 \\ 2 & 15\end{array}$ | ${ }_{0}^{0} \quad 3{ }^{3}$ | $\begin{array}{ll} 0 \\ 0 & 1 \end{array}$ | $\begin{array}{ll}2 & 19 \\ 2 & 19 \frac{1}{4}\end{array}$ | Withered, not weirhed, |
| 5 | $\left\{\begin{array}{l}\text { chen } \\ 1881 \text {, and previously, } 550 \\ \text { lbs. Nitrate of Soda also .. }\end{array}\right.$ | $2 \quad 12 \frac{1}{4}$ | 03 | 0 1 $1 \frac{1}{2}$ | $2{ }^{2} 163$ |  |
| 5 6 |  | $1{ }^{1}$ | ${ }_{0}^{0}$ 4 $4 \frac{1}{3}$ | ${ }_{0}^{0} \mathbf{l}_{0}$ | $1{ }^{1} 8$ | spread on its own Plot |
| 7 |  | ${ }_{3}^{1} 810{ }^{2 \frac{1}{2}}$ | $\begin{array}{ll}0 & 33 \\ 0 & 3 \text { 3 } \\ \text { a }\end{array}$ | 0 0 <br> 0 1 <br> 0 1 | 1 61 <br> 3 $14 \frac{1}{4}$ <br>   | and |
| 8 |  | ${ }^{3}$ | 0 0 3 | ${ }_{0}^{0} 0^{1}$ |  | ploughed in. |
| 10 |  |  |  |  | $\begin{array}{ll} 2 & 1 \\ 2 & 53 \end{array}$ |  |


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Experiments on Potatoes.-hOOS FIELD-continued.-Schwary 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 washed, or exhausted "mare" of the white portion, contained very lititle nitrogen, whilst that
 ash have ben determined; and in some cases complete analyses of the ash have been
mande. Besidered exhaustion of much of both its nitrogen and dits mineral matter, in the development of
mesults obtained relating to the composition of the tabers themselves,
the fungus. There was an increased amount of sugar found in the diseased potatoes, the result





 nitrogen, that of the discoloured portion contained very much less. On the other hand, the $/$ taken for analysis.

$1 \cdot 121$
1.121
1
$1 \cdot 107$
$1 \cdot 115$
-
..

( 89 )

| 1 | Unmanured in 1876, and each year since | $1 \cdot 114$ | $27 \cdot 6$ | $0 \cdot 84$ | 3-02 | $0 \cdot 360$ | $1 \cdot 30$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 2 | Unmanured in 1882, and since. Previously Farmyard Manure ( 14 tons) | 1.119 | $27 \cdot 9$ | $0 \cdot 85$ | 3.04 | $0 \cdot 345$ | $1 \cdot 24$ |
| 3 | Farmyard Manure ( 14 tons) alone 1883 and since; previously $3 \frac{1}{2}$ cwts. Superphosphate also (1) | 1-105 | 25•3 | 1.03 | 4•09 | 0.390 | $1 \cdot 54$ |
| 4 | \{Farmyard Manure ( 14 tons) alone 1883 and since. In 1882, and previously, $3 \frac{1}{2}$ ewts. Superphosphate, and in $\}$ | 1-104 | $25 \cdot 4$ | $1 \cdot 04$ | $4 \cdot 10$ | 0-362 | $1 \cdot 43$ |
| 5 | ( 1881, and previously, 550 lbs . Nitrate of Soda also | 1-110 | $26 \cdot 8$ | 0.78 | $2 \cdot 92$ | $0 \cdot 440$ | -64 |
| 6 | 550 lbs. Nitrate of Soda | $1 \cdot 114$ | $26 \cdot 6$ | $0 \cdot 83$ | $3 \cdot 13$ | $0 \cdot 431$ | $1 \cdot 63$ |
| 7 | 400 lbs. Ammonium-salts, $3 \frac{1}{2}$ ewts. Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs . Sulph. Mag. | 1-106 | $25 \cdot 5$ | $1 \cdot 00$ | 3-90 | 0-340 | $1 \cdot 33$ |
| 8 | 550 lbs . Nitrate of Soda, 312 cwts . Superphos., 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs . Sulph. Mag. | 1-109 | $25 \cdot 6$ | $0 \cdot 97$ | 3•79 | $0 \cdot 332$ | 1-29 |
| 9 |  | 1-116 | $27 \cdot 0$ | $1 \cdot 09$ | $4 \cdot 02$ | 0.321 | 1-19 |
| 10 | $3 \frac{1}{2}$ cwts. Superphosphate, 300 lbs . Sulphate Potash, 100 lbs . Sulphate Soda, and 100 lbs . Sulphate Magnesia .. | $1 \cdot 112$ | $26 \cdot 8$ | $1 \cdot 11$ | $4 \cdot 14$ | $0 \cdot 313$ | $1 \cdot 17$ |




$4\left\{\begin{array}{c}1881 \text {, and previously, } 550 \mathrm{lbs} \text {. Nitrate of Soda also .. .. .. .. .. .. .. .. .. .. .. .. .. } \\ 10\end{array}\right\} \quad 1.114$

400 lbs. Ammonium-salts, $3 \ddot{\frac{1}{2}} \mathrm{cwts}$. Superphos, 300 lbs. Sulph. Potash, 100 lbs. Sulph. Soda, 100 lbs . Sulph. Mag. $1 \cdot 112$
114
.118
.115 1-115

## Viffteenth Season, 1890.



Experiments on potatoes.-HOOS FIELD-continued.

|  | ww are given the particulars of the Manures and Produce, for the Sixteenth, teenth, Eighteenth, Nineteenth, and Twentieth Seasons, 1891, 1892, 1893, and 1895. For the Manures, description of Potatoes grown, and the Produce, 15 preceding years, see $\mathrm{pp} .78-9,82-3$, and $86-7$, and of the succeeding years, -5. arrangement of the plots is precisely the same as for the 15 preceding potato <br> crops. The manures are th of Potato, "Sutton's Abun plant to plant in the rows. <br> In the spring of 1894 and plot. <br> (Area under experiment, 2 acres.) | 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. <br> In the spring of 1894 permanent division paths were laid out between plot and plot. |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Produce fer Acre. |  |  |  |  |
| Plot | Manures per Acre per Annum. | Tubers. |  |  |  |  |
|  |  | Good. | Small. | Diseased. | Total. |  |
| Sixteenth Season, 1891. Potatoes planted, April 1. Crop taken up, September 28-30. |  |  |  |  |  |  |
| 1 | Unmanured in | ts. | Tons. ewts. | Tons. cwits. | ons. cwts. |  |
| 2 | Unmanured in 1882, and since. Previously |  |  |  |  |  |
| 3 |  | $\begin{array}{ll}1 & 144 \\ 5 & 164\end{array}$ | $\begin{array}{ll}0 & 1 \\ 0 & 1\end{array}$ | $\begin{array}{cc} 0 & 1 \\ 0 & 103 \end{array}$ | ${ }_{6}^{1} \quad 16 \frac{1}{4}$ |  |
| 4 |  | $\begin{array}{ll}5 & 16 \frac{1}{4} \\ 5 & 118\end{array}$ | 011 | 0 103 |  | Withered, not |
| 5 | 1881, and previously, 550 lbs . Nitrate of Soda also | $5 \quad 11 \frac{3}{4}$ | 0 1 ${ }^{1}$ | 013 | 6 | ighed, each |
| 6 | 500 lbs . Ammonium-salts ( ${ }^{2}$ ) | $12 \frac{1}{4}$ | 01 | 0 01 $\frac{1}{2}$ | $13 \frac{3}{4}$ | lot spread on |
| 7 |  | 23 | 0 1 1 |  |  |  |
| 8 |  | $4 \quad 178$ | $0 \quad 1 \frac{1}{4}$ | 0 - | $5 \quad 2$ |  |
| 9 | 35 cwts. Superphosphate $3 \frac{1}{2}$ ewts. Superphos., 300 lbs . Sulph. Potash, 100 lbs . Sulph. Soda, 100 lbs . Sulph. Mag. | 5 5 $3 \frac{2}{2}$ | $0{ }^{0} 1$ | $0{ }^{0}$ 4 $\frac{1}{2}$ | $5 \quad 9 \frac{1}{4}$ |  |
| 10 |  |  | $\begin{array}{ll}0 & 1 \\ 0 & 1 \frac{1}{4}\end{array}$ | 0 03 <br> 0 $10 \frac{1}{4}$ | $\begin{array}{ll}2 & 12 \\ 2 & 14 \frac{3}{4}\end{array}$ |  |
|  |  |  |  |  |  |  |
| 1 | Unmanured in 1876, and each year since |  |  |  |  |  |
| 2 |  | $\begin{array}{ll}0 & 15 \\ 1 & 18 \frac{1}{2} \\ \end{array}$ | $\begin{array}{ll}0 & 2 \frac{29}{4} \\ 0 & 2\end{array}$ | $\begin{array}{ll}0 & \\ 0 & 8 \frac{1}{4} \\ \end{array}$ | 0 18 <br> 2 9 |  |
| 3 |  | $4{ }^{1} 11$ |  | $\begin{array}{ll}0 & 9 \frac{1}{4} \\ 0\end{array}$ |  |  |
| 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 | 50 姩 |  | $\begin{array}{ll} 1 \\ 0 & 6 \frac{3}{4} \end{array}$ | $5 \quad 9 \frac{1}{2}$ | Withered, not weighed, each |
| 5 |  | 13 | 0 21 |  |  | lot spread on |
| 6 | 550 lbs . Nitrate of Soda | 119 | $0 \quad 2{ }^{1}$ | 0 0 ${ }^{\frac{3}{4}}$ |  | ts own Plot |
| 7 |  |  | 0 23 |  |  | and ploughed |
| 8 | 550 lbs . Nitrate of Soda, $3 \frac{1}{2}$ cwts. Superphos., 800 lbs . Sulph. Potash, 100 lbs . Sulph. Soda, 100 lbs . SuIph. Mag. | $6 \quad 15 \frac{1}{4}$ | $0 \quad 2$ | 0 5 $0^{\frac{1}{2}}$ | $\begin{array}{ll}7 & 23\end{array}$ |  |
|  |  | 2 13告 | 0 2 ${ }^{\frac{1}{2}}$ | 0 03 | 217 |  |
| 10 | $3 \frac{1}{2} \mathrm{cwts}$. Superphosphate, 300 lbs . Sulphate Potash, 100 lbs . Sulphate Soda, and 100 lbs . Sulphate Magnesia .. | $3 \quad 12 \frac{1}{2}$ | - ${ }^{1}$ |  | 3 171 |  |

( 91 )


Experiments on potatoes．－HOOS FIELD－continued．－Summary of the Composition of the＂Good＂Tubers in the Sixteenth，Seventeenth， see pp．80－1，84－5，and 88－9，and for those in succeeding seasons，see pp．96－
obtained，illustrating the influence of different 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 and its mineral matter，in the development of the fungus．There was an increased amount of tributed to the development of the fungus． The results given in the Table relate to the＂good＂potatoes only．In interpreting the
igures 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 from the original weight of the samples，the results being calculated upon the fresh weights as finally taken for analysis．
 manures，and of different seasons，on the composition of Potatoes，is given below．Ne 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 ash，in the expressed juice have in many cases been determined；in some cases the amount of the nitegen exis juice have been made．It may be remarked，that by far the larger proportion of both the not much more than half exists as albuminoids．In many cases，the small potatoes have been submitted to the same methods of amalysis as the good potatoes．And in some easer， coloured portions of the diseased potatoes．With regard to these latter results，it may be observed，that whilst the juice of the white
approximately the normal amount of nitrogen， approximately the normal amount of nitrogen，
much less．On the other hand，the washed
（ 92

|  |  | 昌禹 |  |
| :---: | :---: | :---: | :---: |
|  |  |  |  ฐ．00－0．00000 |
|  |  |  |  |
|  |  |  | 眊웅․ <br>  |
|  |  |  |  <br>  |



Manures per Acre, per annum.
 Plots．
(For Produce, see pp. 90-1.)


$$
\text { Sixteenth Season, } 1891 .
$$

[^5]( 93 )
Eighteenth Season, 1893.


 1




气函 1-096 . 115 1.104 .099
.115 . 110 . .. .. .. .. .. .. .. .. .. I. : : : $\overbrace{\text { - }}^{\text {: }}$ :


 500 lbs. Nitrate of Soda, $3 \frac{1}{2}$ cwts. Superpuos., 300 lbs . Sulph. Potash, 100 lbs . Nuph. Soda, 100 lbs. Sulph. Mag. $3 \frac{1}{2} \mathrm{cwts}$. Superphosphate, 300 lbs . Sulphate Potash, 100 lbs. Sulphate Soda, and 100 lbs . Sulphate Magnesia Nineteenth Season, 1894.
Experiments on POTATOES.-HOOS FIELD-continued.
Below are given the particulars of the Manures for the Twenty-first, Twenty- The manures are the same as for the crops of 1883, and since; excepting that for the second, and Twenty-third Seasons, 1896, 1897, and 1898; and of the produce of 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, "Deauty 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 The arrangement of the plots is precisely the same as for the 20 preceding potato crops. plot and plot.
(Area under experiment, 2 acres.)

| Plots. | Manures per Acre per Annum. | Produce per acre. |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Tubers. |  |  |  | Tops. |
|  |  | Good. | Small. | Diseased. | Total. |  |
| Twenty-first Season, 1896. Potatoes planted, April 10. Crop taken up, October 23-30. |  |  |  |  |  |  |
|  |  |  | Tons. cwts. | Tons. ewts. | Tons. cwts. |  |
| 2 |  | $\begin{array}{rr} 1 & 1^{\frac{1}{4}} \\ 1 & 11 \frac{3}{4} \\ \hline \end{array}$ | $\begin{array}{ll}0 & 23 \\ 0 & 23 \\ 0 & 24\end{array}$ |  | $\begin{array}{rr}1 & 4 \frac{3}{3} \\ 1 & 15 \frac{1}{2} \\ 7 & \end{array}$ |  |
| 3 |  | ${ }_{5}^{1}$ | $\begin{array}{ll}0 & 1^{2} \\ 0\end{array}$ | $1{ }^{0} 1212{ }^{12}$ | $7{ }^{1}{ }^{1}$ |  |
| 4 | \{Farmyard Manure ( 14 tons) alone 1883 and since In 1882, and previously, $3 \frac{1}{2}$ cwts. Superphosphate, and in | $411{ }^{\text {a }}$ | $0 \quad 2{ }^{2}$ | 1 143 | $6 \quad 8 \frac{1}{2}$ | weighed, each |
| 6 |  | 1 171 <br> 2  | ${ }_{0}^{0}{ }_{0}^{15}$ | ${ }_{0}^{0} \quad 2 \begin{array}{ll}2 \frac{2}{2} \\ 0\end{array}$ | $2{ }_{2}^{2} \quad 1 \frac{1}{4}$ | ${ }_{\text {lot spread on }}^{\text {lote }}$ its own Plot |
| 6 7 |  | 2 1 <br> 5 18 | $\begin{array}{ll}0 & 13 \\ 0 & 1 \\ 2\end{array}$ | $\begin{array}{rrr} 0 & 3 \\ 0 & 15 \\ \hline \end{array}$ | 2 6 <br> 6 $4 \frac{1}{4}$ | and ploughed |
| 8 | 550 lbs. Nitrate of Soda, $3 \frac{1}{2}$ cwts. Superphos., 300 lbs. Sulph. Potash, 100 lbs . Sulph. Soda, 100 lbs . Sulph. Mag. |  | $0{ }^{0} 1^{\frac{7}{2}}$ | $\begin{array}{ll}0 & 148 \\ 0\end{array}$ | ${ }^{6}{ }^{6}$ |  |
| 9 10 | $3 \frac{1}{2}$ ewts. Superphosphate <br>  | 2 $10 \frac{1}{2}$ <br> 2 14 <br> 2 14 | ( |  | 6  <br> 2  <br> 2 15 <br> 2 191 |  |

\footnotetext{
Twenty-second Season, 1897. Potatoes planted, April 8. Crop taken up, September 13-15.

| 1 |  |  |  |  |  |  | 0 |  | Withered, not weighed, each lot spread on its own Plot and ploughed in. |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 2 | Unmanured in 1882, and since. Previously Farmyard Manure (i4 tons) |  | 0 |  | 0 |  | 1 |  |  |
|  |  | 15: | 0 | $3{ }_{3}^{3}$ | 0 | $0 \frac{4}{2}$ |  | 19 |  |
| 4 | \{Farnyard Manure ( 14 tons) alone 1883 and since. In 1882, and previously, 32 owts. Superphosphate, and in $\}$ | 15 | 0 | $3 \overline{\bar{\theta}}$ | 0 | $0{ }^{2}$ |  | $193$ |  |
| 5 | 00 lbs . Ammonium-salts | 115 |  |  | 0 | $0 \frac{1}{5}$ |  |  |  |
| 6 | 550 1bs. Nitrate of Soda |  | 0 |  | 0 | 0 |  |  |  |
| 7 | 400 lbs . Ammonium-salts. 400 lbs . Basic Slag, 300 lbs . Sulph. Potash, 100 lbs . Sulph. Soda, 100 lbs . Sulph. Mag. | $2{ }^{2}$ |  | $4{ }^{\frac{1}{4}}$ | 0 | 0 |  |  |  |
|  | lbs. Nitrate of Soda, 400 lbs . Basic Slag, 300 lbs . Sulph. Potash, 100 lbs . Sulph. Soda, 100 lbs . Sulph. Mag. | $11{ }^{2}$ | 0 | 51 | 0 | $0 \frac{1}{4}$ |  | 16 年 |  |
| 10 |  |  |  |  |  |  |  |  |  |




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                    (98 )
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.]
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The $t$ lower divisions, Unmanured continuously (Plot 1).
The $\pm$ 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 loft-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.]

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

The experiments were commenced in 1848; so that 1898 is the $518 t$ year of their continuance, and the third year of the 13 th Course. In the experiments in other flelds, 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 erops 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 partieular 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 Swedlish 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 11 th and 12 th 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 uneultivated 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 erops 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 ummanured. Further, under all conditions of treatment, the plots with mixed mineral and nitrogenous manure have yiolded 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 continnous 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 drainuge, 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 quantitios 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 diffexence 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 mauure 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 eleaning the land constitute a prominent element of adyantage.

For details of the manuring and produce of the different plots, see pages 100-109.
Experiments on an actual Course of Rotation－Turnips，Barley，Leguminous Crop（or Fallow），and Wheat． （OR FALLOW），AND W ARAN three differently manured plots ；but in each of the subsequent courses，a leguminous erop 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 Fifth and Sixth Courses，beans were taken instead．In the Seventh Course，clover was sown（spring 1873），
Sind 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
 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．




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| :---: |
|  |  |



 34 $\frac{1}{2} \mathrm{cw}$

$$
\begin{aligned}
& \text { Zollverein Pfund. per Pru } \\
& \text { Centner per Pr. Morgen. }
\end{aligned}
$$家宗思

$$
=
$$


（nnoqe）
（nnoqe）


$$
\begin{aligned}
& \hline \begin{array}{ll}
1 & \text { lb. (pound avoir.) per acre } \\
1 \mathrm{cwt.} \\
\hline
\end{array} \text { (hundredweight) per acr } \\
& \hline
\end{aligned}
$$

$$
\begin{aligned}
& = \\
& \text { acre }=
\end{aligned}
$$

Pectare

ssian Morgen. and the growing orop（Beans）is the third of the Thirteenth Course． 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 in thed，as described in foot－note，No． 2 ． Lastly，one－third has been manured（also for the turnip－crop only），with a complex mineral and 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
land．
$\square$
（ 100 ）

$$
\underset{\text { (Area under experiment, about } 3 \text { acres. }}{\text { A GDELL }} \text { FIELD. }
$$

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． －

## －

( 101 )

AGDELL FIELD.
Experiments on an Autual 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, In the First Course, clover was sown over the whole of each of the three differently manured One-third of the land has been continuously unmanured. One-third has, for the first Nine Courses, the three plots, the other half being left fallow, in the third year of each course. In the Second,
 Courses, a complex mineral manure has been applied, as described in foot-note, No. 2. Lastly, and gave three cuttings in 1874. In the Eighth Course beans were grown. In the Tenth Course clover was sown (in the spring of 1885), and yielded two cuttings in 1886. In the Eleventh From half of each of the three differently manured plots, the turnip-crops (roots and leaves) are Course clover was sown (with the barley, in e clover was again sown in April 1893, and gave two
 $T_{\text {able }}$ II. (below), gives the results relating to the portions of each plot from which the turnip-crops were entirely removed;

( 103 )

$\underset{\text { Area under experiment, about } 3 \text { acres.) }}{\text { A GELI }}$ These Experiments were commenced in 1848; so that the present season, 1898, is the 51st, In the First Course, clover was sown over the whole of each of the three difierently manured 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,
 mineral and Nitrogenous manure, as described in the foot-note, No. 3 . (roots and leaves) Eleventh Course clover was sown (with the barley) in 1889, but failed during the winter, and in From half of each of the three differently manured plots, the turnip-crops (r sheep, or spread $\quad 1890$ beans were grown instead. In the Twellth Course clover was again sown in April April 1897, but failed during the winter, and in 1898 beans were grown inste
$T_{\text {able }}$ III. (below), gives the results relating to the portions of each plot on which the turnip-crops were either fed off by sheep,

( 105 )


Fxperiments on an Aotual Course of Rotation-Turnips, Barley, Leguminous Crop (or Fallow), and Wheat. These Experiments were commenced in or i848; so that the present season, 1898, is the 51st, In the First Course, clover was sown over the whole of each of the three differently manured or 36 years, $1848-88$, been manured with Superphosphate of Limealone once every four is for the turnip-crop commencing each course ; but for the Tenth, Eleventh, Twelfth, and Thirteenth $\quad \begin{aligned} & \text { In the Second, Third, and Fourth Courses, clover was sown, but failed; and in them, and in } \\ & \text { the Fifth and Sixth Courses, beans were taken instead. In the Seventh Course, clover wns in }\end{aligned}$ one-third has been manured (also for the turnip-crop only), with a complex mineral and Nitro- (spring 1873), and gave three cuttings in 1874 . In the Eighth Course beans were grown. In the genous manure, as described in the foot-note, No. 3.
From half of each of the Tenth Course clover was sown (in the spring of 1885 ), and yielded two cuttings in 1886. In are removed; and on the other half they are either consumed on the land by sheep, or spread and $\quad$ the ELeventh Course clover was sown (with the barley), in 18989 beans were grown failed during the winter, and Table IV. (below), gives the results relating to the portions of each plot on which the turnip-crops were either fed off by sheep,


$$
\begin{aligned}
& \text { Description of } \\
& \text { Cropn }
\end{aligned}
$$ land.

( 106 )
$\square$
( 107 )

AGDELL FIELD.
(Area under experiment, about 3 acres.)
Efperiments on an Actual Cofrse of Rotation-Turnifs, 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 experi- Courses, on account of the change in the Mineral Manures used on Plot 2 . Averages are averages are given, first of the prodnce of the eight intermediate Courses (Courses 2-9, change in the Mineral Manures applied to Plot 2. For full particulars of the manures 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
pages 101, Plot 2, and also
103 , 105 , or 107 . 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

| 1 lb . (pound avoir.) per acre |
| :--- |
| 1 cwt. (hundredweight) per acre (about) |
| = (about) |
| 125.5 Kilogramme per Hectare, or 0.57 Zollverein Pfund. per Prussian Morgen |


| Years. | Description of Crop. | Produce per acre. |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Plot 1. <br> Unmanured continuously. |  |  | Роот 2. <br> Superphosphate of Lime, alone, Courses 1-9, Complex Mineral Manure, Courses 10-12, for the Turnip Crops only. |  |  | Plot 3. <br> Complex Mineral and Nitrogenous Manure, for the Turnip Crops only. |  |  |
|  |  | Corn (1) (or Roots). | Straw (or Leaf). | $\begin{gathered} \text { Total } \\ \text { Produce. }\left({ }^{2}\right) \end{gathered}$ | Corn (1) <br> (or Roots). | Straw (or Leaf). | $\underset{\text { Produce. } \left.{ }^{(2}\right)}{\text { Total }}$ | $\begin{aligned} & \text { Corn (1) } \\ & \text { (or Roots). } \end{aligned}$ | Straw (or Leaf). | Total <br> 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 <br> Average of 8 Courees (Courses 2-9), 1852-1883. |  |  |  |  |  |  |  |  |  |  |
| 1852, '56, '60, '64, '72,'76, '80 <br> 1853, '57, '61, '65, '69, '73, '77, '81 <br> 1854, '58, '62, '66, '70, '74, '78, '82 <br> 1855, '59, '63, '67, '71, '75, '79, '83 |  |  |  |  | lel 1268 owts. |  |  | $266 \frac{1}{4} \mathrm{cwts}$. 42 $\frac{3}{8}$ bush. 214 bush. $32 \frac{5}{8}$ bush. |  | 2901 $\frac{1}{2}$ cwts. 4962 lbs. 75 cwts. 5847 los 5847 lbs. |



( 110 )
Rebults of Experiments with diffrerent Desoriptions of


DRESSED CORN


[^6]
## （ 111 ）

WHEAT， 12 Years，1871－1882，maoh Year in a different Field．

| 1876 ； <br> Har＇penden Field ； 2 cwts ．Nitrate Soda； after Mangels （with Dung）， 1875，carted off． | 1877 ； <br> Sawpit Field； 18 ${ }^{3} \mathrm{wt}$ ．Nitrate Soda； after Mangels （with Dung）， 1876，carted off． | 1878 ； <br> Foster＇s Field ； 2 cwts ．Nitrate， after White Turnips （with Dung and Artificial）， 1877，part Fed， part carted off． | 1879 ；${ }^{1}$ ） <br> Little Knott－ Wood Field； 2 cwts．Nitrate； after Clover． First and second Crops，as Hay； afterwards Fed． | 1880；${ }^{(2)}$ <br> Harpenden Field； 50 bushels of Soot ； after Clover unmanured． One Crop as Hay ；after－ wards Fed． | 1881； <br> Rackyard Field； 1雰 owt．Nitrate Soda； after Mangels （with Dung and Guano）， 1880，carted off． | 1882 ；${ }^{(3)}$ <br> Foster＇s Field； 2 cwts． Nitrate Soda；after Fallow 1881. | （3） Averages， 8 Years， 1871 to 1878 inclusive． | Nos． |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| PER AORE．Bushels． |  |  |  |  |  |  |  |  |
| $49 \frac{1}{2}$ | $48 \frac{3}{8}$ | 59 | $22 \frac{3}{4}$ | 281 | 54 |  | 487 | 1 |
| $42 \frac{1}{2}$ | 498 | $66^{1}$ | 16 | 223 | $52 \frac{1}{4}$ |  | 535 | 2 |
| 404 | $41 \frac{3}{2}$ | 55！ | $20 \frac{3}{4}$ | 147 | ．． |  | $41{ }_{4}^{1}$ | 3 |
| $43{ }^{\text {a }}$ | 41 | ．．．． | ．．．． | ．．．． |  |  | 39 | 4 |
| 391 | 407 | 491 | 24 | 195 | 471 | $+$ | 415 | 5 |
| 441 $\frac{1}{4}$ | 415 | $52 \frac{1}{8}$ | 22 | $28 \frac{1}{4}$ | $45{ }^{2}$ | \％ | $42{ }^{\frac{3}{6}}$ | 6 |
| 383 | 39 | $46 \frac{1}{4}$ | 27 | 27 | 443 | ${ }_{\text {a }}$ | 39 䂞 | 7 |
| 423 | $44 \frac{1}{8}$ | $52 \frac{1}{6}$ | $21 . \frac{5}{6}$ | $30{ }^{5}$ | 464 | \％ | 42 l | 8 |
| $37 \frac{1}{2}$ | $40 \frac{5}{8}$ | － $47 \frac{3}{4}$ | 307 | 273 | 46 | $\cdots$ | 391 | 9 |
| 42 ${ }^{\frac{1}{2}}$ | 427 | $50 \frac{3}{4}$ | 25. | 285 | 48즐 | d | 415 | 10 |
| $46{ }_{8}^{5}$ | $37 \frac{1}{2}$ | 48 | 20 | － 21 | $44 \frac{1}{8}$ | ． 60 | 413 | 11 |
| 44 | 421 | 54 | $21_{\frac{1}{2}}$ | 248 | 45 需 | \％ | $44 \frac{5}{8}$ | 12 |
| 483 | 4912 | 523 | 21 | $18{ }^{7}$ | $50 \frac{3}{4}$ | $\stackrel{\square}{8}$ | 463 | 13 |
| $41 \frac{1}{\frac{1}{d}}$ | $42_{8}^{5}$ | 437 | 14？ | $15 \frac{3}{4}$ | 44 |  | 4.0 等 | 14 |
| $43 \frac{1}{2}$ | 40 | 424 | $17 \frac{3}{8}$ | $22 \frac{3}{4}$ | ．．．． | － | 377 | 15 |
| $40{ }^{1}$ | 443 | ．．．． | ．．． | ．．．． | ．${ }^{\text {．}}$ |  | $36 \frac{1}{2}$ | 16 |
| $37 \frac{1}{2}$ | $37 \frac{5}{8}$ | 493 | 117 | 278 | 47 ${ }_{\text {I }}$ |  | 371 | 17 |
| 40 | 463 | 57 | $8 \frac{1}{2}$ | 283 | $45 \frac{3}{4}$ | － | 451 | 18 |
| $45 \frac{1}{2}$ | 43 | 479 ${ }^{\text {a }}$ | 153 | $24 \frac{1}{1}$ | 427 | \％ | $42 \frac{1}{8}$ | 19 |
| 383 | 363 | $46 \frac{3}{4}$ | $14 \frac{3}{8}$ | $31 \frac{1}{4}$ | 415 ${ }^{\frac{5}{8}}$ | － | $40{ }^{\frac{3}{y}}$ | 20 |
| 413 | $44 \frac{3}{4}$ | 523 | 31 | $24 \frac{1}{2}$ | $46 \frac{1}{2}$ | \％ | 44 | 21 |
| 475 | 491 | 61 | $23 \frac{1}{2}$ | $16 \frac{3}{8}$ | $43^{3}$ |  | $49 \frac{1}{4}$ | 22 |
| ．$\cdot$ | － | 501. | 321 | $16 \frac{1}{2}$ | $44 \frac{1}{4}$ | ， | $50 \frac{1}{4}$ | 23 |
|  | － | 505 | 24 | 157 | 395 |  | 505 | 24 |
| ．．．． | ．．．． | $52 \frac{1}{2}$ | 213 | $9 \frac{3}{4}$ | ．．．． |  | $52 \frac{1}{2}$ | 25 |
| ．${ }^{\text {a }}$ | ．．． | ．．．． | ．．． | 301 | 391 |  |  | 26 |
| 421 $\frac{1}{2}$ | 427 | 51爯 | $21 \frac{1}{4}$ | $23{ }^{1}$ | 459 |  | 43，$\frac{1}{2}$ | Means． |
| BUSHEL．Libs． |  |  |  |  |  |  |  |  |
| 63 | $60 \frac{8}{4}$ | 607 | 518 | $54 \frac{3}{4}$ | 578 |  | 61 | 1 |
| 597 | 604 | $58 \%$ | $49 \frac{1}{8}$ | 55 | $56{ }^{3}$ |  | 583 | 2 |
| 627 | $60 \frac{1}{4}$ | $61 \frac{1}{4}$ | 53 | 583 | ， |  | $60 \frac{9}{4}$ | 3 |
| $63 \frac{1}{6}$ | $60 \pm$ | ．${ }^{\text {．}}$ | ．${ }^{\text {．}}$ | $\cdots$ | $\cdots$ |  | 613 | 4 |
| $62 \frac{1}{2}$ | $60 \frac{3}{4}$ | 623 | 525 | 547 | 601 | ＋ | 61 | 5 |
| 63 | $61 \frac{1}{4}$ | 63 | $52 \frac{1}{2}$ | $56{ }^{5}$ | 601 | 8 | $61 \frac{1}{4}$ | 6 |
| $64 \frac{3}{4}$ | $61 \frac{1}{4}$ | 64 | $55 \frac{1}{4}$ | 581 | 61 | \％ | $622^{\frac{5}{8}}$ | 7 |
| $62 \frac{3}{4}$ | 593 | 631 | $54{ }^{3}$ | $57 \frac{1}{8}$ | $60 \frac{3}{4}$ | 8 | 614 | 8 |
| 66 | $58 \frac{3}{4}$ | $62^{3}$ | 574 | 598 | $61{ }^{\text {a }}$ | $\cdots$ | 631 | 9 |
| $63^{5}$ | 611 | $63 \frac{1}{8}$ | $54 \frac{1}{2}$ | $56 \frac{3}{4}$ | 59 | ＇®0 | $61{ }^{\frac{5}{8}}$ | 10 |
| $63{ }^{\text {a }}$ | 597 | 621 | $52{ }_{8}^{1}$ | 55.5 | 605 | ． 0 | 613 | 11 |
| $63 \frac{1}{2}$ | 597 | $61 \frac{1}{2}$ | 523 | 55. | 601 | － | 613 | 12 |
| $64{ }^{\text {a }}$ | 61 | $63 \frac{1}{2}$ | $52 \frac{3}{4}$ | $55 \frac{3}{4}$ | 614 | $\stackrel{\square}{6}$ | $62 \frac{1}{2}$ | 13 |
| 63 9 | 61 | $61{ }^{\frac{3}{4}}$ | $51 \frac{1}{2}$ | $56 \frac{1}{4}$ | 607 | ， | 61 爯 | 14 |
| $63{ }^{5}$ | 597 | 621 | 55 | $59 \frac{1}{4}$ | ． | $\ddot{8}$ | $60 \frac{3}{4}$ | 15 |
| $62 \frac{3}{4}$ | 59 | ．${ }^{\text {a }}$ | $\cdots$ ．${ }^{\text {a }}$ | －．${ }^{\text {c }}$ | $\cdots$ ．${ }^{\text {c }}$ | 旡 | 593 | 16 |
| $64{ }^{5}$ | $61{ }^{1}$ | $61 \frac{1}{2}$ | $54 \frac{1}{2}$ | 58 | 605 | 哏 | 62 | 17 |
| $63 \frac{1}{8}$ | 591 | 601 | 54 | 565 | 607 | － | 597 | 18 |
| $63 \frac{1}{8}$ | 593 | $60 \frac{3}{4}$ | $55{ }^{3}$ | 58 2 | 617 | \％ | $60^{\text {需 }}$ | 19 |
| $65 \frac{1}{8}$ | $60 \frac{9}{4}$ | $61 \frac{3}{4}$ | $54 \frac{1}{4}$ | 573 | 621 | \％ | 62 | 20 |
| $63^{7}$ | $60 \frac{1}{4}$ | 631 | $55 \frac{1}{4}$ | 557 | $61 \frac{3}{4}$ | \＆ | $61 \frac{1}{2}$ | 21 |
| $63 \frac{1}{4}$ | 593 | $62{ }^{\frac{1}{8}}$ | 527 | 55. | 603 | H | $61 \frac{1}{1}$ | 22 |
| ．．．． | ．．．． | $61 \frac{3}{4}$ | $56 \frac{1}{4}$ | $57 \frac{1}{8}$ | 61 |  | $61{ }^{\frac{8}{4}}$ | 23 |
| ．$\cdot$ ． | ．．． | 613 | $53 \frac{1}{4}$ | $56 \frac{1}{4}$ | 611 |  | 613 | 24 |
| ．．． | $\cdots \quad$. | $60 \frac{3}{4}$ | $51{ }^{\text {4 }}$ | $53{ }^{3}$ | $\because \cdot$ |  | $60 \frac{3}{4}$ | 25 |
|  | ．．．． |  | $\cdots$ | 591 | 587 |  |  | 26 |
| $68 \frac{1}{2}$ | $60{ }^{1}$ | 62 | $53 \frac{1}{2}$ | $56 \frac{3}{6}$ | 603 |  | 614 | Teang． |

Wheats appeared to suffer most，either from imperfectly developed seed，wire－worm，or blight．The most satisfactory crop was ${ }^{\text {t }}$ Webb＇s （3）Owing to the produce of 1879 and 1880 being so the seedsman，not grown on the farm，as were the others．
（4）The crop of 1882 was completely beaten down by the 1879 and 1880 beilly bad，that of those years is not included in the averages；nor is that of 1881.
of the graln；the produce was therefore not kept separate or welghed；and in some places not even threshed．


[^0]:    Series 1; 5 Lands.(1) Without Manure, or with Mineral Manure only

    | Sertes 2. |  |
    | :--- | :--- |

[^1]:    

[^2]:    

[^3]:    Manures, per Acre, per AnNum.

[^4]:    (1) "Superphosphate of Line "-in all cases made from 200 lbs . Bone-ssh, 150 lbs . Sulphuric acid, ep. gr. $1 / 7$ (and water)
    (2) Ammonium-salts"-in each case equal parts Sulphate and Muriate Ammonia of Commerce.

[^5]:    

[^6]:    (I) 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 weed*, which the wet month of July much favoured and made it impossible to keep under. The white

