

ripe, the produce, and that it was lower in the opposite conditions. Combinations of these several conditions (the two latter of which are each much influenced both by season and manure) determine the actual character of the produce in regard to the point in question.

Percentages of Nitrogen in the Hay.

Table V. (p. 534) shows the percentages of nitrogen in the produce of each plot in each of the four years under consideration, also the average over the four years, and the average over the seven years; the left hand columns give the proportions in the hay as taken from the land, and the right hand ones those in the dry substance of the hay.

It has been already stated—that Leguminous produce, in an equal condition of ripeness, gives a higher percentage of nitrogen than Gramineous produce; that, other things being equal, the more leafy or more unripe the crop, the higher will be the percentage of nitrogen in the dry substance; and that, in succulent and unripe produce more especially, the proportion may be much increased by a liberal or an excessive supply of nitrogen in manure. Keeping in view these few facts, the variations exhibited in the Table become intelligible; and it will be observed that they are less directly traceable to the characters of the seasons, and much more dependent on variation in manuring, than are those of either the dry substance or the mineral matter.

In fact, the general result may be stated to be, that there was much less difference from year to year depending upon season, than between the produce of different plots in one and the same season depending on difference in manuring; that, other things being equal, the more complex and the less Gramineous the herbage (conditions favoured by mineral manures), the more leafy, the less ripe, and the more excessive the nitrogenous manuring, the higher was the percentage of nitrogen; that the more Gramineous, the more stemmy, and the more ripe (conditions favoured by farmyard-manure, and by artificial combinations of both mineral and nitrogenous manure), the lower was the percentage of nitrogen.

It was fully explained in our former paper on this subject, that a percentage of nitrogen in meadow-hay much beyond that found in the produce grown without manure, or by farmyard-manure, is by no means a sure indication of a proportionally increased amount of matured and digestible or assimilable nitrogenous substance. When the increased percentage of nitrogen is due to a large proportion of Leguminous herbage, it will probably indicate a large proportion of nutritive nitrogenous

compounds; but when it is the result of excessive nitrogenous manuring, the produce is then almost exclusively Gramineous and comparatively immatured; and, under such circumstances, a certain portion of the nitrogen may exist in a low condition of elaboration, and a high proportion may, in fact, represent a deficient accumulation of other matters rather than a favourable development of nutritive nitrogenous substance. A percentage of nitrogen in meadow-hay beyond that obtained without manure or by means of farmyard-manure is, therefore, under such conditions, not to be taken as evidence of higher feeding value. The value of the manure voided by the animals feeding on the hay, will, however, be the higher the higher the proportion of nitrogen it contains—especially as it so happens that there is generally with a high percentage of nitrogen a high percentage of mineral matter also.

Produce of Constituents per Acre.

As pointed out in our former report, particular interest attaches to the question of the amount of constituents taken from an acre of land in the hay-crop, because very frequently the system of restoration adopted in the case of the meadow-land of a farm is even less satisfactory than in that of the land under rotation; hence it becomes necessary to impress upon the farmer how great is the exhaustion to which his meadow-land may be subject.

Tables VI., VII., and VIII. (pp. 535-6-7) show, respectively, the amounts of dry substance, of mineral matter, and of nitrogen, removed per acre from each of the experimental plots, in each of the last four years; also the average amounts per annum, both in the produce and in the increase by manure, over the four years, and over the whole seven years of the experiments.

Over the seven years, there has been removed per acre annually from the unmanured land an average of 2358 lbs. (about 21 cwts.) of dry substance, containing 167½ lbs. (1½ cwts.) of mineral matter, and nearly 40 lbs. of nitrogen. This amount of dry substance is somewhat higher than the average of the first three years of the experiments; but it agrees very closely with, though it somewhat exceeds, the amounts annually taken from the land in wheat or barley grown year after year without manure. The above amounts of mineral matter and nitrogen are, however, each fully one-half more than are removed in wheat or barley grown under such circumstances.

The unmanured produce of hay would contain between 900 and 1000 lbs. of carbon. By the use of ammonia-salts alone, or

nitrate of soda alone, the amount of carbon annually removed in the crop was increased to something under or over 1300 lbs., and by means of the mixed mineral manure alone to about the same amount; but by the mixtures of both ammonia-salts and mineral manure it was increased to over 2000 lbs. per acre—that is, without any supply of carbon in the manure. The addition to the latter manures of 2000 lbs. of sawdust, or 2000 lbs. of cut wheat-straw, each containing in round numbers about 700 lbs. of carbon, gave no increased yield of it in the produce. Nor did farmyard-manure, in amount containing at least twice as much carbon as the crop yielded by its use, give a produce containing more than about three-fourths as much as the mixtures of mineral manure and ammonia-salts which supplied none. It may be concluded, therefore, that, even admitting that the carbonaceous manures did supply carbon to the growing plants, the supply from that source was at any rate unnecessary, provided only that mineral or incombustible constituents, and nitrogenous manures were liberally supplied.

As mentioned above, the average amount of mineral or incombustible constituents taken from the land without manure was, over the seven years, $167\frac{1}{2}$ lbs., or about $1\frac{1}{2}$ cwts. per annum. The amount removed in the crop grown by means of ammonia-salts alone was increased to something under, and that by nitrate of soda alone to something over, 2 cwts.; there being, therefore, by such manuring, a further drain upon the resources of the soil.

By means of the mixed mineral manure alone, the amount of incombustible constituents taken away in the crop was raised to about $2\frac{1}{4}$ cwts.; but the manure itself supplied more of almost every such constituent, except silica, than the entire produce would contain; so that, excepting in the item of available silica, the soil was, compared with the unmanured land, annually accumulating most of the important mineral constituents. By the addition of ammonia-salts to the mixed mineral manure, the amount of mineral constituents taken from the land was raised from about $2\frac{1}{4}$ to nearly $3\frac{3}{4}$ cwts. when the smaller amount (Plot 9), and to nearly 4 cwts. when the larger amount of ammonia-salts (Plot 13a) was employed; and, as the produce was in these cases almost entirely Gramineous, the drain upon the available silica of the soil would be very considerable; though, here again, all the other incombustible constituents were supplied in far larger quantity than they were taken off in the crops. By the addition of nitrate of soda to the mixed mineral manure, whether in the smaller amount (Plot 14), or in the larger amount

equal in nitrogen to the ammonia-salts of Plot 9 (Plot 15), the quantity of mineral constituents taken from the land was somewhat less.

Lastly on this point: by means of an annual dressing of farmyard-manure, doubtless supplying much more of every mineral constituent than was contained in the crop yielded, rather under 3 cwts. of incombustible constituents were annually taken from the land; and, when to the farmyard-manure ammonia-salts were added, the amount was raised by only $43\frac{1}{2}$ lbs.—that is, from $328\frac{3}{4}$ to $372\frac{1}{4}$ lbs., or to less than when the artificial mixtures of mineral manure and ammonia-salts were employed.

The result is, then, that without manure the land yielded, over seven years, about $1\frac{1}{2}$ cwt. of mineral constituents per acre per annum, the amount increasing rather than diminishing in the later years; that farmyard-manure supplying, besides other matters, more of every mineral constituent than the produce obtained by its use, gave a crop containing about twice as much; and that artificial mixtures containing both mineral constituents and ammonia-salts gave a still larger yield, even when no silicates were supplied in the manure.

It is obvious, that when purchased nitrogenous and phosphatic manures, such as Peruvian guano, or mixtures of ammonia-salts or nitrate of soda and superphosphate of lime, are alone relied upon for the increased crop of hay, the drain of potash and available silica from the soil must be very great. This was illustrated in some detail in our former report, by reference to the analyses of the ashes of the hay grown by the different manures; and confirmatory evidence of the injurious effects of such exhaustion will be found on comparing the average annual amounts of mineral matter taken from each plot over the seven with that over the last four years. Thus, whilst without manure, with mixed mineral manure, and with farmyard-manure, the average amount of mineral constituents annually taken from the land was greater during the later years than during the whole period of the experiments, it was (with one exception) less in the later years wherever large quantities of ammonia-salts were employed. A similar result is not as yet observable when nitrate of soda has been used; but, as already explained, it is probable that some of the plants then developed would draw their nutriment from a more extended range within the soil; and, if so, a diminution in the annual yield may be only a little postponed.

These results in regard to the mineral constituents taken from the land in the hay crop, clearly show how important it is that due restoration should be made, if the character of the herbage and the amount of crop are to be maintained. This is best accomplished in practice by an occasional dressing of well rotted

stable or farmyard-manure. Taking into account the other constituents at the same time thus supplied, silica and potash are more advantageously and economically provided in this form than in any other; and, as the results with the farmyard-manure show, the increase which a given quantity annually yields, removes but a small amount of mineral constituents compared with that which it supplies, so that the effects extend over several years, causing, unless specially nitrogenous manures be also applied, an accumulation within, rather than an exhaustion of the soil. When farmyard-manure is so employed, a further increase of crop may, without detriment to the land, be annually obtained by the moderate application of the current artificial manures containing nitrogen and phosphoric acid; but to this point we shall recur presently.

Produce of Nitrogen per Acre.

Table VIII. (p. 537) shows the acreage amounts of nitrogen taken off in the crop of each plot, in each of the last four years, also the average annual yield, and the average annual increase of it, over the last four, and over the whole seven years. A comparison of the two columns, giving the annual average yield, shows that, in the majority of cases, it was almost identical over the last four, and the whole seven years. The agreement was the less close where the large amounts of ammonia were used in conjunction with mineral manure, by which very large crops were obtained. It is, however, only in the case of Plot 13a, where the very excessive amount of ammonia-salts was applied in the first, second, third, and seventh years, that the average yield of nitrogen is at all materially reduced during the last four, as compared with the seven years (98.3 lbs. to 85.8 lbs.). But, as the supply of nitrogen in the manure was reduced by one-half in three years out of the four, this is only what might be expected; and it is seen that, in the seventh year, when the larger amount of ammonia-salt was again employed, the yield of nitrogen per acre in the crop was considerably increased.

Taking the average over the seven years, the result is—that the yield of nitrogen per acre without manure was within a fraction of 40 lbs., or about $1\frac{1}{2}$ time as much as has been annually taken from an acre of unmanured land in either wheat or barley; that mineral manures alone increased the yield by nearly one-half, the increase being then due to the large amount per acre, and proportion in the produce, of the highly nitrogenized Leguminous herbage; that ammonia-salts alone (or nitrate of soda containing about an equal amount of nitrogen) increased it more than mineral manures alone, though Leguminous plants were then almost excluded, and the produce was almost wholly Grami-

naceous; and that the mixtures of mineral manure and ammonia-salts (or nitrate supplying an equal amount of nitrogen), which gave a very much increased, and also an almost exclusively Gramineous produce, gave also the highest yield of nitrogen in the series—even more than a mixture of farmyard-manure and ammonia-salts, together supplying much more nitrogen.

The important question arises—What proportion of the nitrogen supplied in the manure is recovered as increased yield of it in the crop?

Proportion of the Nitrogen supplied in the Manure which is recovered as increased yield of it in the Crop.

In our former Report, with the average results over only three years before us, we showed that, under the most favourable conditions, the increased yield of nitrogen in the hay-crop scarcely reached, and in the average of cases fell short of, 50 per cent. of that supplied in the manure. But it was admitted that three years was too short an experience upon which to form a satisfactory estimate on the point. The calculations have now been made for the whole seven years of the experiments.

In Table IX. (p. 538) are recorded the actual amounts of nitrogen per acre (lbs.), and in Table X. (p. 539) the amounts for 100 in manure, which were recovered as increased yield of it, when known quantities were supplied, each being reckoned both over the yield without manure, and over that by mixed mineral manure alone; and, for comparison, the average results over both the last four and the whole seven years are given.

It is obvious that, in a practical or economical sense, the only direct gain to the farmer of nitrogen in the produce by the use of mineral and nitrogenous manures together, is so much as is over and above the amount yielded by the same mineral manures when used alone. But, for reasons explained in our former Report, we deem it, upon the whole, the most consistent with what we know of the facts, to reckon at least so much of the nitrogen of the produce grown by nitrogenous manure as is over and above that yielded without manure, to have its source in the nitrogen supplied, whether the nitrogenous manure be employed alone, or in conjunction with mineral manure.

Reckoned in this way, Table X. shows that, when ammonia-salts were used alone (Plot 4), 27.4 per cent. only of the nitrogen so supplied was recovered as increased yield over the seven years, and very nearly the same proportion, 27.1 per cent., over the last four years. With salts of ammonia and sawdust (Plot 5), reckoning of course the nitrogen in the sawdust, the proportion recovered was rather less, but again about equal over the seven and the last four years. With the smaller amount of

nitrate of soda (Plot 6), the estimated return of nitrogen was 37.7 per cent., and with the larger amount (Plot 7) only 29.9 per cent., taking the average of the five years of its use; but over the last four years the figures show rather more recovered than when the first year is included. It is worthy of remark, that the proportion recovered with the larger amount of nitrate (Plot 7), is higher than with the corresponding amount of nitrogen in the form of ammonia-salts (Plot 4).

With the same amount of ammonia-salts as was applied to Plot 4 (400 lbs.), and the mixed mineral manure in addition (Plot 10), the increased yield of nitrogen estimated as attributable to that supplied was 46.5 per cent. reckoning over the seven, but only 43.4 per cent. over the last four years; indicating, therefore, that, even under these comparatively favourable conditions, the proportion recovered is diminishing rather than increasing from year to year. It is to be borne in mind, however, not only that the silica so specially required by Gramineous crops was not supplied in the mineral manure in question, but also that the amount of ammonia-salts annually used (400 lbs., containing about 82 lbs. nitrogen) was very large. It is remarkable, too, that although when used alone (Plot 4), the ammonia-salts gave a less return of nitrogen than nitrate of soda containing an equal amount of it (Plot 7), yet, when used in conjunction with the mixed mineral manure, the proportion estimated as recovered was less with the nitrate (Plot 15) than with the ammonia-salts (Plot 10). However, when the smaller amount of nitrate of soda was used with the mineral manure (Plot 14), the nitrogen estimated as recovered amounted to about 62 per cent. of that supplied; that is, to more than in any of the experiments where the larger amounts of nitrogen were supplied, which gave larger, though not proportionally larger, amounts of produce.

When to the mixed mineral manure and ammonia-salts, sawdust or cut wheat-straw (Plots 11 or 12) was added, and their nitrogen reckoned in the supply, the proportions estimated as recovered are less than when they are not employed.

Where the double or very excessive amount of ammonia-salts was applied in the first, second, third, and seventh years (Plot 13a), the proportion of nitrogen recovered was exactly the same over the seven years (and even more over the last four) as where the less amount of ammonia-salts with the same mineral manures was used (Plot 10). The increase of gross produce or hay was, however, not in proportion either to the increased supply or increased yield of nitrogen; the large yield of it being due to a very high—perhaps an objectionably high—percentage in the produce in the years in which the large amount

of ammonia-salts was used; in fact, it was then higher than in any other case where mineral manures were used in conjunction with ammonia-salts. The Table records the results of only one year (1862) in which, to this mixture of 800 lbs. of ammonia-salts and the "mixed mineral manure," silicates (so much exhausted by the hay crop) were added (13b), and the figures show almost exactly the same proportion of nitrogen recovered as in the same year without the silicates (13a).

Lastly, when ammonia-salts were added, in comparatively small or moderate amount, to a quantity of farmyard-manure itself containing a very large amount of nitrogen, the increased yield of nitrogen beyond that in the produce by farmyard-manure alone amounted, over the seven years, to only 21.9 per cent., and over the last four years to only 13.8 per cent. of that supplied in the ammonia-salts. It may be further remarked that, if the farmyard-manure employed be assumed to have been of fair average composition, the proportion of its nitrogen reckoned as recovered in the increased yield (beyond that without manure), reaches to even a still lower amount.

To sum up on this point, the average results taken over the seven years are, that, when the nitrogenous manures (ammonia-salts or nitrate) were used alone 29.9, and when in conjunction with the mixed mineral manure 45.1 per cent. of the supplied nitrogen were reckoned as recovered as increased yield of it in the crop. In our former Report, then taking the results of three years only, the amounts were 26.1 per cent. without, and 46.6 per cent. with the mineral manure. The result over the more extended period is, therefore, somewhat higher without, and somewhat lower with, the mineral manure. When ammonia-salts were superadded to an amount of farmyard-manure doubtless containing nitrogen, carbon, and every mineral constituent, in larger quantity than the crop it yielded (though in comparatively slowly available condition), the increased yield of nitrogen due to the ammonia-salts was then less than in any of the other conditions of their use; and it was considerably less over the later than over the earlier years. It may be remarked that nitrate of soda containing the same amount of nitrogen as that in the ammonia-salts added to the farmyard-manure, but used in conjunction with the mixed mineral manure, was reckoned to return nearly three times as much of the supplied nitrogen.

Before leaving the question of the amount of nitrogen estimated as recovered in the increase for a given amount supplied in manure, it should be observed that, inasmuch as the whole of the nitrogen of the after-grass is not returned to the land by the animals fed upon it, the amount will be

somewhat higher than that represented by the increase in the hay crop merely. But were it attempted to make allowance for this, the results would not differ very widely from those recorded in the Tables. For, not only would by far the larger proportion of the nitrogen of the after-grass be returned to the land, but it would be only so much of the remainder as was due to increase by manure, that would have to be taken into the calculation. Nor are the data requisite for such a mode of estimation sufficiently established to render any such supposed correction at all desirable. It is, however, well to make this reservation in regard to the figures recorded in the Tables.

It may be interesting here to observe that, in experiments with wheat conducted over six years, 43 per cent., and in others with barley, also over six years, 42.5 per cent. of the nitrogen supplied in the manure was estimated to be recovered as increased yield. Against these amounts the average result obtained with the meadow-hay over seven years was, in parallel cases, 45.1, which, raised by the small amount due to the after-grass, as above explained, would show that the mixed herbage of meadow-land probably gathers up within the season of application a somewhat larger proportion of the nitrogen supplied as manure than either wheat or barley.

In our former report we directed attention to the probable explanations of the real or apparent loss of nitrogen here indicated; and we would refer the reader to a discussion of the subject in a paper "On the Sources of the Nitrogen of Vegetation; with special reference to the question whether plants assimilate free or uncombined nitrogen," in the 'Journal of the Chemical Society of London,' Ser. 2, Vol. 1, 1863.

Upon the whole, the evidence goes to show, that stable or farmyard-manure is a much more perfect restorer of the constituents removed in the hay-crop than those purchased or so-called artificial manures which, in a practical or economical point of view, can be advantageously employed. Farmyard-dung is, however, comparatively slow in its action. These characters point to the peculiar fitness of such manure for meadow-land mown for hay; and it was shown in our Report in the last number of the Journal, that the description of herbage developed by it was much more complex, and upon the whole superior in quality, to that developed by the more active artificial manures. On the other hand, provided the restoration of the potash and silica of the hay-crop be duly accomplished by means of farmyard-manure occasionally applied, its slowness of action may

be advantageously compensated by a judicious use of some of the more active artificial or purchased manures.

In the experiments which form the subject of this paper, the amount of farmyard-manure annually employed was 14 tons per acre, which would doubtless contain very much more of every constituent of the hay-crop than the produce yielded. Under these circumstances, although the superaddition of ammonia-salts considerably increased the crop, they gave a less result than under any of the other conditions of experiment. If the same amount of farmyard-manure, or even less of well-rotted dung, were employed once in four or five years, this would supply sufficient of most of the mineral constituents for a larger amount of increase than would be obtained in several years by its use alone; and, under such circumstances, the additional application of moderate quantities of the more rapidly active manures, such as Peruvian-guano, or ammonia-salts or nitrate of soda and superphosphate of lime, would not only serve to bring into more rapid use the constituents of the dung, but the increase of crop would be obtained without injury to the permanent condition of the land, and with little detriment to the character of the herbage developed.

Under some circumstances ammonia-salts, and under others nitrates, seem to be the more active in proportion to the nitrogen they contain. But, as the mixed herbage of grass-land includes plants of very different habits of growth, seeking their nutriment at very different ranges within the soil, and as the nitrogen of nitrate of soda becomes distributed much more rapidly than that of ammonia-salts, it is desirable to employ a mixture of these two manures. By this means the growth of a greater variety of plants is favoured, and very probably a greater amount of increase will be obtained within a given time for a given amount of nitrogen applied.

Assuming the dung to be employed in quantity sufficient for the due restoration of the alkalies, alkaline earths, and silica, it would, of course, at the same time supply a considerable amount of phosphoric acid also. But experience shows that, even when this is done, activity of growth is frequently considerably increased if direct phosphatic manures be also employed. The phosphoric acid may be advantageously and economically applied either in the form of Peruvian guano, which at the same time supplies a large quantity of ammonia or ammonia-yielding matter and a little potash also, or as superphosphate of lime.

EXPERIMENTS at ROTHAMSTED with DIFFERENT MANURES on PERMANENT MEADOW LAND.

TABLE I.—PRODUCE of HAY per Acre; Tons, cwt., qrs., and lbs.

Plot, Nos.	MANURES PER ACRE, PER ANNUM (For detailed description, see pp. 504-5.)	Annual Produce.				Average Annual Increase by Manure.	
		1859. Cut June 27; Carted July 3.	1860. Cut July 7; Carted July 13.	1861. Cut June 29; Carted July 3.	1862. Cut June 25; Carted July 4-8.	Of 4 Years (1859-62).	Of 7 Years (1859-62).

SERIES 1.—Without Direct Mineral Manure.

Plot, Nos.	Manures per Acre, per Annum	1859	1860	1861	1862	Of 4 Years	Of 7 Years
1	Unmanured (duplicate plot)	1 2 2 20	1 4 2 16	1 5 1 16	1 7 1 0	1 4 3 27	1 6 0 15
2	Unmanured (duplicate plot)	1 3 0 0	1 5 3 0	1 9 2 0	1 10 2 8	1 7 0 15	1 6 0 15
3	Mean, or Standard Unmanured	1 2 3 10	1 5 0 22	1 7 1 22	1 8 3 18	1 6 0 11	1 5 0 24
4	200 lbs. each, Sulphate and Muriate Ammonia	1 12 2 4	1 6 2 14	1 15 1 0	1 14 1 18	1 11 3 6	1 13 0 23
5	200 lbs. each, Sulphate and Muriate Ammonia, and 200 lbs. Sawdust	1 12 2 4	1 6 2 14	1 15 1 0	1 19 3 0	1 13 2 10	1 14 1 3
6	200 lbs. Nitrate of Soda	1 12 0 4	1 15 1 0	1 16 2 4	1 19 2 22	1 15 3 15	1 13 3 25
7	500 lbs. Nitrate of Soda	1 15 3 0	1 19 1 14	1 19 3 0	1 16 1 26	1 18 0 10	1 16 3 10

SERIES 2.—With Direct Mineral Manure.

Plot, Nos.	Manures per Acre, per Annum	1859	1860	1861	1862	Of 4 Years	Of 7 Years
3a	Superphosphate of Lime	1 5 1 0	1 8 1 12	1 10 1 12	1 9 0 4	1 8 1 0	0 2 0 17
3b	Superphosphate of Lime, and 200 lbs. each, Sulphate and Muriate Ammonia	2 4 2 12	2 2 3 0	2 4 1 12	2 2 1 24	2 3 2 5	0 17 1 22
8	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	1 10 2 0	1 15 0 8	2 0 0 8	1 19 2 0	1 16 1 4	1 14 3 27
9	"Mixed Mineral Manure," and 200 lbs. Sawdust	1 10 1 8	1 15 1 14	2 0 1 14	2 0 1 16	1 17 0 6	1 16 2 9
10	"Mixed Mineral Manure," and 500 lbs. each, Sulphate and Muriate Ammonia	2 15 1 10	2 10 0 24	2 16 1 16	2 17 0 18	2 14 3 3	2 16 3 1
11	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia	2 12 1 0	2 7 3 14	2 17 1 20	2 15 0 20	2 13 0 21	2 15 2 0
12	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 200 lbs. Sawdust	3 2 1 0	2 11 1 16	2 18 0 0	2 14 3 24	2 16 2 17	2 14 3 27
13a	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 200 lbs. Nitrate of Soda	3 3 3 10	2 11 1 4	2 19 3 18	3 3 1 24	2 19 2 14	3 1 1 16
13b	"Mixed Mineral Manure," (including 200 lbs. each Sulphate and Muriate Ammonia), and 400 lbs. each, Sulphate and Muriate Ammonia	2 4 1 0	2 2 3 24	2 9 0 26	2 6 0 26	2 5 2 19	2 4 0 11
14	"Mixed Mineral Manure," and 275 lbs. Nitrate of Soda	2 14 0 24	2 9 3 14	2 12 2 12	2 11 0 6	2 11 3 21	2 11 2 15
15	"Mixed Mineral Manure," and 500 lbs. Nitrate of Soda	2 14 0 24	2 9 3 14	2 12 2 12	2 11 0 6	2 11 3 21	2 11 2 15

SERIES 3.—With Farnyard Manure.

Plot, Nos.	Manures per Acre, per Annum	1859	1860	1861	1862	Of 4 Years	Of 7 Years
16	14 tons Farnyard Manure	2 0 3 20	2 6 2 0	2 5 0 12	2 5 0 20	2 4 1 20	2 2 2 15
17	14 tons Farnyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	2 7 3 8	2 10 3 20	2 7 2 0	2 9 2 12	2 8 3 24	2 8 3 8

* With Sulphate of Potash excluded, and the amount of Sulphate of Soda increased, in 1862. † Only 200 lbs. each, in 1859, 1860, and 1861. ‡ Average of 5 years only.

EXPERIMENTS at ROTHAMSTED with DIFFERENT MANURES on PERMANENT MEADOW LAND.

TABLE II.—SHOWING the QUANTITY of HAY to which the AFTER-GRASS (consumed by Sheep on the Land) is estimated to be equivalent; calculated on the assumption that each Sheep would eat Grass = 16 lbs. of Hay per Week.

Plot, Nos.	MANURES PER ACRE, PER ANNUM. (For detailed description, see pp. 504-5.)	After-grass estimated as Hay (per Acre, per Annum).			
		1859. Second Crop.	1860. Second and Third Crop.	1861. Second Crop.	1862. Second and Third Crop.

SERIES 1.—Without Direct Mineral Manure.

Plot, Nos.	Manures per Acre, per Annum	1859	1860	1861	1862
1	Unmanured (duplicate plot)	914	2112	1286	1718
2	Unmanured (duplicate plot)	882	2146	1664	1755
3	Mean, or Standard Unmanured	893	2129	1545	1737
4	200 lbs. each, Sulphate and Muriate Ammonia	906	2222	1664	1846
5	200 lbs. each, Sulphate and Muriate Ammonia, and 200 lbs. Sawdust	882	2222	1664	1846
6	200 lbs. Nitrate of Soda	882	1507	1426	2304
7	500 lbs. Nitrate of Soda	900	1507	1426	2304

SERIES 2.—With Direct Mineral Manure.

Plot, Nos.	Manures per Acre, per Annum	1859	1860	1861	1862
3a	Superphosphate of Lime	822	2112	1535	1883
3b	Superphosphate of Lime, and 200 lbs. each, Sulphate and Muriate Ammonia	914	2112	1535	1883
8	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	1234	2378	1782	2157
9	"Mixed Mineral Manure," and 200 lbs. Sawdust	1234	2378	1782	2157
10	"Mixed Mineral Manure," and 500 lbs. each, Sulphate and Muriate Ammonia	1234	2378	1782	2157
11	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia	1234	2378	1782	2157
12	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 200 lbs. Sawdust	1234	2378	1782	2157
13a	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia	1234	2378	1782	2157
13b	"Mixed Mineral Manure," (including 200 lbs. each Sulphate and Muriate Ammonia), and 400 lbs. each, Sulphate and Muriate Ammonia	1234	2378	1782	2157
14	"Mixed Mineral Manure," and 275 lbs. Nitrate of Soda	882	1507	1426	2304
15	"Mixed Mineral Manure," and 500 lbs. Nitrate of Soda	900	1507	1426	2304

SERIES 3.—With Farnyard Manure.

Plot, Nos.	Manures per Acre, per Annum	1859	1860	1861	1862
16	14 tons Farnyard Manure	1098	2432	1755	2395
17	14 tons Farnyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	1098	2432	1755	2395

* With Sulphate of Potash excluded, and the amount of Sulphate of Soda increased, in 1862. † Only 200 lbs. each, in 1859, 1860, and 1861. ‡ Average of 5 years only.

EXPERIMENTS at ROTHAMSTED with DIFFERENT MANURES on PERMANENT MEADOW LAND.
TABLE III.—PERCENTAGES of DRY SUBSTANCE in the HAY (Means of Duplicate Determinations).

Plot, No.	MANURES PER ACRE, PER ANNUM. (For detailed description, see pp. 504-5.)	Average.				
		1859. Cut June 27; Carried July 2.	1860. Cut July 7; Carried July 12.	1861. Cut June 23; Carried July 3.	1862. Cut June 23; Carried July 4-8.	Of 4 Years (1859-62).
SERIES 1.—Without Direct Mineral Manure.						
1	Unmanured (duplicate plot)	88.7	82.9	85.3	78.5	84.0
2	Unmanured (duplicate plot)	86.3	79.7	84.1	79.5	82.4
3	Mean, or Standard Unmanured	87.5	81.3	84.7	79.0	83.8
4	200 lbs. each, Sulphate and Muriate Ammonia	87.6	81.0	83.1	78.9	82.6
5	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	87.6	81.0	83.1	78.9	82.6
6	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	87.6	81.0	83.1	78.9	82.6
7	200 lbs. Nitrate of Soda	83.7	79.3	89.0	77.5	81.4
8	Mean	85.0	80.5	84.1	78.6	82.3
SERIES 2.—With Direct Mineral Manure.						
24	Superphosphate of Lime	87.4	81.3	83.6	78.8	82.8
25	Superphosphate of Lime, and 200 lbs. each, Sulphate and Muriate Ammonia	87.4	80.3	83.9	77.4	82.0
8	Mixed Mineral Manure	87.7	79.9	84.7	76.3	83.7
9	Mixed Mineral Manure, and 2000 lbs. Sawdust	87.7	79.9	84.7	76.3	83.7
10	Mixed Mineral Manure, and 2000 lbs. Sawdust	87.7	81.2	83.9	79.0	82.9
11	Mixed Mineral Manure, and 2000 lbs. Sawdust	87.7	78.9	83.7	78.2	81.5
12	Mixed Mineral Manure, and 2000 lbs. Sawdust	87.7	78.4	83.7	79.7	82.2
13	Wheat-Straw	87.0	76.9	83.6	78.0	80.9
13a	Mixed Mineral Manure, and 400 lbs. each, Sulphate and Muriate Ammonia	87.0	76.9	83.6	78.0	80.9
13b	Mixed Mineral Manure, (including 200 lbs. each, Silicates Soda, and Lime), and 400 lbs. each, Sulphate and Muriate Ammonia	87.0	76.9	83.6	78.0	80.9
14	Mixed Mineral Manure, and 200 lbs. Nitrate of Soda	84.4	78.6	84.5	79.4	81.7
15	Mixed Mineral Manure, and 500 lbs. Nitrate of Soda	85.0	80.3	84.7	79.4	82.7
16	Mean	85.9	79.7	84.0	78.7	82.1
SERIES 3.—With Farmyard Manure.						
16	14 tons Farmyard Manure	89.2	82.7	84.6	77.9	83.4
17	14 tons Farmyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	87.3	81.2	84.3	75.4	82.9
* With Sulphate of Potash excluded, and the amount of Sulphate of Soda increased, in 1862. † Average of 5 years only.						

* With Sulphate of Potass excluded, and the amount of Sulphate of Soda increased, in 1862. † Only 200 lbs. each in 1859, 1860, and 1861. ‡ Average of 5 years only.

EXPERIMENTS at ROTHAMSTED with DIFFERENT MANURES on PERMANENT MEADOW LAND.
TABLE IV.—PERCENTAGES of MINERAL MATTER (Ash) in the HAY (Means of Duplicate Determinations).

Plot Nos.	MANURES PER ACRE, PER ANNUM (For detailed description, see pp. 504-5.)	Percentages in the Hay as taken from the Land.					Percentages in the Dry Substance of the Hay.				
		1859. Cut June 27; Carried July 2.	1860. Cut July 7; Carried July 12.	1861. Cut June 23; Carried July 2.	1862. Cut June 23; Carried July 2.	Average. Of 4 Years (1859-62).	1859. Cut June 27; Carried July 2.	1860. Cut July 7; Carried July 12.	1861. Cut June 23; Carried July 2.	1862. Cut June 23; Carried July 2.	Average. Of 4 Years (1859-62).
SERIES 1.—Without Direct Mineral Manure.											
1	Unmanured (duplicate plot)	6.32	6.27	5.77	6.12	5.96	7.13	7.37	6.76	7.30	7.16
2	Unmanured (duplicate plot)	6.34	6.29	5.84	6.12	5.96	7.35	7.23	6.94	7.10	7.08
3	Mean, or Standard Unmanured	6.33	6.02	5.81	5.80	5.99	7.24	7.40	6.85	7.21	7.12
4	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	5.48	5.33	5.19	5.36	5.34	6.42	6.33	6.23	6.78	6.54
5	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	5.56	5.33	5.19	5.36	5.34	6.42	6.33	6.23	6.78	6.54
6	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	5.56	5.33	5.19	5.36	5.34	6.42	6.33	6.23	6.78	6.54
7	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	5.56	5.33	5.19	5.36	5.34	6.42	6.33	6.23	6.78	6.54
8	Mean	5.84	6.06	5.70	6.42	6.01	6.98	7.04	6.71	6.98	7.11
SERIES 2.—With Direct Mineral Manure.											
32	Superphosphate of Lime, and 200 lbs. each, Sulphate and Muriate Ammonia	6.30	6.28	5.84	6.12	5.96	7.13	7.37	6.76	7.30	7.16
33	Superphosphate of Lime, and 200 lbs. each, Sulphate and Muriate Ammonia	6.30	6.28	5.84	6.12	5.96	7.13	7.37	6.76	7.30	7.16
8	Mixed Mineral Manure, and 2000 lbs. Sawdust	7.16	6.92	6.33	6.30	6.68	8.17	8.06	7.85	8.24	8.03
9	Mixed Mineral Manure, and 2000 lbs. Sawdust	7.08	6.60	6.06	6.08	6.43	7.75	7.60	7.56	7.70	7.63
10	Mixed Mineral Manure, and 2000 lbs. Sawdust	6.43	6.34	6.06	6.08	6.43	6.81	6.68	6.67	6.77	6.73
11	Mixed Mineral Manure, and 2000 lbs. Sawdust	6.99	6.85	6.42	6.42	6.55	7.93	7.81	7.79	7.81	7.83
12	Mixed Mineral Manure, and 2000 lbs. Sawdust	6.94	6.40	6.08	6.08	6.50	7.93	7.81	7.79	7.81	7.83
13	Mixed Mineral Manure, and 2000 lbs. Sawdust	6.61	6.56	6.30	6.40	6.48	7.77	7.23	7.54	8.21	7.69
14	Mixed Mineral Manure, and 2000 lbs. Sawdust	6.61	6.56	6.30	6.40	6.48	7.77	7.23	7.54	8.21	7.69
15	Mean	6.65	6.55	6.48	6.54	6.55	7.88	7.88	7.88	7.88	7.88
16	Mixed Mineral Manure, and 2000 lbs. Sawdust	6.25	6.04	6.09	6.09	6.14	7.38	7.32	7.20	7.60	7.61
17	Mixed Mineral Manure, and 2000 lbs. Sawdust	6.73	6.45	6.30	6.32	6.45	7.83	7.80	7.50	8.03	7.83
SERIES 3.—With Farnyard Manure.											
15	14 tons Farnyard Manure	6.95	6.74	6.78	7.27	6.94	7.89	8.16	8.02	9.33	8.34
16	14 tons Farnyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	6.76	6.81	6.50	6.96	6.76	7.74	8.39	7.71	8.98	8.26
17	Muriate Ammonia	6.76	6.81	6.50	6.96	6.76	7.74	8.39	7.71	8.98	8.26

* With Sulphate of Potass excluded, and the amount of Sulphate of Soda increased, in 1862. † Only 200 lbs. each in 1859, 1860, and 1861. ‡ Average of 5 years only.

EXPERIMENTS at ROTHAMSTED with DIFFERENT MANURES on PERMANENT MEADOW LAND.
TABLE V.—PERCENTAGES of NITROGEN in the HAY (Means of Duplicate Determinations).

Plot, Nos.	MANURES PER ACRE, PER ANNUM. (For detailed description, see pp. 504-5.)	Percentages in the Hay as taken from the Land.										Percentages in the Dry Substance of the Hay.			
		1859.	1860.	1861.	1862.	Average.	1859.	1860.	1861.	1862.	Average.	1859.	1860.	1861.	Average.
		Cut June 25, carted July 5.	Cut June 25, carted July 5.	Cut June 25, carted July 5.	Cut June 25, carted July 5.	Of 4 Years (1859-62).	Cut June 25, carted July 5.	Cut June 25, carted July 5.	Cut June 25, carted July 5.	Cut June 25, carted July 5.	Of 4 Years (1859-62).	Cut June 25, carted July 5.	Cut June 25, carted July 5.	Cut June 25, carted July 5.	Of 4 Years (1859-62).
SERIES 1.—Without Direct Mineral Manure.															
1	Unmanured (duplicate plot)	1.50	1.36	1.31	1.19	1.34	1.39	1.74	1.64	1.53	1.57	1.62	1.60	1.67	1.65
2	Unmanured (duplicate plot)	1.50	1.36	1.31	1.19	1.34	1.39	1.74	1.64	1.53	1.57	1.62	1.60	1.67	1.65
3	Mean, or Standard Unmanured	1.50	1.36	1.31	1.19	1.34	1.39	1.74	1.64	1.53	1.57	1.62	1.60	1.67	1.65
4	200 lbs. each, Sulphate and Muriate Ammonia	1.50	1.41	1.30	1.22	1.36	1.41	1.73	1.73	1.53	1.55	1.63	1.63	1.69	1.66
5	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	1.74	1.64	1.71	1.71	1.71	1.68	2.03	2.25	2.06	2.17	2.13	2.13	2.03	2.08
6	275 lbs. Nitrate of Soda	1.68	1.70	1.67	1.47	1.63	1.60	1.92	2.10	2.01	1.87	1.87	1.96	1.92	1.92
7	350 lbs. Nitrate of Soda	1.59	1.38	1.49	1.20	1.42	1.42	1.56	1.74	1.67	1.67	1.66	1.73	1.78	1.75
	Mean	1.62	1.57	1.54	1.43	1.54	1.55	1.89	1.94	1.83	1.87	1.87	1.87	1.87	1.87
SERIES 2.—With Direct Mineral Manure.															
8	Superphosphate of Lime	1.59	1.37	1.39	1.22	1.39	1.39	1.81	1.68	1.66	1.54	1.67	1.67	1.74	1.74
9	"Mixed Mineral Manure"	1.41	1.43	1.49	1.38	1.43	1.43	1.63	1.77	1.77	1.78	1.67	1.71	1.71	1.76
10	"Mixed Mineral Manure," and 200 lbs. Sawdust	1.57	1.49	1.29	1.31	1.42	1.46	1.79	1.86	1.51	1.67	1.71	1.79	1.79	1.79
11	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	1.60	1.56	1.34	1.27	1.44	1.49	1.83	1.92	1.59	1.59	1.45	1.51	1.49	1.49
12	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	1.18	1.20	1.19	1.16	1.17	1.17	1.32	1.52	1.42	1.48	1.44	1.44	1.44	1.44
13	"Mixed Mineral Manure," and 2000 lbs. Cut Wheat-Straw	1.22	1.22	1.32	1.09	1.21	1.28	1.40	1.55	1.58	1.36	1.47	1.56	1.47	1.56
14	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	1.29	1.19	1.23	1.41	1.28	1.42	1.52	1.55	1.47	1.81	1.59	1.75	1.75	1.75
15	"Mixed Mineral Manure," and 275 lbs. Nitrate of Soda	1.42	1.20	1.28	1.13	1.28	1.33	1.69	1.66	1.50	1.42	1.57	1.61	1.61	1.61
	Mean	1.21	1.17	1.18	1.13	1.17	1.20	1.43	1.45	1.39	1.43	1.43	1.43	1.43	1.43
	Mean	1.26	1.31	1.31	1.24	1.30	1.32	1.59	1.65	1.55	1.57	1.59	1.59	1.59	1.59
SERIES 3.—With Farnyard Manure.															
16	14 tons Farnyard Manure	1.20	1.19	1.25	1.10	1.19	1.23	1.36	1.44	1.49	1.41	1.42	1.42	1.43	1.49
17	14 tons Farnyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	1.17	1.20	1.23	1.12	1.18	1.24	1.34	1.48	1.45	1.43	1.43	1.43	1.43	1.50

* With Sulphate of Potash excluded, and the amount of Sulphate of Soda increased, in 1862. † Only 200 lbs. each in 1859, 1860, and 1861. ‡ Average of 5 years only.

EXPERIMENTS at ROTHAMSTED with DIFFERENT MANURES on PERMANENT MEADOW LAND.

TABLE VI.—PRODUCE of TOTAL DRY SUBSTANCE per Acre; lbs.

Plot, Nos.	MANURES PER ACRE, PER ANNUM. (For detailed description, see pp. 504-5.)	Annual Produce.					Average Annual Increase by Manure.	
		1859.	1860.	1861.	1862.	Average.	Of 4 Years (1859-62).	Of 7 Years (1856-62).
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
SERIES 1.—Without Direct Mineral Manure.								
1	Unmanured (duplicate plot)	2252	2297	2277	2295	2295	2295	2295
2	Unmanured (duplicate plot)	2252	2297	2277	2295	2295	2295	2295
3	Mean, or Standard Unmanured	2252	2297	2277	2295	2295	2295	2295
4	200 lbs. each, Sulphate and Muriate Ammonia	3104	3400	3293	3553	3338	3338	3338
5	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	3210	3400	3293	3553	3338	3338	3338
6	275 lbs. Nitrate of Soda	3139	3400	3293	3553	3338	3338	3338
7	350 lbs. Nitrate of Soda	3444	3400	3293	3553	3338	3338	3338
SERIES 2.—With Direct Mineral Manure.								
8	Superphosphate of Lime	3472	3846	3804	4063	3846	3846	3846
9	"Mixed Mineral Manure"	2975	3306	3270	3574	3283	3283	3283
10	"Mixed Mineral Manure," and 200 lbs. Sawdust	2975	3306	3270	3574	3283	3283	3283
11	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	4986	4223	4223	4801	4558	4558	4558
12	"Mixed Mineral Manure," and 2000 lbs. Cut Wheat-Straw	6068	4510	5439	4963	5231	5231	5231
13	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	6080	4418	5604	5434	5412	5412	5412
14	"Mixed Mineral Manure," and 275 lbs. Nitrate of Soda	4181	3780	4657	4128	4182	4182	4182
15	"Mixed Mineral Manure," and 350 lbs. Nitrate of Soda	5163	4487	4988	4384	4734	4734	4734
SERIES 3.—With Farnyard Manure.								
16	14 tons Farnyard Manure	4934	4307	4275	3943	4163	4163	4163
17	14 tons Farnyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	4678	4603	4487	4334	4524	4524	4524

* Only 200 lbs. each in 1859, 1860, and 1861. † Average of 5 years only.