figure meat will unquestionably be dear in price; but much will depend upon the ability of the speculators to hold tallow, and the value of money in the discount market.

## Supplies, Demand, and Value, during the past Six Months.

Notwithstanding that the total number of beasts exhibited and disposed of in the metropolitan cattle-market in the last six months has been a full average one, viz.—114,702 head against 113,373 head in the corresponding period in 1859, and 111,592 in 1858, prices, from causes to which we have already alluded, have ruled unusually high. The average value of the best Scots has been 5*s.* 6*d.*, against 5*s.* in the previous six months, and 4*s.* 6*d.* in 1858. But here we may observe that at least a moiety of the various breeds has been disposed of in little more than a half-fat state, and hence the actual supply of meat has been trifling. The same remark may be applied to sheep, especially to the long-woolled qualities. Compared with last year—taking the average of the six months—the value of that description of stock has advanced from 4*d.* to 6*d.* per 8 lbs., though at one period the rise was much greater, viz., 1*s.* to 1*s.* 4*d.* per 8 lbs. The annexed returns show the total supplies exhibited, the quarters from whence they were derived, and the prices at which they were disposed of:—

*Supplies of each kind of Stock Exhibited and Sold during the first Six Months of the following Years:—*

| | 1855. | 1856. | 1857. | 1858. | 1859. | 1860. |
|---|---|---|---|---|---|---|
| Beasts .. .. .. | 113,089 | 115,115 | 112,309 | 111,592 | 113,373 | 114,702 |
| Cows .. .. .. | 2,440 | 2,977 | 2,682 | 2,917 | 2,977 | 2,904 |
| Sheep and Lambs | 651,600 | 636,030 | 536,790 | 588,758 | 668,702 | 662,030 |
| Calves .. .. .. | 8,610 | 6,125 | 8,420 | 8,878 | 7,272 | 9,515 |
| Pigs .. .. .. | 16,590 | 15,344 | 13,240 | 13,096 | 14,869 | 14,201 |

*"District" Bullock Supplies.*

| | 1855. | 1856. | 1857. | 1858. | 1859. | 1860. |
|---|---|---|---|---|---|---|
| Northern Districts .. | 600 | 900 | .. | 4,000 | 4,000 | 4,000 |
| Eastern Districts .. .. | 54,989 | 51,700 | 60,500 | 66,890 | 67,460 | 68,520 |
| Other parts of England | 12,530 | 13,850 | 14,490 | 14,560 | 19,090 | 21,420 |
| Scotland .. .. .. .. | 9,827 | 10,008 | 8,860 | 8,456 | 10,030 | 5,033 |
| Ireland .. .. .. .. .. | 4,000 | 3,400 | 2,700 | 4,820 | 2,217 | 1,477 |
| Foreign .. .. .. .. | 13,612 | 7,830 | 9,238 | 5,649 | 7,580 | 9,058 |

*Average Prices of Beef and Mutton.*

| | 1855. | 1856. | 1857. | 1858. | 1859. | 1860. |
|---|---|---|---|---|---|---|
| Beef:— | *s. d.* | *s. d.* | *s. d.* | *s. d.* | *s. d.* | *s. d.* |
| Inferior .. .. .. .. | 3 2 | 3 0 | 3 2 | 3 0 | 3 2 | 3 6 |
| Middling .. .. .. | 4 0 | 3 10 | 4 0 | 3 10 | 4 0 | 4 6 |
| Prime .. .. .. .. | 4 10 | 4 8 | 5 0 | 4 6 | 5 0 | 5 6 |
| Mutton:— | | | | | | |
| Inferior .. .. .. .. | 3 2 | 3 0 | 3 10 | 3 2 | 3 4 | 3 10 |
| Middling .. .. .. | 4 2 | 4 0 | 5 0 | 4 2 | 4 8 | 5 2 |
| Prime .. .. .. .. | 5 4 | 5 2 | 6 0 | 5 2 | 5 10 | 6 2 |

From the above returns it will be seen that average *number* of beasts has been drawn from our grazing districts; that we have drawn extensively upon foreign resources; but that the arrivals both from Ireland and Scotland have considerably fallen off. In reference to the value of lambs, we may state that at one period it was 8*s.* per 8 lbs. for the best Down breeds, now it is 7*s.* Both calves and pigs have ruled high; the top figure for the former having been 6*s.*, the latter 5*s.* 4*d.* per 8 lbs. to sink the offal.

In a comparative sense the arrivals of meat up to Newgate and Leadenhall, both from Scotland and different parts of England, have fallen off considerably. Prices have, consequently, kept pace with the rise in the live markets; but our impression is, that they have seen their highest range for the year, and that they will tend to stimulate the production of stock both in the United Kingdom and on the Continent.

5, *Argyle-square, St. Pancras, London.*

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## XI.—*Report of Experiments on the Growth of Red Clover by different Manures.* By J. B. Lawes, Esq., F.R.S., F.C.S., and Dr. J. H. Gilbert, F.R.S., F.C.S.

### Part I.

Few questions in connexion with agriculture have excited more attention, or have been the subject of a greater variety of explanations, than the failure of Red Clover. It certainly seems somewhat strange that, whilst some of our farm crops can be grown year after year, or in pretty close succession, on the same land for a considerable period of time, and, for what we yet know to the contrary, continuously, others will only succeed when some years have elapsed since the same description of crop was grown.

In works on agriculture the failure of clover is accounted for in a great number of ways, among which the following assumed causes may be mentioned :—

Exhaustion of the soil ;
The growth of parasitic plants, which strike their roots into the clover and exhaust its juices ;
Destruction by insects ;
The injurious influences arising from the matter excreted by the roots of the former crop, or from the decay of the roots themselves ;
The growth of the young plant under the shade of a corn crop.

Although the Clover crop may be found to suffer from more than one of the above-enumerated causes, the phenomena which present themselves are nevertheless by no means satisfactorily explained ; and, so far as prevention is concerned, our knowledge is pretty nearly limited to that of the fact, that the only chance of growing the crop with success is to allow a certain number of years to elapse before repeating it on the same land. We have experimented for some years on the subject with a view to ascertain, if possible, by what means the crop can be grown year after year on the same land. In this we have not been successful. Still it is thought that a short account of the course pursued, and of the results obtained, may be of service, by showing some of the difficulties involved in the inquiry, and by limiting or indicating the direction of future investigations.

Experiments on this farm have satisfactorily shown that some of the crops which are generally grown in rotation, will yield a large amount of produce year after year on the same land, on the application of certain constituents as manure. Thus, a part of the same field, in which the experiments on Clover now in question were made, has grown barley for ten years in succession, and on some plots large crops have always been obtained. In like manner, in an adjoining field, wheat has been successfully grown for sixteen years consecutively. Nor is there at present anything in the results to lead to the supposition that these crops might not be so grown continuously for a century. The results of somewhat similar experiments with Clover are very different, as the records we are about to give will show.

In 1847 a heavy crop of swedish turnips was grown by farm-yard manure and superphosphate of lime, a large proportion of which was carted from the land. In 1848 barley and Red Clover were sown ; and in the spring of 1849 four acres were set apart for experiment. These were divided into a number of plots, which were manured as shown in Table I.

## Experiments on the Growth of Red Clover by Different Manures.

Table I.—Showing the Description and Amount of Manures employed, and the Amount of Produce obtained per Acre.
First Season, 1849.

| Plot, Nos. | MANURES per Acre. | PRODUCE per Acre. 3 Cuttings—June 26 and 28; August 6; October 19. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Weights Fresh, as Cut. | | | | Weights calculated as Hay.* | | | |
| | **Series 1.—Unmanured, or with Mineral Manures alone.** | tons. | cwts. | qrs. | lbs. | tons. | cwts. | qrs. | lbs. |
| 1 | Unmanured | 14 | 1 | 3 | 6 | 3 | 15 | 0 | 14 |
| 2 | Superphosphate of Lime (150 lbs. Bone-ash and 112½ lbs. Sulphuric Acid, sp. gr. 1·7) | 15 | 5 | 2 | 16 | 3 | 19 | 3 | 4 |
| 3 | 300 lbs. Sulphate of Potash | 17 | 19 | 2 | 18 | 4 | 17 | 2 | 8 |
| 4 | 300 lbs. Sulphate of Potash, and "Superphosphate of Lime" | 16 | 19 | 3 | 5 | 4 | 9 | 2 | 20 |
| 5 | Mixed Alkalies (300 lbs. Sulphate of Potash, 100 lbs. Sulphate of Soda, and 100 lbs. Sulphate of Magnesia) | 18 | 1 | 0 | 0 | 4 | 11 | 0 | 21 |
| 6 | "Mixed Alkalies," and "Superphosphate of Lime" | 16 | 6 | 3 | 21 | 4 | 12 | 2 | 26 |
| | **Series 2.—With Ammonia Salts alone, or in addition to Mineral Manures.** | | | | | | | | |
| 1 | 100 lbs. each, Sulphate and Muriate of Ammonia | 14 | 17 | 0 | 18 | 3 | 18 | 1 | 26 |
| 2 | 100 lbs. each, Sulphate and Muriate of Ammonia, and "Superphosphate of Lime" | 14 | 8 | 0 | 16 | 3 | 18 | 0 | 1 |
| 3 | 100 lbs. each, Sulphate and Muriate of Ammonia, and 300 lbs. Sulphate of Potash | 13 | 10 | 1 | 17 | 3 | 11 | 0 | 11 |
| 4 | 100 lbs. each, Sulphate and Muriate of Ammonia, and 300 lbs. Sulphate of Potash and "Superphosphate of Lime" | 17 | 12 | 2 | 22 | 4 | 9 | 3 | 16 |
| 5 | 100 lbs. each, Sulphate and Muriate of Ammonia, and "Mixed Alkalies" | 17 | 10 | 0 | 22 | 4 | 14 | 2 | 20 |
| 6 | 100 lbs. each, Sulphate and Muriate of Ammonia, "Mixed Alkalies," and "Superphosphate of Lime" | 17 | 10 | 0 | 2 | 4 | 12 | 0 | 2 |
| | **Series 3.—With Rape-Cake.** | | | | | | | | |
| 1 2 3 4 5 6 | 1000 lbs. Rape-Cake | 12 | 17 | 1 | 23 | 3 | 7 | 2 | 25 |

* On the supposition that the Hay would consist of 5 parts dry substance, and 1 part water.

As our object in the present short communication is to do little more than call attention to the great variety of conditions under which the Clover-plant has failed, we shall not enter, on this occasion, into any detailed examination of the action of the various manures, in regard either to the amount of produce obtained under the different circumstances of season and manuring, or to the chemical composition of the plant. It will be sufficient to point out, that, in every case, the crop of this first year of the experiment was a very large one; amounting, in three cuttings, to about 14 tons of fresh green produce, equal to about $3\frac{3}{4}$ tons of hay, without the addition of manure of any kind; and where sulphate of potash, sulphate of potash and superphosphate of lime, or sulphates of potash, soda, and magnesia, were employed, 17 to 18 tons of green produce (equal to from about $4\frac{1}{2}$ to nearly 5 tons of hay), per acre were obtained. When to the mineral manures were added those salts of ammonia which so greatly increase the produce of our Cereal crops, the produce of this Leguminous plant was upon the whole less than where the mineral manures were used alone. It will be seen too, that the rape-cake (Series 3) gave a smaller crop than either the mineral manures alone, or the mineral manures together with ammoniacal salts.

After the third cutting of Clover (1849) had been taken from the land, it was ploughed up and sown with wheat, about the middle of November, without any further manuring. The produce—corn, straw, &c.—is given in Table II.

It will be observed that the weight per bushel of corn, of this wheat-crop, scarcely in any case reached 58 lbs.; and in its case, as well as in that of an adjoining experimental field, the proportion of corn to straw was rather low. The wheat grown after the Clover on the unmanured plot gave, however, $29\frac{1}{2}$ bushels of corn, or 14 bushels more than was obtained in the adjoining field, where wheat was grown after wheat without manure. This result is quite consistent with that obtained in ordinary farm-practice. It should be observed, however, that in the unmanured Clover-crop of 1849, very much larger quantities both of mineral constituents and of nitrogen were taken from the land, than were removed in the unmanured wheat-crop in the same year, in the adjoining field; and it is seen that, notwithstanding this, the soil from which the Clover had been taken, was in a condition to yield 14 bushels more wheat per acre than that upon which wheat had been previously grown.

Where salts of ammonia had been applied, in addition to the mineral manures, for the Clover of 1849, there was an average of about 2 bushels more wheat per acre in 1850, than where the ammonia-salts had not been supplied.

On

## Experiments on the Growth of Red Clover by different Manures.

Table II.—Showingthe Produce of Wheat, without direct Manure, after the removal of 3 Cuttings of Red Clover, from plots of Land variously manured. Harvest 1850.

| Plot, Nos. | MANURES per Acre, applied in 1849 for the CLOVER. | PRODUCE OF WHEAT per Acre, &c. | | | | |
|---|---|---|---|---|---|---|
| | | Dressed Corn. | Weight per Bushel of Dressed Corn. | Total Corn. | Total Straw, &c. | Total Produce (Corn and Straw). |
| | **Series 1.—Unmanured, or with Mineral Manures alone, in 1849.** | | | | | |
| | | Bush. Pks. | lbs. ozs. | lbs. | lbs. | lbs. |
| 1 | Unmanured | 29 2 | 55 6 | 1792 | 3512 | 5304 |
| 2 | Superphosphate of Lime (150 lbs. Bone-ash and 112½ lbs. Sulphuric Acid, sp. gr. 1·7) | 32 2¾ | 56 14 | 2029 | 3811 | 5840 |
| 3 | 300 lbs. Sulphate of Potash | 30 1¼ | 55 4 | 1867 | 3906 | 5773 |
| 4 | 300 lbs. Sulphate of Potash, and "Superphosphate of Lime" | 33 3¼ | 56 2 | 2097 | 4197 | 6294 |
| 5 | Mixed Alkalies (300 lbs. Sulphate of Potash, 100 lbs. Sulphate of Soda, and 100 lbs. Sulphate of Magnesia) | 31 1 | 56 6 | 1962 | 4088 | 6050 |
| 6 | "Mixed Alkalies," and "Superphosphate of Lime" | 33 1 | 55 15 | 2264 | 4176 | 6440 |
| | **Series 2.—With Ammonia Salts alone, or in addition to Mineral Manures, in 1849.** | | | | | |
| 1 | 100 lbs. each, Sulphate and Muriate of Ammonia | 32 1¾ | 57 4 | 2058 | 3917 | 5975 |
| 2 | 100 lbs. each, Sulphate and Muriate of Ammonia, and "Superphosphate of Lime" | 32 3 | 57 0 | 2062 | 3720 | 5782 |
| 3 | 100 lbs. each, Sulphate and Muriate of Ammonia, and 300 lbs. Sulphate of Potash | 32 3 | 56 15 | 2031 | 3842 | 5873 |
| 4 | 100 lbs. each, Sulphate and Muriate of Ammonia, and 300 lbs. Sulphate of Potash and "Superphosphate of Lime" | 36 0¾ | 57 11 | 2292 | 4296 | 6588 |
| 5 | 100 lbs. each, Sulphate and Muriate of Ammonia, and "Mixed Alkalies" | 35 1 | 58 1 | 2253 | 4135 | 6388 |
| 6 | 100 lbs. each, Sulphate and Muriate of Ammonia, "Mixed Alkalies," and "Superphosphate of Lime" | 33 2¼ | 56 11 | 2093 | 3967 | 6060 |
| | **Series 3.—With Rape-Cake, in 1849.** | | | | | |
| 1 | 1000 lbs. Rape-Cake | 27 0¾ | 56 10 | 1781 | 3520 | 5301 |
| 2 | | 30 1¾ | 57 13 | 1916 | 3692 | 5608 |
| 3 | | 25 2¾ | 55 15 | 1695 | 3468 | 5163 |
| 4 | | 29 2¼ | 56 10 | 1910 | 3822 | 5732 |
| 5 | | 31 3 | 57 9 | 2002 | 3795 | 5797 |
| 6 | | 30 0 | 56 14 | 1891 | 3342 | 5233 |

On comparing the amount of produce of wheat in these experiments, with that obtained in the adjoining field on the plots where large quantities of both mineral and nitrogenous manures were employed, there is every reason to believe that it would have been considerably greater had the season been more favourable. For, as it was, the yield after the Clover, was fully equal to that in the other field where very large amounts of manure were used. It would appear, therefore, that the crop had reached the limit of development which the characters of that particular season admitted of.

In the spring of 1850, Red Clover was sown upon the young wheat; but after the removal of the corn-crop, it was considered that there was not a sufficient plant of Clover to stand. It was, therefore, ploughed up, re-manured, and re-sown with Clover, as described below.

The same mineral manures as were applied for the Clover-crop of 1849, were re-sown on the same spaces—that is, both on the plots which before received mineral manure alone, and on those which had received both mineral manure and ammoniacal-salts. The application of ammoniacal salts was, however, not repeated; but, in order to secure a greater variety of manuring, a portion of the plots which had before been dressed with mineral manure alone (Series 1 of Tables I. and II.), and an equal portion of those formerly manured with both mineral manure and ammoniacal salts (Series 2 of Tables I. and II.), were now manured with a compost of dung and lime (in addition to the newly-supplied mineral manures), at the rate of 15 tons of farmyard-manure, and 60 bushels of fresh lime, per acre. The dung and lime were mixed, and then clamped on the respective plots, some time before being spread and ploughed into the land. The object of this experiment was to get a more rapid decomposition of the dung, with possibly the formation of certain organic compounds, somewhat of the nature of humus or its derivatives. For similar reasons the portion of the experimental land manured with rape-cake in 1849, was now divided, and manured with soot; with soot and lime; or with soot, lime, the mixed alkalies, and superphosphate of lime.

Instead therefore of three Series of plots as formerly, the experimental land was now divided into four Series, as under:—

*Series* 1. With mineral manure alone (or unmanured on Plot I.), as in 1849.

*Series* 2. With mineral manure (or without, on Plot I.), and a mixture of farmyard-manure rotted with lime, in addition; half of each plot having, in 1849, the mineral manure alone, and the other half the mineral manure and ammoniacal-salts.

*Series* 3. With mineral manure alone (or without it, on Plot I.), ammoniacal-salts having been also applied in 1849.

*Series* 4. With soot, soot and lime, or soot, lime, and the mixed mineral manure; these plots having been manured with rape-cake in 1849.

With these explanations, the detailed statement of the manures applied, and of the produce obtained, given in Table III., will be at once understood. It may be added, however, that on most of the plots of Series 1, 2, and 3, the mineral manures (mixed with clay-ashes) were sown on January 25, 1851. On the same day the dung and lime were mixed and clamped on the plots of Series 2; the mineral manures of Plots V. and VI., Series 2, being mixed with the dung and lime, instead of being sown at once as in the other cases. The heaps of dung and lime were turned over on the 10th of February, and spread on April 28. The manures of Series 4 (soot, lime, &c.) were mixed into heaps on the respective plots on January 27, and sown February 3. The whole of the land was ploughed immediately after spreading the dung and lime, on April 28; and, being brought to a proper tilth, Red Clover seed was drilled, on May 8, in rows 8 inches apart. The plants came up well, and the crop was cut on September 3. The details of the manuring and produce are given in Table III.

It was not to be expected that the produce obtained in September, from seed sown only on May 8 of the same year, would be in any way equal to that yielded from seed sown, as is usually the case, in the spring of the preceding year. Accordingly, it is seen that the maximum crop (Plot 7, Series 2) amounted to only 5 tons 9½ cwts. of green-clover, equal to about 1 ton 6 cwts. of hay.

On comparing the produce of Plots 1, 2, and 3, of Series 1, 2, and 3, with that of Plots 4, 5, and 6, of the same Series, it will be seen that the crop on the latter was about double that on the former; the Plots 4, 5, and 6, which thus give so much the higher amounts of produce, being those which received as mineral manure—sulphate of potash, and superphosphate of lime—sulphates of potash, soda, and magnesia—or sulphates of potash, soda, and magnesia, and superphosphate of lime together.

The dung and lime (Series 2), and soot and lime (Series 4), produced but very little effect. The greatest increase obtained by the addition to the mineral manures of the dung and lime compost (at the rate of 15 tons of dung and 60 bushels of lime per acre), beyond the produce from the corresponding mineral manures used alone, was only equal to 4 or 5 cwts.

In the autumn, after the crop was cut, the plant grew remarkably

## Experiments on the Growth of Red Clover by Different Manures.

### Table III.—Showing the Description and Amount of Manures Employed, and the Amount of Produce Obtained, per Acre. Second Season, 1851.

| Plot Nos. | MANURES, per Acre, for the Clover of 1851. | PRODUCE, per Acre, Cut September 1 and 3, 1851. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Weight Fresh, as Cut. | | | | Weight, calculated as Hay. | | | |
| | | tons. | cwts. | qrs. | lbs. | tons. | cwts | qrs. | lbs. |
| **Series 1.—Unmanured, or with Mineral Manures alone (the same as in 1849).** | | | | | | | | | |
| 1 | Unmanured | 1 | 15 | 2 | 8 | 0 | 8 | 3 | 5 |
| 2 | Superphosphate of Lime (150 lbs Bone-ash and 112½ lbs. Sulphuric Acid, sp. gr. 1·7) | 1 | 1 | 0 | 12 | 0 | 5 | 1 | 9 |
| 3 | 300 lbs. Sulphate of Potash | 2 | 4 | 0 | 24 | 0 | 11 | 1 | 0 |
| 4 | 300 lbs. Sulphate of Potash, and "Superphosphate of Lime" | 4 | 0 | 0 | 19 | 0 | 19 | 1 | 23 |
| 5 | Mixed Alkalies (300 lbs. Sulphate of Potash, 100 lbs. Sulphate of Soda, and 100 lbs. Sulphate of Magnesia) | 4 | 12 | 1 | 12 | 0 | 19 | 2 | 25 |
| 6 | "Mixed Alkalies," and "Superphosphate of Lime" | 4 | 17 | 3 | 26 | 1 | 2 | 2 | 19 |
| **Series 2.—With Farmyard Manure and Lime, either alone, or with Mineral Manures in addition (Ammonia-salts, &c., on Half of each Plot in 1849).** | | | | | | | | | |
| 1 | 15 tons Farmyard Manure with 3720 lbs. Lime | 2 | 9 | 0 | 11 | 0 | 11 | 2 | 25 |
| 2 | 15 tons Farmyard Manure with 3720 lbs. Lime, and "Superphosphate of Lime" | 2 | 4 | 2 | 13 | 0 | 10 | 2 | 23 |
| 3 | 15 tons Farmyard Manure with 3720 lbs. Lime, and 300 lbs. Sulphate of Potash | 2 | 18 | 2 | 12 | 0 | 13 | 3 | 12 |
| 4 | 15 tons Farmyard Manure with 3720 lbs. Lime, and 300 lbs. Sulphate of Potash, and "Superphosphate of Lime" | 5 | 1 | 0 | 0 | 1 | 3 | 1 | 7 |
| 5 | 15 tons Farmyard Manure with 3720 lbs. Lime, and "Mixed Alkalies" | 4 | 12 | 1 | 12 | 1 | 0 | 2 | 1 |
| 6 | 15 tons Farmyard Manure with 3720 lbs. Lime, and "Mixed Alkalies," and "Superphosphate of Lime" | 5 | 5 | 1 | 4 | 1 | 3 | 2 | 0 |
| 7 | 15 tons Farmyard Manure with 3720 lbs. Lime, and "Mixed Alkalies," and "Superphosphate of Lime" | 5 | 9 | 2 | 0 | 1 | 6 | 0 | 2 |
| **Series 3.—Unmanured, or with Mineral Manures alone (Ammonia Salts alone, or with Mineral Manure, in 1849).** | | | | | | | | | |
| 1 | Unmanured | 1 | 18 | 2 | 25 | 0 | 9 | 1 | 4 |
| 2 | "Superphosphate of Lime" | 1 | 16 | 2 | 9 | 0 | 9 | 0 | 7 |
| 3 | 300 lbs. Sulphate of Potash | 2 | 13 | 0 | 21 | 0 | 13 | 0 | 25 |
| 4 | 300 lbs Sulphate of Potash, and "Superphosphate of Lime" | 4 | 8 | 3 | 14 | 1 | 0 | 0 | 0 |
| 5 | "Mixed Alkalies" | 4 | 10 | 2 | 21 | 1 | 0 | 0 | 27 |
| 6 | "Mixed Alkalies," and "Superphosphate of Lime" | 4 | 16 | 2 | 9 | 1 | 3 | 0 | 20 |
| **Series 4.—With Soot, &c. (Rape Cake, in 1849).** | | | | | | | | | |
| 1 2 | 1240 lbs. Soot | 2 | 10 | 3 | 2 | 0 | 12 | 2 | 12 |
| 3 4 | 1240 lbs. Soot and 1240 lbs. Lime | 3 | 18 | 2 | 25 | 0 | 18 | 3 | 16 |
| 5 6 | 1240 lbs. Soot, and 1240 lbs. Lime, "Mixed Alkalies," and "Superphosphate of Lime" | 4 | 18 | 3 | 1 | 1 | 2 | 3 | 27 |

ably well, and was very regular throughout the plots. It was therefore left without further treatment during the winter of 1851-2.

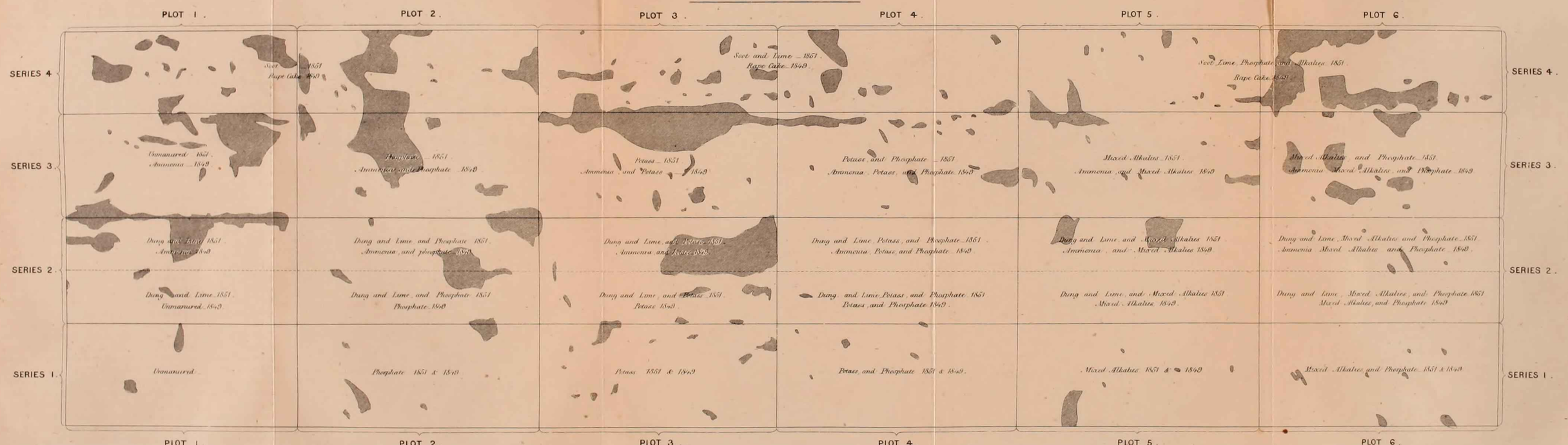
Those who have paid attention to the spread of disease in clover, on land which is said to be "clover-sick," will have observed that, however luxuriant the plant may be in the autumn and winter, it will show signs of failure in March or April, the spread and final limit of the disease being, however, subject to great variation. In the month of March, 1851, symptoms of failure became apparent on many of the experimental plots. It was quite plain however that the spread of the disease was much more extensive and rapid on some of them than on others. And, since such a great variety of manures had been employed, it was thought very desirable to determine the effect of the different conditions of growth so provided, in aggravating, or lessening, the progress of the failure. Accordingly, on April 15, when the disease had extended pretty nearly to its limits, and the surviving plants were showing vigorous growth, a plan of the plots, with the patches where the plant had died off, carefully laid down by measurement, was made, of which the annexed Diagram is a copy.

The black lines show the division of the plots at the time the plan was taken. The dotted line, along the centre of the plots marked Series 2, shows the division between the portion which was manured with ammonia-salts in 1849, and that which was not so manured; and, as already described, the plots of "Series 2," of 1851 and afterwards, to which farmyard-manure and lime were then applied, comprised a portion of land on each side of the line indicated on the plan by this dotted line; that is to say, a portion which had, and a portion which had not, been manured with ammonia-salts in 1849. The shaded portions show the patches where the clover-plant had died off.

On the first glance at the Diagram, it is seen that the plots which had not been manured with either farmyard-manure, ammonia-salts, or rape-cake (Series 1), were by far the freest from disease. The next in order in this respect was that half of Series 2 indicated below the dotted line; that is to say, the portion of the dung and lime plots which had not been manured with ammonia-salts in 1849. The other half of the plots of Series 2, namely, the portions which had received ammonia-salts in 1849—the plots of Series 3, which had also received ammonia-salts in 1849—and those of Series 4, which had been manured with rape-cake in that year, all show a very great failure of the plant. It is, however, equally clear, that the Plots 4, 5, and 6 of these Series (with the exception of Plot 6, Series 4) were much less affected than Plots 1, 2, and 3 of the same Series; that is to say,

# PLAN OF EXPERIMENTAL CLOVER PLOTS.. APRIL 1852.

*The Shaded Portions represent the places where the Plant had died off*



although the ammonia-salts and the rape-cake seemed to have provided conditions in the soil very injurious to the healthy development of the Clover, the sulphate of potash, and superphosphate of lime (Plots 4), and the sulphates of potash, soda, and magnesia, both with and without superphosphate of lime (Plots 5 and 6), obviously greatly mitigated the injury, whilst they seem almost to have prevented it, up to the date now in question, where they were used without either ammonia-salts or rape-cake.

In some cases, as will be readily seen from the number and the size of the patches, the produce was considerably reduced by the disease. But there was still, upon the whole, a good plant remaining, and such variety of result in regard to the disease, according to the manure employed, that it was thought quite worth while to continue the experiment. Acordingly, the crop was cut on June 24, fresh manures were applied on June 26, and a second crop was cut August 29. In Table IV. are given the amounts of produce obtained at the first cutting, the description and amount of the manures applied, and the amount of produce at the second cutting.

The produce of the first cutting of the clover, in 1852, is given in the first two columns of the Table (IV.). It will be seen that it is in no case equal in amount to 2 tons of hay per acre. On comparing the amount of crop on the plots of one Series with that on those of another, it is seen that it is generally the highest where only the mineral manures were used, that is, in Series 1. It is the next best in Series 2, where, in addition to mineral manures, dung and lime had been used in 1851. It is less in Series 3, where, with the same mineral manures in 1851, as in Series 1 and 2, ammonia-salts, with or without mineral manures, had been employed in 1849; and it is the worst in Series 4, where rape-cake had been supplied in 1849, and soot, lime, &c., in 1851. The results within each Series, however, show a greater produce where sulphate of potash and superphosphate of lime, the "mixed alkalies," and the "mixed alkalies" and superphosphate of lime together, were employed.

There was then, as before, some benefit arising from the use of mineral manures, especially those which contained *potash* and *phosphoric acid*. And as the object of the experiments was to ascertain whether by liberal manuring, and especially by a supply of the mineral constituents which the Clover crop removes so largely from the soil, it were possible to grow the crop year after year on the same land, an abundant top-dressing of mineral constituents was applied on June 28 (1852), after the removal of the first cutting. The second division of the Table (IV.) shows the description, and amount, of the manures employed; and the third division the amount of crop obtained on August 29.

The

## Experiments on the Growth of Red Clover by Different Manures.

Table IV.—Showing the Amount of Produce obtained per Acre in the First Crop, the Description and Amount of Manures Employed, and the Amount of Produce afterwards obtained in the Second Crop.

Third Season, 1852.

| Plot, Nos. | Produce per Acre. 1st Cutting, June 24, 1852. Weight Fresh, as Cut. | Produce per Acre. 1st Cutting, June 24, 1852. Weight, calculated as Hay. | MANURES Per Acre, Sown June 26, 1852. | Produce per Acre. 2nd Cutting, August 29, 1852. Weight, Fresh, as Cut. | Produce per Acre. 2nd Cutting, August 29, 1852. Weight, calculated as Hay. | Total Produce per Acre, 1852. 1st and 2nd Cuttings. Weight Fresh, as Cut. | Total Produce per Acre, 1852. 1st and 2nd Cuttings. Weight, calculated as Hay. |
|---|---|---|---|---|---|---|---|
| **Series 1.—Unmanured, or with Mineral Manures Alone, in 1852, 1851, and 1849.** | | | | | | | |
| | ton. cwt. qr. lb. | ton. cwt. qr. lb. | | ton. cwt. qr. lb. | ton. cwt. qr. lb. | ton. cwt. qr. lb. | ton. cwt. qr. lb. |
| 1 | 4 14 2 8 | 1 3 2 12 | Unmanured | 2 17 0 27 | 0 16 3 25 | 7 11 3 7 | 2 0 2 9 |
| 2 | 5 3 3 7 | 1 4 3 18 | Superphosphate of Lime (300 lbs. Bone-ash and 225 lbs. Sulphuric Acid, sp. gr. 1·7) | 2 15 0 11 | 0 17 2 8 | 7 18 3 18 | 2 2 1 26 |
| 3 | 5 1 0 7 | 1 4 2 14 | 500 lbs. Sulphate of Potash | 3 3 2 4 | 0 19 0 10 | 8 4 2 11 | 2 3 2 24 |
| 4 | 7 13 0 3 | 1 16 0 24 | 500 lbs. Sulphate of Potash, and "Superphosphate of Lime" | 3 13 2 16 | 1 2 2 22 | 8 6 2 19 | 2 18 3 18 |
| 5 | 7 3 0 6 | 1 12 1 14 | Mixed Alkalies (500 lbs. Sulphate of Potash, 225 lbs. Sulphate of Soda, and 100 lbs Sulphate of Magnesia) | 3 8 1 27 | 0 14 3 14 | 10 11 2 5 | 2 7 1 0 |
| 6 | 6 13 2 20 | 1 12 1 17 | "Mixed Alkalies," and "Superphosphate of Lime" | 3 0 0 6 | 0 19 1 1 | 9 13 2 26 | 2 11 3 0 |
| **Series 2.—Unmanured, or with Mineral Manures Alone, in 1852; with Farmyard Manure and Lime, either Alone or with Mineral Manures in Addition, in 1851; and with Ammonia-Salts Alone, or with Mineral Manures, on Half of each Plot, in 1849.** | | | | | | | |
| 1 | 3 16 0 17 | 0 18 2 5 | Unmanured | 2 0 1 13 | 0 12 3 17 | 5 16 2 2 | 1 11 1 22 |
| 2 | 5 3 1 3 | 0 12 0 0 | Superphosphate of Lime (300 lbs. Bone-ash and 225 lbs. Sulphuric Acid, sp. gr. 1·7) | 2 1 3 2 | 0 14 1 22 | 7 5 0 5 | 1 6 1 22 |
| 3 | 5 2 3 14 | 1 4 2 5 | 500 lbs. Sulphate of Potash | 2 9 2 27 | 0 15 3 25 | 7 12 2 13 | 2 0 2 2 |
| 4 | 8 8 2 22 | 1 19 1 2 | 500 lbs. Sulphate of Potash, and "Superphosphate of Lime" | 3 5 0 23 | 1 2 1 16 | 11 13 3 17 | 3 1 2 18 |
| 5 | 7 5 2 11 | 1 12 2 27 | Mixed Alkalies (500 lbs. Sulphate of Potash, 225 lbs. Sulphate of Soda, and 100 lbs. Sulphate of Magnesia) | 2 14 3 16 | 0 16 3 12 | 10 0 1 27 | 2 9 2 11 |
| 6 | 6 19 2 15 | 1 12 3 6 | "Mixed Alkalies," and "Superphosphate of Lime" | 3 0 3 27 | 0 18 3 22 | 10 0 2 14 | 2 11 3 0 |
| 7 | 6 12 2 1 | 1 11 3 2 | "Mixed Alkalies," and "Superphosphate of Lime" | 1 18 1 27 | 0 13 1 15 | 8 11 0 0 | 2 5 0 17 |
| **Series 3.—Unmanured, or with Mineral Manures Alone, in 1852, and 1851; Ammonia-Salts Alone, or with Mineral Manure, in 1849.** | | | | | | | |
| 1 | 2 13 2 25 | 0 13 3 22 | Unmanured | 1 4 1 20 | 0 7 2 27 | 3 18 0 17 | 1 1 2 21 |
| 2 | 3 0 3 15 | 0 14 3 3 | "Superphosphate of Lime" | 1 10 3 27 | 0 11 1 6 | 4 11 3 14 | 1 6 0 9 |
| 3 | 3 19 3 25 | 0 19 2 22 | 500 lbs. Sulphate of Potash | 2 5 0 6 | 0 13 2 18 | 6 5 0 3 | 1 13 1 12 |
| 4 | 6 3 2 22 | 1 7 2 22 | 500 lbs. Sulphate of Potash, and "Superphosphate of Lime" | 2 10 0 23 | 0 16 3 9 | 8 13 3 17 | 2 4 2 3 |
| 5 | 7 4 1 16 | 1 12 1 20 | "Mixed Alkalies" | 2 19 2 9 | 0 19 3 13 | 10 3 3 25 | 2 12 1 5 |
| 6 | 4 11 1 12 | 1 2 0 9 | "Mixed Alkalies," and "Superphosphate of Lime" | 1 19 1 20 | 0 12 2 24 | 6 10 3 4 | 1 14 3 5 |
| **Series 4.—With Mineral Manures Alone in 1852; with Soot, Soot and Lime, or Soot, Lime, and Mineral Manures, in 1851; and Rape-Cake in 1849.** | | | | | | | |
| 1 | 3 15 3 26 | 0 19 0 2 | 500 lbs. Sulphate of Potash | 1 18 0 20 | 0 12 2 23 | 5 14 0 18 | 1 11 2 25 |
| 2 | 2 9 1 26 | 0 12 2 16 | 900 lbs. Sulphate of Soda | 1 13 0 10 | 0 12 0 21 | 4 2 2 8 | 1 4 3 9 |
| 3 | 3 5 2 6 | 0 17 0 15 | 700 lbs. Sulphate of Magnesia | 1 13 0 0 | 0 11 2 4 | 4 18 2 6 | 1 8 2 19 |
| 4 | 5 16 1 2 | 1 8 1 17 | 500 lbs. Sulphate of Potash, and "Superphosphate of Lime" | 2 14 1 20 | 0 18 0 22 | 8 10 2 22 | 2 6 2 11 |
| 5 | 7 1 2 14 | 1 12 3 17 | 900 lbs. Sulphate of Soda, and "Superphosphate of Lime" | 2 2 2 6 | 0 15 0 22 | 9 4 0 20 | 2 8 0 11 |
| 6 | 3 1 3 6 | 0 14 3 11 | 700 lbs. Sulphate of Magnesia, and "Superphosphate of Lime" | 1 11 3 20 | 0 11 0 5 | 4 13 2 26 | 1 5 3 16 |

The produce, after the heavy dressing of mineral manure upon the removal of the first cutting, is seen to be, in every case, small. In only two instances is it equal to more than a ton of hay per acre, namely, on Plot 4, Series 1 and 2; that is, where sulphate of potash and superphosphate of lime were applied. In all the Series, however, the effect of the potash, and of the potash and phosphate together, is more or less marked. In fact, notwithstanding that this was the third season of Clover in four years, the produce with these manures, taking the two cuttings of 1852 together, was, in several cases, equal to from $2\frac{1}{2}$ to 3 tons of hay per acre.

A good deal of the plant stood tolerably well during the winter of 1852-3, but almost all died off in the spring. The land was therefore ploughed up, and fresh Red Clover-seed *drilled* in April, in rows 20 inches apart, in order to admit of the use of the horse-hoe. The plant came up very weak; there was no crop worth cutting in the autumn; and nearly the whole died off during the winter of 1853-4.

In the spring of 1854, the land was again ploughed up, and allowed to remain fallow until September. The whole piece consisted of 15 "lands," each 13 feet 3 inches wide, divided into 6 lengths, forming the 6 "Plots" numbered from 1 to 6 respectively, in the Tables. It was now divided into three widths only, of 5 lands each, represented in subsequent Tables as Series 1, 2, and 3.* One of these (Series 1), the whole length of the 6 plots of course, was left unmanured; the second (Series 2) was manured with 20 tons of farmyard manure down the whole length of the 6 plots; and the third (Series 3), also throughout the 6 plots, was manured with 20 tons of farmyard manure, and 5000 lbs. of freshly burnt lime, per acre. These were ploughed in on September 25, 1854, and Clover-seed was drilled on October 10. Plants just came up, but all died off during the winter of 1854-5.

Clover-seed was again drilled on April 14, 1855, at the rate of 20 lbs. per acre, without further manure. The following Table (V.) shows the manures applied in 1854, and the produce of Clover obtained in September, 1855, without manure since 1854, but after a second and heavy sowing of seed.

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* The Plots designated in Tables III. and IV. as Series 1, 2, and 3, consisted of four lands each; and those as Series 4, of three lands, each running the length of the six Plots which had either no mineral manure, or one of the five different descriptions enumerated in the Tables. Under the new arrangement, Series 1 (now to be unmanured) includes the four lands of the former Series 1, which from the beginning were manured with mineral manures only, and one land of the former Series 2, which had the dung and lime applied in 1851; Series 2 (now to be manured with farmyard manure alone) includes the remaining three lands of the former Series 2, and two lands of the former Series 3, which, besides the several dressings of mineral manures, was manured in 1849 with ammonia salts; and Series 3 (now to receive farmyard manure and freshly burnt lime) includes the two remaining lands of the former Series 3, and the three lands of the former Series 4, which latter (besides the mineral manures as specified) were manured with rape-cake in 1849, and with soot, lime, &c. in 1851.

EXPERIMENTS on the GROWTH of RED CLOVER by DIFFERENT MANURES.

TABLE V.—Showing the MANURES applied in 1854, and the PRODUCE of CLOVER, obtained in September, 1855, from Seed sown in April of that year, after the failure of Seed sown in April, 1853, and in October, 1854.

SIXTH SEASON, 1855.

| Plot, Nos. | MANURES per Acre. Put on September 25, 1854. | PRODUCE OF CLOVER per Acre, September, 1855. | |
|---|---|---|---|
| | | Weight Fresh, as Cut. | Weight calculated as Hay. |
| | **SERIES 1.** | | |
| | | tons. cwts. qrs. lbs. | tons. cwts. qrs. lbs. |
| 1 | Unmanured .. .. .. .. .. .. | 1 7 3 6 | 0 4 2 14 |
| 2 | | 1 14 3 2 | 0 5 3 4 |
| 3 | | 1 13 1 26 | 0 5 0 18 |
| 4 | | 3 11 2 26 | 0 11 3 21 |
| 5 | | 2 16 1 18 | 0 9 1 15 |
| 6 | | 3 18 0 6 | 0 12 3 26 |
| | **SERIES 2.** | | |
| 1 | 20 tons Farmyard Manure .. .. .. | 4 12 2 2 | 0 19 3 22 |
| 2 | | 3 14 0 4 | 0 15 3 24 |
| 3 | | 3 15 1 2 | 0 16 0 26 |
| 4 | | 5 6 0 8 | 1 2 3 13 |
| 5 | | 5 4 3 16 | 1 2 2 13 |
| 6 | | 5 12 3 2 | 1 4 1 8 |
| | **SERIES 3.** | | |
| 1 | 20 tons Farmyard Manure, and 5000 lbs. fresh-burnt Lime .. .. .. .. .. | 4 1 3 6 | 1 0 0 16 |
| 2 | | 2 17 2 10 | 0 14 0 20 |
| 3 | | 3 6 2 4 | 0 16 1 15 |
| 4 | | 3 12 3 12 | 0 17 3 21 |
| 5 | | 4 3 2 2 | 1 0 2 7 |
| 6 | | 3 5 0 22 | 0 16 0 6 |

The figures in the Table show that the produce in this sixth season of the attempt to grow Clover continuously on the same land, and after two years of entire failure, was in every case small. Comparing Series with Series, the crop is the best where the farmyard manure alone was employed; the next best, where the Farmyard manure and Lime were used; and it was the worst where no manure was now employed, and where, for the most part, mineral manures alone had previously been employed. Still, comparing the results within each Series, there is again evidence of some increase on those plots which had formerly received manures containing *potash*, and *phosphoric acid*.

The plant of 1855 died off in the succeeding winter. The land was ploughed up and allowed to remain fallow during 1856 and 1857.

In the spring of 1858, it was decided to take a crop of Barley, without manure, before making any further attempt to grow Clover. It was, however, not thought worth while to determine the produce of Barley on each of the many differently manured Clover-plots separately. Accordingly, only the main divisions, represented by the Series 1, 2, and 3, of 1854 and 1855, were adopted. The produce of Barley, per acre, over each of these three portions of land, is shown in Table VI.

EXPERIMENTS on the GROWTH of RED CLOVER by DIFFERENT MANURES.

TABLE VI.—Showing the MANURES applied for CLOVER in 1854, and the PRODUCE of BARLEY in 1858, after the removal of a small Crop of Clover in 1855 (the Sixth Season), and a Fallow in 1856 and 1857.

| Plot, Nos. | MANURES Per Acre, for Clover, in 1854. | PRODUCE OF BARLEY per Acre, &c., in 1858. | | | | |
|---|---|---|---|---|---|---|
| | | Dressed Corn. | Weight per Bushel of Dressed Corn. | Total Corn. | Total Straw, &c. | Total Produce. (Corn and Straw). |
| | SERIES 1. | | | | | |
| 1 2 3 4 5 6 | Unmanured .. .. .. .. | bush. pks. 58 0 | lbs. 52·0 | lbs. 3181 | lbs. 3417 | lbs. 6598 |
| | SERIES 2. | | | | | |
| 1 2 3 4 5 6 | 20 tons Farmyard Manure .. | 65 2 | 52·0 | 3562 | 4016 | 7578 |
| | SERIES 3. | | | | | |
| 1 2 3 4 5 6 | 20 tons Farmyard Manure, and 5000 lbs. fresh-burnt Lime | 64 0 | 52·5 | 3486 | 3738 | 7224 |

It is obvious, that although the land was incapable of yielding a crop of Red Clover, it embraced all the conditions requisite for the production of a very luxuriant crop of Barley. The lowest produce, that on the plots of Series 1, of this "clover-sick" land, was 7¼ quarters of Barley per acre, of 52 lbs. weight per bushel. The highest produce, that on the plots of Series 2, where the

Farmyard manure alone had been applied in 1854, was about 8¼ quarters; and that where the Farmyard manure and Lime were used together (in 1854), was just 8 quarters of Barley, weighing 52½ lbs. per bushel.

After growing this luxuriant crop of Barley, one more attempt to grow Clover was made, but without any further manuring. In the spring of 1859, Clover-seed was sown, without a corn crop; but by a mistake of the seedsman, Cow-grass, instead of Red Clover, was sent, and the error was only discovered when it was too late for correction. The crop was cut in September. The amount of produce on each plot is recorded in Table VII. which now follows:—

EXPERIMENTS on the GROWTH of CLOVER by DIFFERENT MANURES.

TABLE VII.—Showing the MANURES applied for CLOVER in 1854, and the PRODUCE of CLOVER in 1859, after the removal of a small Crop of Clover in 1855 (the Sixth Season), Fallow in 1856 and 1857, and after removing a Crop of Barley in 1858.

| Plot, Nos. | MANURES Per Acre, for Clover, in 1854. | PRODUCE OF CLOVER per Acre, September, 1859. | |
|---|---|---|---|
| | | Weight Fresh, as Cut. | Weight calculated as Hay. |
| | SERIES 1. | | |
| | | tons. cwts. qrs. lbs. | tons. cwts. qrs. lbs. |
| 1 | Unmanured .. .. .. .. .. .. | 2 9 1 22 | 0 17 1 18 |
| 2 | | 3 5 2 8 | 1 0 3 11 |
| 3 | | 3 1 3 8 | 1 1 0 11 |
| 4 | | 3 10 3 8 | 1 2 3 8 |
| 5 | | 3 12 2 22 | 1 3 2 3 |
| 6 | | 4 4 1 8 | 1 7 1 14 |
| | SERIES 2. | | |
| 1 | 20 tons Farmyard Manure .. .. .. | 3 13 3 8 | 1 3 1 7 |
| 2 | | 4 2 1 22 | 1 4 1 19 |
| 3 | | 4 11 1 22 | 1 7 0 10 |
| 4 | | 4 5 1 22 | 1 6 1 1 |
| 5 | | 4 11 3 8 | 1 8 3 1 |
| 6 | | 4 6 2 8 | 1 7 2 24 |
| | SERIES 3. | | |
| 1 | 20 tons Farmyard Manure, and 5000 lbs. freshly-burnt Lime .. .. .. .. | 4 13 2 22 | 1 7 3 16 |
| 2 | | 4 10 1 8 | 1 5 3 2 |
| 3 | | 4 15 0 22 | 1 7 1 10 |
| 4 | | 5 5 1 8 | 1 8 2 13 |
| 5 | | 5 0 3 8 | 1 9 0 12 |
| 6 | | 5 4 3 4 | 1 10 3 6 |

As in the case of the last crop of Clover, that of 1855, the year after the heavy dressing of Farmyard manure on one-third, and of Farmyard manure and Lime on another third of the experimental land, the so-manured portions, again, in 1859, yield a somewhat larger crop than the corresponding plots of Series 1, which had no such application. The plots of each Series, however, yield somewhat more produce in 1859, than they did in 1855. The crops are, however, in all cases, insignificant, being generally equal to not much more than 1 ton of hay per acre; but there is still slight indication of improvement where the mineral manures containing potash, or potash and phosphoric acid, had been liberally employed in the earlier years of the experiment.

The plant continued to look tolerably well throughout a good part of the winter (1859-60), but as the spring advanced it died off rapidly, and, at the time we write, the end of June, the small proportion of the original plants that still survive have a very stunted and unhealthy appearance.

From the numerous results which have been recorded, in the foregoing pages, of experiments in which Clover has been submitted to a very great variety of manurial, and other conditions of growth, it is evident that no direct supply of manure, in the ordinary form of farmyard dung, or of the current artificial manures, is capable of restoring the soil from which a heavy crop of Clover has been taken, to a condition of immediate productiveness for the same crop. In the experiments in question, not even the most complex conditions, and the repeated supply of those constituents which are found most to increase the Clover-crop when it is grown in the usual manner, after an interval of several years, have restored the Clover-yielding capabilities which the soil possessed at the commencement of the experiment, in 1849.

Before entering upon any consideration of the probable causes of the failure of the Clover in the experiments which have been already described, it will be well to give the results of some experiments conducted on a small scale in the kitchen-garden at Rothamsted. The soil was in ordinary garden cultivation, and has probably been so for two or three centuries. Early in 1854, $\frac{1}{500}$ of an acre (about $9\frac{3}{4}$ square yards) was measured off and sown with Red Clover, on March 29. From that time to the end of 1859, fourteen cuttings have been taken, without any re-sowing of seed. In 1856, this little plot was divided into three equal portions. Of these, No. 1 has been kept continuously without manure; No. 2 was manured with gypsum; and No. 3 with sulphates of potash, soda, and magnesia, and superphosphate of lime. Table VIII. shows the amount of produce obtained, both green, as cut, and calculated as hay, per acre; but as the space

allotted to each experiment was so extremely small, the results must by no means be taken as absolutely correct. They can, indeed, be only looked upon as rough approximations; but, as such, they may be trusted as indicating the large amount of produce of Clover that has been taken from this garden soil, and as affording some idea of the relative amount of produce under the three different conditions of manuring.

The estimated total amount of green Clover obtained in six years from this garden soil, without further manure, is nearly 126 tons per acre—equal to about $26\frac{1}{2}$ tons of hay, or to an average of nearly $4\frac{1}{2}$ tons of Clover-hay, per acre, per annum. The produce was considerably increased by the application of gypsum, and still more so by that of the sulphates of potash, soda, and magnesia, and superphosphate of lime. In four years, the increase by the use of gypsum amounted to about $15\frac{1}{2}$ tons of green Clover, or about $3\frac{1}{2}$ tons of hay—nearly 1 ton of hay per acre per annum. The increase in the four years, by the use of the alkalies and phosphate, is estimated to amount to $28\frac{3}{4}$ tons of green produce, or rather more than $6\frac{1}{2}$ tons of hay—equal to nearly $1\frac{3}{4}$ tons increase of hay per acre per annum.

It is worthy of remark, that it was in some of the very same seasons in which these heavy crops of Clover were obtained from the garden-soil, even though grown year after year, and without fresh seed, that we entirely failed to get anything like a moderate crop of Clover in the experimental field, only a few hundred yards distant. The failure in the latter case would, therefore, appear to be connected with the conditions of *soil* in relation to the plant, rather than to those of the *atmosphere*.

We now come to another and not very satisfactory part of our task; namely, that of endeavouring to seek, among the various causes of Clover-failure which have been suggested, for some explanation of the signal failure of the crop in our experimental field.

The comparison of the results in the garden with those in the field, seems to lead to the exclusion of some of the reasons enumerated in the early part of our Paper, as having been brought forward to account for the Clover failure. It may be well, however, to make a few passing remarks on some of them.

With regard to the *attacks of Insects*:—Those who have examined the plants on a field of Clover failing in the ordinary way, will probably sometimes have found a small insect in those plants which are beginning to show signs of dying off. It is generally found near the junction of the root and crown. Now, as experience teaches us that the plant seldom suffers serious injury if a sufficient number of years has elapsed since Clover was grown before,

TABLE VIII.—Showing the *estimated* PRODUCE per ACRE, of CLOVER grown 6 Years consecutively on the same Plots of Garden Soil, from One Sowing of Seed only.

| | ESTIMATED PRODUCE PER ACRE. | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | WEIGHED GREEN. | | | | | | | | | | | | CALCULATED AS HAY. | | | | | | | |
| | Unmanured. | | | | With Gypsum, applied May 22, 1856. | | | | With Sulphates of Potash, Soda, and Magnesia, applied May 22, 1856. | | | | Unmanured. | | | | With Gypsum, applied May 22, 1856. | | | | With Sulphates of Potash, Soda, and Magnesia, applied May 22, 1856. | | | |
| | tons. | cwts. | qrs. | lbs. | tons. | cwts. | qrs. | lbs. | tons. | cwts. | qrs. | lbs. | tons. | cwts. | qrs. | lbs. | tons. | cwts. | qrs. | lbs. | tons. | cwts. | qrs. | lbs. |
| 1854—2 Cuttings .. .. | 10 | 18 | 3 | 0 | .. | | .. | | .. | | .. | | 2 | 7 | 2 | 24 | .. | | .. | | .. | | .. | |
| 1855—3 Cuttings .. .. | 39 | 10 | 0 | 20 | .. | | .. | | .. | | .. | | 8 | 1 | 2 | 24 | .. | | .. | | .. | | .. | |
| 1856—2 Cuttings .. .. | 23 | 5 | 1 | 17 | 25 | 8 | 3 | 20 | 29 | 5 | 3 | 21 | 4 | 6 | 2 | 10 | 4 | 19 | 1 | 25 | 5 | 12 | 1 | 6 |
| 1857—3 Cuttings .. .. | 27 | 10 | 3 | 3 | 30 | 16 | 3 | 18 | 33 | 2 | 0 | 12 | 6 | 2 | 0 | 14 | 6 | 14 | 1 | 10 | 7 | 6 | 0 | 25 |
| 1858—2 Cuttings .. .. | 14 | 1 | 1 | 0 | 19 | 18 | 1 | 21 | 24 | 5 | 1 | 27 | 3 | 1 | 1 | 19 | 4 | 5 | 3 | 15 | 5 | 5 | 1 | 8 |
| 1859—2 Cuttings .. .. | 10 | 17 | 2 | 15 | 14 | 19 | 2 | 18 | 17 | 18 | 1 | 1 | 2 | 7 | 2 | 0 | 3 | 7 | 0 | 1 | 4 | 6 | 0 | 7 |
| Total Produce, 6 years .. | 125 | 13 | 3 | 27 | .. | | .. | | .. | | .. | | 26 | 7 | 0 | 7 | .. | | .. | | .. | | .. | |
| Average Annual Produce, 6 years .. .. .. .. | 20 | 19 | 0 | 0 | .. | | .. | | .. | | .. | | 4 | 7 | 3 | 10 | .. | | .. | | .. | | .. | |
| Total Produce, last 4 years | 75 | 15 | 0 | 7 | 91 | 3 | 3 | 21 | 104 | 11 | 3 | 5 | 15 | 17 | 2 | 15 | 19 | 6 | 2 | 23 | 22 | 9 | 3 | 8 |
| Average Annual Produce, last 4 years .. .. .. | 18 | 18 | 3 | 2 | 22 | 15 | 3 | 26 | 26 | 2 | 3 | 22 | 3 | 19 | 1 | 18 | 4 | 16 | 2 | 20 | 5 | 12 | 1 | 25 |
| Total Increase by Manure, last 4 years .. .. .. | .. | | .. | | 15 | 8 | 3 | 14 | 28 | 16 | 2 | 26 | .. | | .. | | 3 | 9 | 0 | 8 | 6 | 12 | 1 | 3 |

before, it would appear that the prevalence of the insect, and its consequent injury to the plant, is the result, rather than the original cause, of the diseased condition. In fact, it is probable that the success of the attack of the insect upon the plant, may be mainly due to the weak or unhealthy condition of growth of the latter; and that, had the plant been perfectly vigorous, the insect would not be so freely developed, or its injury would at least be more successfully resisted.

*Excrementitious Matters.*—There is evidence of various kinds to show that plants give out certain substances by their roots to the soil. It is not probable, however, that any mineral constituents which may be so rejected during the growth of one Clover-crop, are prejudicial to the growth of a similar crop on the same land for a number of years to come. If the failure of the Clover-plant, when repeated too soon upon the same land, be due at all to the excrementitious matters left by the former crop, it is much more probable that the injury is in some way connected with the organic matters which have been rejected. Unfortunately, we are not yet able, by the aid of chemistry, to distinguish those organic compounds of the soil which are convertible into the substance of the growing plant, and those which are not so. Nor do we know how far the excreted organic matters may be necessary complimentary products in the formation of some of the essential constituents of the plant. Experience teaches us that when a crop of Clover is eaten by sheep folded upon the land, animals dislike the growth which immediately succeeds. It might be inferred, therefore, that, in such a case, the plant had taken up from the soil, certain matters which it had not finally elaborated. Whether these organic substances would, in process of time, be converted into living plant-matter, or whether they would wholly, or in part, be rejected as excrementitious organic compounds, to undergo in the soil certain chemical changes before being adapted for plant-food, we are not able to determine.

In connexion with this question, of whether or not the failure of the Clover-crop be due to the injurious influence of excrementitious organic matters, left by the last crop of the same kind, attention may be called to the fact, that in the case of the failure in our field experiments, two years of fallow, and one year of barley, intervened between the poor crop of Clover in 1855, and the almost equally poor one in 1859. *A priori*, we should certainly be disposed to think, that any deleterious matters left in the soil by the Clover-crop of 1855 would, under the circumstances in question, have undergone pretty complete decomposition during the three succeeding years. At the same time, it should be remembered that, in 1852, the plant of Clover suffered very much

more where Rape-cake, or Salts of Ammonia had been applied in 1849, than where mineral manures only had been employed.

*Exhaustion of the Soil.*—Some of the plots in the experimental Clover-field have doubtless been subjected to great exhaustion of certain constituents, by the removal of the whole of the produce, without adequate restoration by manure. On others, however, there has been considerable accumulation of constituents. Calculation shows, indeed, that, on many of the plots, there have been much larger quantities of every "mineral" constituent supplied in the manures, than have been removed in the total produce, during the entire period of the experiments. Of certain organic constituents, however, including nitrogen, more has been taken off in the crops than has been supplied in the manures. But if, in the cases in question, the produce grown without manure, be deducted from that grown with it, it then appears, that the manures have provided very much more, not only of the mineral constituents, but of nitrogen also, than was contained in the increase due to the manures. It cannot be supposed, therefore, that, in the instances here referred to, any of the ultimate elements of the crop could be wanting.

It should be remembered, too, that in some of the experiments mineral manures alone were employed, in others mineral manures and ammonia salts, and in others large quantities of farmyard dung, mineral manures, and ammonia salts, and so on; so that the proportions, and conditions of combination, in which the different constituents were supplied, were very variable.

How then are we to account for the fact, that whilst, under the conditions described, the Clover-plant would not grow healthily in the experimental field, we have been able to cut fourteen crops from seed sown six years ago in a garden only a few hundred yards distant? Are we to suppose, simply, that the ultimate constituents required by the Clover, were more abundantly available to the plant in the garden soil? or is it that they there existed in different states of combination? It will not be out of place to make a few observations bearing upon the latter supposition.

According to Mulder, who has investigated the organic compounds of the soil, the vegetable matters, rich in carbon, decomposing in the soil, go through a gradationary series of changes before being finally converted into carbonic acid. He supposes the intermediate compounds to constitute a series of acids, which combine with ammonia, and with fixed bases, in the soil, forming so many organic-acid salts. Now, if we were to suppose that some plants (Clover for example) required for healthy growth a certain proportion of their food to be presented to them in the form of such carbon-compounds, more complex than carbonic acid, and perhaps combined with ammonia, we should then the

more easily comprehend why it should be necessary for a certain period of time to intervene before again cultivating certain crops on the same land ; for, we could easily understand that this might be requisite for the gradual formation and accumulation of a sufficient amount of the compounds in question.

Whatever may be the precise chemical character of the carbon compounds of the soil, more complex than carbonic acid, there are numerous facts in horticulture, and even in agriculture, leading to the supposition that some plants take up a part at least of their carbon from some other form of combination than carbonic acid.

In one of our experimental fields we have grown very large crops of wheat for 17 consecutive years, without the supply, by manure, of a single ounce of carbon. The crops have been considerably greater on some plots where no carbon has been supplied in the manure, than on others to which it had been very largely supplied. There are, indeed, good reasons for supposing that carbonic acid is, at any rate, the chief, if not the exclusive source, of the carbon of many of the plants yielding food largely to man and other animals—which, by their respiration, return so much carbonic acid to the atmosphere. Were it not so, as forests make way for the growth of food, the proportion of carbonic acid in the atmosphere would gradually increase. The cultivation of the cereal crops, which enter so largely into the food of man and other animals, seems admirably adapted for preserving the equilibrium in the composition of the atmosphere ; for an acre of wheat will decompose as much, or more, carbonic acid, liberating a corresponding amount of oxygen, as an acre of the forest which it may have supplanted.

Provided the soil yield a sufficient supply of the necessary mineral constituents, the amount of carbonic acid decomposed by a cereal crop over a given area, will very much depend upon the amount of nitrogen, in an available condition of combination, and distribution, within the soil. But the direct supply of nitrogen to the soil in the form of ammonia, which so much increases the vigour of growth of Graminaceous crops generally, and consequently the amount of carbon which the plants will assimilate from carbonic acid, so far from effecting the same result in the case of Leguminous crops, is generally injurious to them.

In the early years of our experiments, both upon Clover and upon Beans, the application of the fixed alkalies as manure, and especially of potash, caused a considerably increased assimilation of both carbon and nitrogen over a given area ; whilst the direct use of ammonia-salts, which are so efficacious in the case of our Graminaceous crops, had either little or no such effect, or was more frequently injurious, in the case of these Leguminous crops. Where the supply of mineral constituents is sufficiently kept up, the supply of ammonia is as efficient as ever in enabling the wheat

growing in the experimental field to assimilate an increased amount of carbon from carbonic acid. The alkalies, potash, &c., have ceased to be as useful as manures for the Leguminous crops, as they were at the commencement of the experimental period; yet, so far as the atmosphere is a source of constituents to these plants, its supplies must be the same now as formerly. The decline in the beneficial influence of the potash, &c., would appear, therefore, to be connected with some defective condition within the soil.

If we were to assume that the Leguminous plants required a certain portion of their organic food to be supplied to them in the form of certain organic compounds in the soil, it is evident that the beneficial action of the potash, &c., would cease when these organic compounds were exhausted. On this assumption, too, it would seem intelligible, on the one hand, that an ordinary soil should require a considerable period of time after the growth of a Leguminous crop, to become again fertile for the same crop, and—on the other, that a garden soil, liberally manured with organic matter, perhaps for centuries, should support a considerable number of such crops in succession.

It is further worthy of remark, in connexion with the beneficial action of the alkalies as manures for Leguminous crops, and with the supposition that these crops may require a portion of their organic food in the form of certain carbon compounds which are more complex than carbonic acid, that it is chiefly by the aid of the alkalies that the organic compounds of the soil are rendered soluble. On recently cleared lands in America, where there is such a great accumulation of vegetable remains, the employment of ashes, and of gypsum, as top-dressings for Clover, has been attended with remarkable success. Vegetable ashes have been found to be beneficial to the crop in this country also, which, independently of the mere *supply* of potash, &c., may be partly due to the action above referred to. Gypsum, however, is by no means to be depended upon as a manure for Clover in this country. The action of gypsum has been very variously explained upon high authority. The following distinct explanations are on record, namely:—that it serves as a supply of sulphuric acid—that it serves as a supply of lime—that it serves as a supply of sulphur—and that it serves for the fixation of ammonia. It is perhaps not less likely that its beneficial action may be connected with changes in the organic matters of the soil. M. Risler has indeed shown, that an aqueous solution of gypsum will take up more organic matter from soil, than will water.

We are far from asserting that there is evidence enough to show that the failure of Clover, when grown too frequently on the same land, is altogether due to the want of a sufficient supply of certain organic compounds in the soil. At the same time, we think that the facts of horticultural and agricultural practice, as

well as the evidence of direct experiment, must lead to the conclusion, that the view—that the organic compounds of the soil are only valuable to plants as a source of carbonic acid—requires modification. It is, indeed, probable, that some plants derive a considerable amount of their substance from carbon compounds other than carbonic acid, and that others depend for their carbon mainly, if not exclusively, upon carbonic acid.

Those of our crops which, in the course of cultivation, are subjected to pretty natural conditions of growth, and which accumulate the greater portion of their substance during the period at which the sun's rays are known to be most powerful in influencing the decomposition of carbonic acid by plants, appear to depend chiefly on that source for their carbon. Those, on the other hand, which are grown under somewhat abnormal conditions, and which store up a large amount of succulent products of a comparatively low degree of elaboration, are probably partly dependent on other carbon compounds, yielded by the soil. The Leguminous crops, again, though generally coming more within the former than the latter category, still seem to be dependent, for luxuriant growth, more or less upon a supply, within the soil, of complex organic compounds.

But whatever may be the precise result to which investigation may lead, in regard to the questions here involved, it may, at any rate, be pretty safely affirmed, that we shall not arrive at the true explanation of the phenomena upon which depend some of the most striking advantages of a rotation of crops, until we are better able than at present, to define the relations of the different crops to the different sources of *carbon*, and of *nitrogen*.

The practical conclusions from the inquiry may be very briefly stated:—

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 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.