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this arrangement be adopted, the liquid in the tank may frequently be pumped over the manure in the pit without doing any harm, which it would be sure to do if no provision were made for the excess of liquid to drain back into the tank. This is of particular importance on farms where cattle, for want of straw, are insufficiently littered, and the manure consequently is very wet. The bulk of the solid manure, as well as the quantity of absorbing materials, might be considerably increased if coal-ashes, dry sawdust, and dry refuse matters of every description, and even dry earth, were thrown upon the manure-heap; and I feel convinced that, with a little care and management, the whole of the liquid excrements might gradually be absorbed and incorporated with the solid manure and litter.

The third plan of disposing of liquid manure is most beneficially adopted on farms upon which much more straw is produced than can be sold or consumed in feeding-boxes. On many farms in the neighbourhood of Cirencester it is impossible to convert in boxes the excess of straw into manure. There is not sufficient moisture to rot the straw.

On our own farm we have so much straw in the manure that it would not ferment properly if it were not exposed in the manure-pit to the rain that falls, and if it were not besides moistened with the sewage that flows from the College into the liquid-manure tank. Where there is an excess of straw, no difficulty exists of disposing of liquid manure, since the straw is capable of taking up more liquid than is supplied in the urine of animals. For this reason it is of no use to erect a roof over the manure-pit on farms where a large excess of straw is employed in the making of manure. On such farms I think no sensible man would contemplate for a moment the introduction of the system of liquid manuring.

*Royal Agricultural College, Cirencester,
December, 1858.*

XXV.—*Report of Experiments with different Manures on Permanent Meadow Land.* By J. B. LAWES, F.R.S., F.C.S., and Dr. J. H. GILBERT, F.C.S.

PART I.—PRODUCE OF HAY PER ACRE.

THE extent of land in this country in Permanent Grass, and the importance of the crop, both as regards its yield of food for animals, and its relations, under existing circumstances, to the crops under tillage, establish for it a high claim to investigation, with a view to increased productiveness. In several of its

aspects—and in some involving its most intricate relations—the subject has received the attention of investigators at once competent and laborious. The pages of the ‘Journal of the Royal Agricultural Society of England’ sufficiently bear out this statement. Among them are to be found valuable records of practical observation, and experience, as to the distribution, the adaptation, and the comparative utility, of the most important plants composing this heterogeneous crop, according to character of soil, climate, and other circumstances.* We have elaborate examinations by Professor Way, into the composition of the several plants, each grown under circumstances favourable to its development, and all taken as far as possible at an equal stage of growth.† And in the last Number of the Journal will be found three Papers, each of great but distinctive value, bearing upon the practical management and manuring of the Grass crop.

As the title of the present Paper will indicate, its scope and objects are sufficiently distinct from those of the inquiries above alluded to. And, whilst the plan of the investigation which has been undertaken, and the character of the data which it has afforded, will necessarily lead to a somewhat special treatment of the subject, we shall endeavour, as far as circumstances will permit, to pay due regard to what appears to have been established hitherto.

An inquiry into the comparative effects of different manuring substances upon permanent grass, has, however, other grounds of interest than such as relate merely to determining the best means of increasing the gross amount of its produce. There is perhaps no crop more influenced in its *character*, as well as its *quantity*, by the attention bestowed upon it. Our Grass-crop comprises, as is well known, not only a great number of genera and species belonging to the *Graminaceous* family—the Natural Grasses commonly so called—but also various members of other families of plants, among which, by far the most important is the *Leguminous*. It so happens, then, that in our Meadows and Pastures there are associated members of those two families of plants that afford us the crops which are not only the most important among those which enter into our rotations, but which, as there grown separately, and in alternation, exhibit very characteristically different degrees of dependence upon the direct artificial supply of some of their constituents; and coincidentally with this, show very distinctive relationships to one another in the course of cropping.

* See ‘Prize Report,’ by Mr. John Bravender, Jour. Roy. Ag. Soc., vol. v.: also Papers by Professor Buckman, Jour. Roy. Ag. Soc., vol. xv. p. 462; vol. xvii. p. 162; and vol. xvii. p. 513.

† Jour. Roy. Ag. Soc., vol. xi. p. 530, and vol. xiv. p. 171.

Thus, Wheat, Barley, and Oats are of the *Graminaceous* family, and have, therefore, so far, their points of close relationship with the so-called "Natural Grasses." Beans, Peas, and the cultivated Clovers, Lucerne, &c., of our rotations, are, on the other hand, of the *Leguminous* family; and hence their relationship to the clovers, and allied plants, of our Meadows and Pastures. It is true that the circumstances of growth, and the treatment, of the plants composing the mixed herbage of our Pastures and Meadows, are widely different from those of the allied plants—especially of the seeding ones—in our arable fields. In the one case, too, the plants are chiefly perennial, and in the other chiefly annual. It might well be expected, therefore, that, notwithstanding their natural alliances, crops which differ so widely both in certain comparatively incidental conditions of growth, and in some intrinsic qualities, should, at the same time, manifest somewhat different manurial requirements.

Among the most interesting of the points incidentally brought out by the experiments which form the subject of the present Report, is the striking confirmation which the results afford of the (so to speak) special adaptation, in a course of practical agriculture, of certain constituents of manure, to the growth of certain of the crops of our rotations, accordingly as they belong to the one or to the other of the two great families of plants above referred to. That is to say, the comparative action of different descriptions of manure, upon the development of the different plants of the mixed herbage of our Meadow, was found to accord with, and further to illustrate, points independently established regarding the manurial requirements, and the mutual relations, of the plants of our rotations to which they are botanically allied. At the same time, independently of the difference in other conditions of growth and management, the permanent and alternating crops generally differ so widely, both in regard to the amount of certain constituents which they respectively remove from the land, and to the proportion of these which will probably be in due course returned in the home manures, that the character of the supplementary manures required by even much allied crops, must obviously be somewhat different in the two cases.

To turn to the experiments themselves: The plan adopted was, to apply a number of different combinations of manuring substances, each, year after year, to the same plot of land. And in order to provide proper standards of comparison, two plots were left continuously unmanured, and another portion was annually manured with farm-yard manure.

The land selected comprised about 6 acres of the Park at Rothamsted, and it had been under permanent grass for certainly

more than a century; indeed, for as long a period as is included in any record that can be found relating to it. The general mode of treatment for many years prior to 1851, was to manure occasionally with farm-yard dung, road scrapings, and the like; and sometimes with Guano, or other purchased manure. One crop of Hay was removed annually, amounting in weight to from $1\frac{1}{4}$ to 2 tons per acre; and the second crop was always eaten off by sheep. In the spring of 1851, and again in that of 1852, 4 separate acres of the allotted area were appropriated to the consumption by sheep of as many lots of differently manured turnips; 10 tons of the roots being eaten upon each acre. Neither the 4 acres so appropriated, nor the remaining 2, were manured in any other way in those two seasons; nor were they manured at all in the three succeeding ones prior to the commencement of these experiments in 1856. It should be mentioned too, that the consumption on the land of the different turnips did not in any case increase the produce over the 5 years, 1851-5 inclusive, by more than about 2 cwts. per acre annually. The land is a somewhat heavy loam, with a red clay subsoil resting upon chalk; and although not artificially is very well naturally drained. The area selected was perfectly level. Lastly, no fresh seed of any kind has been sown either within the period of the experiments, or for many years before it.

Early in 1856, 9 plots, of half an acre each, were measured off for as many different combinations of so-called artificial manuring substances; 2 of a quarter of an acre each, to be continuously unmanured; and 2, also of a quarter of an acre each, to be manured annually with farm-yard dung. In 1858, 4 additional plots, of one-sixth of an acre each, were appropriated to trials with nitrate of soda; the land so selected having been unmanured for several preceding seasons. The description, and quantities per acre, of the different manures employed, are given in the Tables, by the side of the results they yielded; but it will be well to state them here, at one view, a little more fully than there is there room to do.

Plot 1. Unmanured.

Plot 2. Unmanured (duplicate plot at the further end of the series).

Plot 3. 2000 lbs. sawdust.

Plot 4. 200 lbs. each sulphate and muriate ammonia (good samples of the salts so named in commerce).

Plot 5. 2000 lbs. sawdust, and 200 lbs. each sulphate and muriate ammonia.

Plot 6. 275 lbs. nitrate of soda.*

* The experiments with nitrate of soda did not commence until the third season, 1858.

Plot 7. 550 lbs. nitrate of soda* (equal in nitrogen to the ammoniacal salts of plot 4).

Plot 8. Mixed mineral manure, composed of—

200 lbs. bone ash	} superphosphate of lime.
150 lbs. sulphuric acid (sp. gr. 1.7)	
300 lbs. sulphate of potash.†	
200 sulphate of soda.†	
100 lbs. sulphate of magnesia.†	

Plot 9. "Mixed mineral manure," as plot 8, and 2000 lbs. sawdust.

Plot 10. "Mixed mineral manure," as plot 8, and 200 lbs. each sulphate and muriate ammonia.

Plot 11. "Mixed mineral manure," as plot 8, 200 lbs. each sulphate and muriate ammonia, and 2000 lbs. sawdust.

Plot 12. "Mixed mineral manure," as plot 8, 200 lbs. each sulphate and muriate ammonia, and 2000 lbs. cut wheat-straw.

Plot 13. "Mixed mineral manure," as plot 8, and 400 lbs. each sulphate and muriate ammonia.

Plot 14. "Mixed mineral manure," as plot 8, and 275 lbs. nitrate of soda.*

Plot 15. "Mixed mineral manure," as plot 8, and 550 lbs. nitrate of soda* (equal in nitrogen to the ammoniacal salts of plots 4, 10, &c.).

Plot 16. 14 tons farm-yard dung.

Plot 17. 14 tons farm-yard dung, and 100 lbs. each sulphate and muriate ammonia.

It would have been desirable to have had some plots with the superphosphate of lime, and the mixed alkali-salts, used separately; but it was considered, that to increase the number of the experiments, would be to extend the series beyond convenient practicable limits.

The artificial manures were, for the purpose of equal distribution, mixed with ashes prepared by burning soil with a portion of weeds and turf. They were sown broadcast. The date of sowing was, in 1856, the middle of February; in 1857, the 24th February; and in 1858, the 31st of March; excepting that the nitrate of soda (used in 1858 only) was not applied until the 8th of April. The farm-yard manure and the sawdust, excepting in the first season, were put on in the previous November or December.

The first crop only, in each year, was mown; and the produce

* The experiments with nitrate of soda did not commence until the third season, 1858.

† The sulphates of potash and soda used, are the rough commercial articles; the sulphate of magnesia, Epsom salts.

of each plot was weighed separately as *hay*, at the time of being carted to the rick. The second crop was eaten off by sheep having no other food; each plot, according to the bulk of its produce, having a given number penned upon a portion of it, the area being extended, day by day, as the feed was eaten down. To the further particulars of the feeding, and to the estimates made of the produce of the second crop, we shall recur presently.

The weight of hay (one cutting) taken from the different plots, in each of the 3 seasons, is given in Table I., p. 558.

Although the three seasons over which the experiments have extended differed widely one from another in climatic characters, the amounts of *gross produce*, under equal conditions of manuring, were upon the whole much the same in the three seasons. There was indeed a tendency to increase, from year to year, as the experiments proceeded; but this tendency is the more apparent when the acreage amounts of *dry matter*, instead of gross produce of hay merely, are considered. Viewed in this way, the increase was moreover much greater in the second year as compared with the first, than in the third as compared with the second. It was too, perhaps upon the whole, the more marked where the most liberal manuring was employed, and the largest crops thereby obtained. On this point it should be remembered, that the manure from the sheep consuming the second crop, so far as it was due to the residual manures applied for the preceding first crop, would be so much addition to that supplied for the first crop of the succeeding season; and that the addition would be the greater, the more liberal had been the manuring, and the larger the amount of after-grass. It would too, with excess of manure, be somewhat cumulative, and relatively the more so, the more excessive the manuring, and the greater the produce of after-grass. The difference in the produce by the same manure, in one season compared with another—at any rate the increase in the amount of it in the second year of manuring over that in the first—cannot therefore be *wholly* attributed to differences in the characters of the seasons themselves.

With regard to the seasons themselves, a few general observations may nevertheless be made. The growing period of the first season, 1856, was generally much colder and wetter than that of either 1857 or 1858. Its rain was in April above the average, in May very large, and in the final month, June, but small. The moisture in the atmosphere, as indicated by the dew-point, was generally comparatively low; and with this the range of temperature above that point was also low.

The grass season of 1857 ranged higher both in maximum and in minimum temperatures, and also in mean range, than that of 1856; and in that of 1858 higher numbers still were registered
in

EXPERIMENTS WITH DIFFERENT MANURES ON PERMANENT MEADOW LAND.

TABLE I.—PRODUCE OF HAY per Acre: tons, cwts., qrs., and lbs.

Plot, Nos.	MANURES. (Per Acre, per Annum).	ANNUAL PRODUCE.				Average Annual Increase or Loss by Manure.	
		1856.		1857.			Average of 3 Years.
		Cut June 25; carted July 1.	Cut June 23; carted Ju. 26-27.	Cut June 26; carted Ju. 29-30.	1858.		
		tns. cwt. qrs. lb.	tns. cwt. qrs. lb.	tns. cwt. qrs. lb.	tns. cwt. qrs. lb.	tns. cwt. qrs. lb.	
1	Unmanured (duplicate plot)	1 2 1 23	1 5 2 0	1 2 0 8	1 3 1 10	• • •	
2	Unmanured (duplicate plot)	1 0 3 27	1 3 0 16	1 10 0 0	1 4 2 24	• • •	
3	Mean, or Standard Unmanured	1 1 2 25	1 4 1 8	1 6 0 4	1 4 0 3	• • •	
4	2000 lbs. Sawdust	1 0 2 16	1 0 3 16	1 0 0 4	1 0 2 3	-0 3 2 0	
5	200 lbs. each, Sulphate and Muriate Ammonia	1 15 3 24	1 13 2 22	1 15 2 6	1 15 0 8	0 11 0 5	
6	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	1 15 1 5	1 13 0 14	1 17 0 22	1 15 0 14	0 11 0 11	
7	275 lbs. Nitrate of Soda *	• • •	• • •	1 6 1 12	• • •	0 2 1 9	
	550 lbs. Nitrate of Soda *	• • •	• • •	1 11 3 8	• • •	0 7 3 5	
SERIES 1.—Without Direct Mineral Manure.							
SERIES 2.—With Direct Mineral Manure.							
8	"Mixed Mineral Manure"†	1 10 2 13	1 12 2 26	1 16 1 22	1 13 1 2	0 9 0 27	
9	"Mixed Mineral Manure," and 2000 lbs. Sawdust	1 13 0 13	1 15 2 18	1 19 0 8	1 15 3 23	0 11 3 20	
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	2 16 3 7	2 17 1 10	3 4 0 4	2 19 1 16	1 15 1 13	
11	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	2 16 3 13	2 17 1 16	3 1 2 4	2 18 2 11	1 14 2 8	
12	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Cut Wheat Straw	2 8 1 8	2 14 0 2	3 0 1 4	2 14 0 23	1 10 0 20	
13	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	3 2 0 26	3 1 3 24	3 7 0 4	3 3 2 27	1 19 2 24	
14	"Mixed Mineral Manure," and 275 lbs. Nitrate of Soda*	• • •	• • •	1 17 3 8	• • •	0 13 3 5	
15	"Mixed Mineral Manure," and 550 lbs. Nitrate of Soda*	• • •	• • •	2 10 1 8	• • •	1 6 1 13	
SERIES 3.—With Farmyard Manure.							
16	14 tons Farmyard Manure	1 15 3 26	2 7 2 8	1 17 0 20	2 0 0 27	0 16 0 24	
17	14 tons Farmyard Manure, and 100 lbs. each, Sulphate and Muriate of Ammonia	2 4 2 25	2 13 2 16	2 7 2 0	2 8 2 14	1 4 2 11	

* The experiments with Nitrate of Soda were not undertaken until the third year (1858), and the land devoted to it had been unmanured during several preceding seasons.
 † For further description of this, and other manures, see page 556.

in regard to these several characters ; but especially to that of the maximum temperature of the final month June, which in this third season, 1858, was very excessive. Both in amount and distribution of rain, April differed not very materially in the three seasons. May, as already mentioned, gave in 1856 a very large amount of rain, and also a large number of rainy days. In the same month of 1857, with at the same time much higher temperatures than in 1856, both the actual fall, and the distribution of rain, were very small. In May of 1858, again, with still higher temperatures than in the same month of 1856, both the actual amount and the distribution of rain were pretty full. In June, 1856, with again lower temperatures than in the other years, there was, after the very wet May, now but very little rain. In the warmer June of 1857 there was a fair amount of rain ; and in the still hotter June of 1858 there was, after a moderately wet May, but little rain.

The three seasons were therefore very different from one another, both in actual character as to heat and moisture, and in the mutual adaptations of these two qualities. As has been observed, however, the gross amount of the heterogeneous produce—*hay*—did not differ very widely in the three seasons ; though the acreage amount of *dry matter*, and consequently of carbon assimilated, was nevertheless notably less in the first, and colder and wetter season 1856, than in either of the others. And, as will afterwards be seen, with the prevailing wet and cold of 1856, the percentage of dry matter in the produce was low, and that of the mineral matter, and of the nitrogen in that dry substance, high—characters which indicate comparatively backward conditions as to the stage of growth and the maturation of the plants. In a subsequent division of this Report we shall illustrate by pretty full detail on the point, the fact that the proportions of the different descriptions of herbage, as well as the character of the development of each, were very much affected within equal periods of the season, according to the kind of manure employed. Had we equal means of deciding upon the varying character of the produce dependent on the varying character of the seasons, there can be little doubt that the produce of these three very different seasons would show great differences, both as to the relative amounts of the various plants developed, and as to the character of the development of each.

Directing attention now to the comparative effects of the different *manures*, little more need be said as to the produce of the individual seasons. The results, as between one condition of manuring and another, will be both better and more easily

traced by confining attention to the column showing the *average annual produce over the 3 years*, and to the concluding one of the Table (I.) showing the *average annual increase by manure*. These records relate, as will be remembered, to the produce of one cutting only. An estimate will be given further on, as to the actual and relative amounts of hay, to which the after-feed on the several plots was probably equivalent. At present it is only necessary to consider how far the consumption of the after-grass upon the land should influence the judgment to be formed of the effects of the different manures according to the weights of the produce of the first crop alone. On this point it may be remarked, that the knowledge we possess as to the average proportion of the nitrogen and of the mineral matter of the food consumed by stock, which they probably finally store up in their bodies (and in the case of nitrogen exhale), is such as to lead to the conclusion that the land would lose comparatively little of these manuring substances by the consumption upon it of the after-grass by sheep. By far the larger proportion of these contained in the second crop of one year would, therefore, remain towards the produce of the first crop in the succeeding year. Taken over a series of years, the annual produce yielded in the first crop will thus pretty closely represent the average annual result of the manure on any particular plot; at any rate sufficiently so for a general comparison of the effects of one manure with that of another.

On one of the unmanured plots the average annual produce of hay was 1 ton 3 cwts. 1 qr. 10 lbs.; and it varied but little from year to year. The duplicate unmanured plot was somewhat shaded from the afternoon sun. It gave in the first two years about 2 cwts. less of hay annually per acre than the other, but in the third year as much as 8 cwts. of hay more. The fact was, as the result of the after-feeding showed, that this second plot, though it gave less mown hay in the first two years than the first plot, gave, on the other hand, more aftergrass in those years. Hence there was less removal from the land in the first two years; and, compared with the other plot, some accumulation of manuring matter for the first crop of the third season. The average annual yield of mown hay on the duplicate plot was, however, only $1\frac{3}{8}$ cwts. more than on the other. The mean of the two may therefore be fairly taken as the average annual yield of the land and seasons in question. This amounted to 1 ton 4 cwts. and 3 lbs. of hay, as the *standard unmanured produce* of the experimental meadow-land.

Sawdust contains very little of either nitrogen or mineral matter; but, upon high authority, it has been stated to produce great effects as manure, by virtue of the solvent action of the car-

bonic acid it yields in its decomposition, upon the mineral constituents of the soil. The plot where there were employed per acre annually 2000 lbs. of sawdust (containing 4 to 5 lbs. of nitrogen), yielded, however, an average annual produce of about $3\frac{1}{2}$ cwts. less hay than the unmanured land. Where 2000 lbs. of sawdust were employed *with ammoniacal salts* (Plot 5), there were only 6 lbs. per acre per annum more produce than where the same description and amount of ammoniacal salts were used alone (Plot 4). When the same amount of sawdust was added with a liberal mineral manure (Plot 9), the mixture gave annually about $2\frac{5}{8}$ cwts. more hay than when the same mineral manure (Plot 8) was used alone. Lastly, when the sawdust was employed in admixture with both the ammoniacal salts and the mineral manure (Plot 11), the produce per acre per annum was about $\frac{3}{4}$ cwt. less than when the same ammoniacal salts and mineral manure (Plot 10) were used without the sawdust. The nearly a ton per acre per annum of organic matter rich in carbon, in the form of sawdust, was then practically of no avail.

As the previous enumeration and the Table show, the ammoniacal salts employed consisted of an equal mixture of the sulphate and the muriate of ammonia of commerce. This mixture is reckoned to contain about 25 per cent. of ammonia, which is equal to about 20.5 per cent. of nitrogen. The 400 lbs. of ammoniacal salts per acre per annum, as used on several of the plots, would therefore bring annually on to the land about 100 lbs. of ammonia.

Where the 400 lbs. of ammoniacal salts were used alone (Plot 4), they gave an average annual *increase* of 11 cwts. of hay. The average annual *produce* by the ammoniacal salts was 1 ton 15 cwts. of hay.

The "*mixed mineral manure*" alone (Plot 8), which contained an ample supply of acid—phosphate, and sulphate of lime, and of potash, soda, and magnesia, in the form of sulphates, but which did not afford, in a direct manner, an increased supply of available silica, gave an average annual increase of about $9\frac{1}{4}$ cwts. of hay per acre.

The ammoniacal salts alone, it has been seen, gave an annual increase of 11 cwts. of hay; only $1\frac{3}{4}$ cwt. more, therefore, than purely mineral manures. It will be shown, however, in some detail in a subsequent section, that the description of the increase differed extremely in the two cases. In fact, where the ammoniacal salts were employed, the increase was exclusively due to the increased growth of *Graminaceous plants*—the so-called *Natural Grasses*—there being scarcely a *Leguminous* plant to be found upon the plot. Where the purely mineral manures were used, on the other hand, the *Grasses*, properly so called, were

observed scarcely to have increased at all; whilst the whole plot was thickly covered with Perennial Red Clover (*Trifolium pratense perenne*) and some other Leguminous plants. Such a result is perfectly consistent with what has been before established regarding the (so to speak) characteristic adaptation of mineral and nitrogenous manures respectively, to those crops of the respective families which are grown in our rotations.

Mineral manures alone have then much increased the growth of the Leguminous plants on the meadow land. They enabled the Gramineous ones, on the other hand, to assimilate but little more of nitrogen or carbon from natural sources, than did the normal supply of available mineral constituents in the unmanured land. Very different was the action of mineral manures upon the growth of the Gramineous plants of the Meadow, when those manures were associated with a liberal artificial supply of *available nitrogen*. In the case of experiments both upon Wheat and upon Barley, too, it has been shown that the land experimented upon was competent, for a series of years, to yield up annually enough of mineral constituents for a considerably larger crop than could be grown under the influence of the annually available natural supplies of nitrogen alone. The annually available mineral constituents were, however, not sufficient for such full crops as the seasons would yield, *when there was a liberal artificial supply of available nitrogen*. There appear to be obvious reasons why this should be expected to hold good to a greater extent with Meadow Grass than with these Gramineous corn crops. In land of pretty equal original characters, the amount of mineral matter taken annually from a given area in Grass (mown for hay) is, under the same annual climatic circumstances, much greater than that taken off in the corn and in the straw of the seeding crop. The mechanical operations, and the exposure to the atmosphere, in the case of the arable land, would appear to indicate a greater annual disintegration and liberation of total mineral constituents over a given area, though not perhaps more within the limits of the immediately superficial layers. In the case of Meadow Grass, therefore, the original characters of the soil, and the seasons, being equal, both the annual demand for mineral constituents would be greater, and the total annual yield of them from the soil would be less, than in the case of the cereal crop.

Consistently with the foregoing considerations, it was found, that although the ammoniacal salts when used alone gave an annual increase of only 11 cwts. of hay, the same amount of ammoniacal salts, when in conjunction with the "*mixed mineral manure*" (Plot 10), gave an annual increase of 1 ton 15 $\frac{3}{8}$ cwts. of hay. Thus, the combination of ammoniacal salts and the

mixed mineral manure gave more than three times as much increase as the ammoniacal salts alone, and four times as much as the mineral manure alone. The average annual produce, by the mixture of the ammoniacal salts and mineral manure, amounted in fact to within less than a hundredweight of 3 tons of hay per acre, by the side of 1 ton 4 cwts. per acre on the continuously unmanured land.

Now, this produce, by the mixed mineral manure and ammoniacal salts (Plot 10), consisted almost exclusively of Gramineous plants. There was scarcely a clover, or any other Leguminous plant, to be found upon the plot. The action of the mineral manures, in this conjunction with ammoniacal salts, was *not* therefore to yield increase by aiding the development of Leguminous plants, as was the case when the same mineral manures were used alone. The mineral manure has now acted by supplying, within the reach of the plants, a sufficiency of certain mineral constituents, to enable the Gramineous plants to appropriate, and turn to the account of growth, a much larger portion of the *artificially supplied nitrogen* than they could do when the ammoniacal salts were used alone. In fact, there were 1 ton 4 $\frac{1}{4}$ cwts. per acre per annum more Gramineous hay grown when the artificial supply of nitrogen was accompanied by a liberal artificial supply of certain mineral constituents, than when it was not so accompanied.

It has been shown that the mineral manures had little or no effect in increasing the assimilation of nitrogen by the Meadow Grasses, when that constituent *was not artificially supplied*. On the other hand, they very considerably aided that assimilation, when available nitrogen *was artificially supplied*. It has also been shown that the addition to the mixed mineral and nitrogenous manure of a large quantity of sawdust—a substance rich in carbon—did not further increase the produce. In fact, neither did the sawdust (whether alone or in admixture) seem to aid the solution of mineral constituents by the evolution of carbonic acid; nor did this possible source to the plant of carbonic acid itself seem to have been of any avail. The addition to the mixed mineral and ammoniacal manure, of an equal weight of cut wheat-straw instead of sawdust (Plot 12), was equally without effect with that of the latter substance. Indeed, notwithstanding the large amount of mineral constituents, and especially of silicious compounds, contained in the cut wheat-straw, as compared with the sawdust, there was, whether compared with the produce by the mixed mineral and nitrogenous manure, or with that by the mixed mineral and nitrogenous manure and sawdust, an average annual deficit of 4 to 5 cwts. of first-crop hay, where the cut wheat-straw was employed. The plot with the cut wheat-

straw, like the duplicate unmanured one, was, however, somewhat shaded; and like the latter, though it gave a somewhat deficient first crop, gave at the same time rather more after-grass than the plots most comparable with it. It remains to be seen, therefore, whether the less exhaustion by the first crop hitherto, and the greater return of constituents as manure in the consumption of the second crop, will not, before long, tell upon the amount of produce of the first crop. And how far the inefficiency of both sawdust and cut wheat-straw was due to the slowness of their decomposition, will perhaps be apparent in the course of years.

The mixed mineral manures in conjunction with 400 lbs. per acre, per annum, of ammoniacal salts, gave an annual *produce* of more than 2 tons 19 cwt., and an annual *increase* (over the unmanured) of 1 ton 15 $\frac{3}{8}$ cwt. of strictly Gramineous hay. The same mineral manures, together with double the above amount of ammoniacal salts, gave even more produce and increase still. The mineral manures and the double supply of ammoniacal salts gave, on the average, 3 tons 3 $\frac{3}{4}$ cwt. of annual *produce*, and 1 ton 19 $\frac{3}{4}$ cwt. of annual *increase* of Gramineous hay.

When we bear in mind the fact, that the mixed mineral manure alone scarcely increased the Gramineous produce at all, it would appear that the increase of such produce, upon the super-addition of the 400 lbs., or of the 800 lbs. of ammoniacal salts, was (so far as its nitrogen was concerned) at any rate mainly due to that which was thus *artificially supplied*. Assuming this to have been the case, it would result that the first increment of 400 lbs. of ammoniacal salts (= 100 lbs. ammonia) yielded an increase of 1 ton 15 $\frac{3}{8}$ cwt. of hay, but that the second increment of the same amount gave a further increase of only 4 $\frac{3}{8}$ cwt. The two together, as above stated, gave 1 ton 19 $\frac{3}{4}$ cwt. of increase. As the nitrogenous supply was increased, the effect of a given amount of it was therefore very greatly diminished. Nor is this result to be attributed to a deficiency of mineral constituents where the larger amount of ammoniacal salts was employed. The produce on the addition to the mineral manure of the *smaller* amount of ammoniacal salts, was indeed quite as heavy, if not heavier, than the soil and seasons were suited to mature advantageously. Further evidence on the point will be adduced in a subsequent section of the Report. But it may be here stated in passing, that the crop grown by the larger amount of ammoniacal salts—supplying as it did the enormous quantity of 200 lbs. of ammonia per acre per annum—was so over-luxuriant, as to be much laid, matted together, and dead at the bottom, some time before the bulk was ready for cutting.

It has been already stated that the trials with *nitrate of soda* were not commenced until the last of the three seasons, over

which the other experiments extended. The nitrate too, was sown about a week later than the other manures. The result of this single season's trial with the nitrate was, that a given amount of nitrogen so supplied, did not increase the produce of hay equally with the same amount in the form of ammoniacal salts. Still the influence of artificial nitrogenous supply upon the Grass crop is here again illustrated.

Nitrate of soda, in amount supplying nitrogen equal to about 50 lbs. of ammonia per acre (Plot 6), gave scarcely any increase whatever over the *mean* unmanured produce of the same season.* Double this amount of nitrate of soda (Plot 7), containing nitrogen equal to the ammoniacal salts of Plot 4, gave about $3\frac{3}{4}$ cwts. less increase of hay per acre than the equivalent amount of ammoniacal salts. When the smaller amount of nitrate of soda was used in conjunction with the "mixed mineral manure," the produce amounted to 1 ton $17\frac{3}{4}$ cwts. of hay, or to $11\frac{1}{2}$ cwts. more than when the same amount of nitrate was used alone. Lastly, with the larger amount of nitrate of soda (= in nitrogen to the 400 lbs. of ammoniacal salts), together with the "mixed mineral manure" (Plot 15), there were 2 tons $10\frac{3}{8}$ cwts. of produce instead of 1 ton $11\frac{3}{4}$ cwts. by the same amount of nitrate of soda without the mineral constituents. This increased produce by the nitrate of soda and mineral constituents was, however, considerably less than either the average annual yield, or that of the third season taken alone, by an equal amount of nitrogen in ammoniacal salts, with the mineral manure in addition. So far, however, as the action of the manures applied in such full quantity is cumulative from year to year, it will of course to that extent be illegitimate to draw any strict comparison between the produce of one manure in its third season, and that of another in its first season of application. The character of nitrate of soda as an efficient Grass manure, and as acting, both on this and other crops, by virtue of the nitrogen it contains, is too well established by other experiments—indeed by common experience also—to admit of doubt. It remains to be seen, what will be the comparative effects of a given amount of nitrogen supplied in nitrate of soda and in ammoniacal salts respectively, when the trials have been continued over numerous and various seasons.

Before leaving the results with the nitrate of soda, it should be stated that it had the same effects as the ammoniacal salts, in discouraging the growth of the Leguminous herbage, and in encou-

* It will be remembered, however, that in this third season the duplicate unmanured plot gave an obviously somewhat excessive produce of hay; it having given smaller *mown* crops than the other in the preceding seasons, but more after-feed, and hence the condition of the land on the duplicate plot would be relatively somewhat too high for the third mown crop.

raging that of the Gramineous plants, or Grasses. The increase of action when the mineral constituents were added to the nitrogen in the form of the nitrate, was, therefore, as in the case of their addition to the ammoniacal salts, *not* to be attributed to their enabling Gramineous plants to take up more nitrogen *from natural or unaided sources*, but to their supplying, within a limited range of the soil, the mineral constituents requisite for the efficient action upon the collective and assimilative processes of the plants, of the *nitrogen artificially supplied*. It will be shown, on a future occasion, that the *percentage* of nitrogen in the dry substance of the hay, grown both by ammoniacal salts alone, and by nitrate of soda alone, was comparatively very high—in fact, considerably higher than when the mineral manures were also employed, whereby the Gramineous produce was much increased. So far then as there was an excessive amount of nitrogen, in the form of elaborated nitrogenous vegetable compounds, where the supplied nitrogen was liberal—the mineral constituents in defect—and the growth restricted thereby—it was that there was a relative deficiency in the formation of the non-nitrogenous vegetable substances.

Attention has now been called to the annual amount of hay obtained both without manure, and by the use of certain individual, or classified constituents of manure. In this way, some information has been acquired as to the manurial requirements for the growth of a heavy produce of the crop in question. Let us now examine—what were the effects upon the hay crop of that complex substance—*Farmyard manure*? And, bearing in mind the facts already brought to view, in regard to the action of certain individual manures, let us endeavour to form a judgment as to which of the constituents, or classes of constituents, of farmyard manure, its effects upon the hay crop are mainly, or at any rate characteristically, due.

The annual application of 14 tons of farmyard manure per acre, gave, over the three years, an average annual produce of 2 tons $\frac{1}{4}$ cwt. of hay, = $16\frac{1}{4}$ cwts. per acre per annum more than the unmanured plot. This increase by farmyard manure is greater than that by either the mixed mineral manure alone, or the ammoniacal salts alone; but it is less than half the increase obtained when these two descriptions of manure were used conjointly. This increase of $16\frac{1}{4}$ cwts. of hay per annum, by the use of 14 tons of dung is, it will be seen, little more than 1 cwt. of hay for every ton of the manure employed.

It has been seen that *carbonaceous substance*, whether applied in the form of sawdust or of cut wheat-straw, had little or no effect upon the hay crop. It is probable that the carbonaceous substance of the dung would yield up its carbon in the form of

carbonic acid, or of other products of decomposition, more readily than that of either of the substances just mentioned. But the farmyard manure contained, besides carbonaceous substance, a large amount of both mineral constituents, and of ammonia, or nitrogen in some form. It has been seen, too, that these latter substances, when used without carbonaceous matter, gave greatly increased crops of hay. Under these circumstances, we can hardly hesitate to attribute the main effects of the farmyard manure upon the hay crop, rather to the conjoint action of its mineral and nitrogenous constituents than to its enormous bulk of carbonaceous substance.

That the *mineral* constituents of the dung had their share of effect, would appear from the fact, that the Leguminous herbage was moderately luxuriant on the dung plot, and that those of the Grasses were the most developed which were increased in their proportion to the rest by the artificial mineral manures. And again, that the *nitrogen* also of the dung was effective, may be judged, not only from the general development of the Gramineous plants under its use, but from the fact of a like fullness in the proportion of the Grasses *in flowering and seeding stem*, as where ammoniacal salts were employed in conjunction with the mixed mineral manure. It would appear, however, that a much less proportion of the whole nitrogen supplied to the land was active, when it was provided in the form of farmyard manure, than when in that of ammoniacal salts. There would, in fact, be considerably more of nitrogen applied per acre in the 14 tons of farmyard manure, than in the 400 lbs. of the mixed ammoniacal salts. Nevertheless, the encouragement of the Leguminous plants was much greater, and that of the Gramineous ones much less, where the farmyard manure was employed, than where the 400 lbs of ammoniacal salts, together with the mixed mineral manure, were used.

That the less produce by the farmyard manure, than by the mixed mineral manure and 400 lbs. of ammoniacal salts, was due to a deficiency of *available* nitrogen, notwithstanding the large actual *amount* of it in the dung, would appear from the fact, that on the employment of 200 lbs. of ammoniacal salts *in addition* to the farmyard manure (Plot 17), there was a further average annual increase of $8\frac{3}{8}$ cwts. of hay per acre. Still, even with this addition, there was about $\frac{1}{2}$ a ton less of hay annually than where the "mixed mineral manure" and the 400 lbs. of ammoniacal salts were applied.

The evidence regarding the action of the farmyard manure goes to show, that, though it is doubtless a very complete and important restorer of both the mineral constituents and the nitrogen required to repair the exhaustion of this most greedy

crop, yet, the amount of these constituents supplied by its means is proportionally much less active within a given time than that provided in the artificial combinations. As, however, permanent meadow-land, especially when attached to an arable farm, does not, as practice goes, so much as a matter of course, come in for a due periodic supply of farmyard manure as does the land under rotation, it becomes far more necessary in its case to bestow special consideration that the mineral constituents be not exhausted, than in that of rotation crops under ordinary good management. In fact, the grass-land of the arable farm is but too frequently looked upon as the legitimate sphere for robbery for the other crops. Indeed, considering the nature of the exhaustion of permanent grass-land generally, when mown for hay, and at the same time bearing in mind the character of the artificial manures, which are, in point of economy, at the command of the farmer, it would seem that the *permanent* condition of such land should be kept up by farmyard manure, stable dung, town manures, and the like, and the *active growth* aided, year by year, by the so-called artificial, nitrogenous—or, better still, nitrogenous and phosphatic—manures. Where hay is grown for the supply of a neighbouring town, the (in the above sense) permanent condition of the land is very generally maintained by town manures of some kind brought by the return carriage. But where hay is grown on an arable farm, and is mown for consumption by the stock (or, still worse, for sale), the return is but too often by no means so complete. The question of keeping up the fertility of grass-land by sewage, or other irrigation, is one of course of entirely separate consideration from that now before the reader.

Before giving a summary enumeration of the results and conclusions thus far indicated, it will be well to direct attention to the relative, and, as far as they can be estimated, the *actual* amounts of after-grass yielded, on the differently manured plots.

In TABLE II. are given:—

In the 1st Division—the actual number of sheep that were put upon each plot of after-grass, and the actual number of days they were fed upon it, in each of the three seasons of the experiments;

In the 2nd Division—the number of sheep calculated to be kept per acre, on each plot for one week, in each of the individual seasons, and on the average of the three seasons; and

In the last column of the Table—the estimated average annual amount of hay per acre, to which the after-grass consumed would be equivalent, reckoning the sheep to eat grass equal in amount to 16 lbs. of hay per head, per week.

Calculating the after-grass into its assumed equivalent of hay,
as

TABLE II.—SHOWING the Number of SHEEP fed by the AFTER-GRASS, and the quantity of HAY to which it is estimated to be equivalent.

Plot, Nos.	MANURES (Per Acre, per Annum).		ACTUAL PARTICULARS OF THE FEEDING.						CALCULATED RESULTS.			Estimated Average Amount of Hay per Acre, per Ann. in the After-grass.* lbs.	
			1856.		1857.		1858.		Number of Sheep kept for One Week per Acre.				
			Area of Plots.	Sheep put on, Oct. 10.	Number of Days of Feeding.	Number of Sheep.	Sheep put on, Sept. 23.	Number of Days of Feeding.					Number of Sheep.	Number of Days of Feeding.
SERIES 1.—Without Direct Mineral Manure.													
1	Unmanured	. . . . .	10	13	8	13	10	12	37.1	29.7	34.3	33.7	539
2	Unmanured (duplicate plot)	. . . . .	10	17	10	13	49†	12	48.7	34.3	32.6	38.5	617
Mean, or Standard Unmanured													
3	2000 lbs. Sawdust	. . . . .	10	15	9	13	49†	12	43.9	32.0	33.4	36.1	578
4	200 lbs. each, Sulphate and Muriate Ammonia	. . . . .	20	13	16	13	16	12	37.1	29.7	27.4	31.4	503
5	200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	. . . . .	20	14	20	13	20	12	40.6	37.1	34.3	37.1	594
6	275 lbs. Nitrate of Soda	. . . . .	20	14	20	13	20	12	40.0	37.1	34.3	37.1	594
7	550 lbs. Nitrate of Soda	. . . . .	. . .	. . .	. . .	. . .	60	1	. . .	. . .	51.4	51.4	823
SERIES 2.—With Direct Mineral Manure.													
8	"Mixed Mineral Manure"	. . . . .	20	14	25	13	25	12	40.0	46.4	42.9	43.1	689
9	"Mixed Mineral Manure," and 2000 lbs. Sawdust	. . . . .	20	14	25	13	25	12	40.0	46.4	42.9	43.1	689
10	"Mixed Mineral Manure," and 200 lbs. each, Sulphate and Muriate Ammonia	. . . . .	30	11	30	12	30	12	47.1	51.4	51.4	50.0	800
11	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Sawdust	. . . . .	30	11	30	12	30	12	47.1	51.4	51.4	50.0	800
12	"Mixed Mineral Manure," 200 lbs. each, Sulphate and Muriate Ammonia, and 2000 lbs. Cut Wheat Straw	. . . . .	30	17	30	13	30	12	72.8	51.4	51.4	58.5	937
13	"Mixed Mineral Manure," and 400 lbs. each, Sulphate and Muriate Ammonia	. . . . .	40	11	40	12	40	12	62.9	68.6	68.6	66.7	1067
14	"Mixed Mineral Manure," and 275 lbs. Nitrate of Soda	. . . . .	. . .	. . .	. . .	. . .	60	1	. . .	. . .	51.4	51.4	823
15	"Mixed Mineral Manure," and 550 lbs Nitrate of Soda	. . . . .	. . .	. . .	. . .	. . .	60	1	. . .	. . .	51.4	51.4	823
SERIES 3.—With Farmyard Manure.													
16	14 Tons Farmyard Manure	. . . . .	10	13	12	13	11	12	37.1	44.6	37.8	39.8	638
17	14 Tons Farmyard Manure, and 100 lbs. each, Sulphate and Muriate Ammonia	. . . . .	10	13	12	13	11	12	37.1	44.6	37.8	39.8	638

* The calculation is made on the assumption that each Sheep would eat grass = 16 lbs. of Hay per week.
 † One Sheep was taken from this plot to be killed when it had been only half the period feeding.

as above described, the result is, of course, only an approximation to the truth. Looked upon as such, it is not without its value and interest. The so-estimated amounts of after-feed on the respective plots show, as compared one with another, relations very coincident, in general direction, with those indicated by the mown first-crops of hay.

It has already been noticed that the produce of first-crop hay on Plot 2 (the duplicate unmanured plot) was less in the first two seasons, and more in the third, than on Plot 1, the other unmanured one. Table II. shows, on the other hand, that there was rather more after-feed in the two first seasons on the duplicate unmanured plot than on the other. Taking the mean of the two plots, the unmanured land shows an average annual yield of after-grass = 578 lbs. of hay. The sawdusted plot, as in the first crop, so again in the second, gives rather less produce than the unmanured one. The ammoniacal salts alone gave rather more after-feed than the unmanured plot; and the ammoniacal salts and sawdust gave the same amount as the ammoniacal salts alone. The Plot with the "mixed mineral manure" alone, with its luxuriant Leguminous herbage, gave more after-feed than the one with ammoniacal salts alone. The addition of the sawdust to the "mixed mineral manure" gave no further increase. The Plot with both the "mixed mineral manure" and the 400 lbs. of ammoniacal salts, as in the first crop, so now in the second, gave more produce than either of the plots where the respective manures were used separately. The addition of sawdust to the mixture of the two manures gave no further increase. The addition of cut wheat-straw, instead of sawdust, showed some advantage in the second crop, the produce in the first crop being somewhat deficient. The combination of the "mixed mineral manure," and the double amount (= 800 lbs. per acre) of ammoniacal salts, gave the largest amount of first-crop hay, and now again the largest amount of after-grass, of any manure in the series.

The nitrate of soda, which was used only in the third season, and then yielded less of first-crop hay than an amount of ammoniacal salts equal to it in contents of nitrogen, appears, according to the figures in the Table, to have given, on the other hand, a larger amount of after-grass. As, however, a large and equal number of sheep was put upon each of the nitrate plots, and *for one day only*, not even the relative amounts, still less the actual quantities recorded as estimated second-crop hay, can be much relied upon in these cases of experiment with the nitrate.

The farmyard manure plots gave of second crop, as they did of first, a produce intermediate between that without manure, and that by the "mixed mineral manure" and 400 lbs. of ammoniacal salts.

Were these estimated amounts of hay in the second crop of the respective plots to be added to those actually removed in the first crop, the *comparative* action of the different manures as it would be then represented, would not appear to differ in any material point from that indicated by the amounts of hay actually taken off in the first crop. Independently of this, however, by far the larger proportion of both the mineral constituents and the nitrogen of the second crop would, as before stated, be returned to the land by the sheep feeding upon it. It would, therefore, obviously be a further deviation from the true representation of the actual facts, to take into account the estimated second crop as a part of the removed produce of the manures employed, than to omit it from the calculation altogether. These estimated amounts of second crop, varying as they do in the proportion of from 1 to 2, according to the manure employed, are, nevertheless, interesting of themselves, as showing great differences in vegetative activity after removal of the first crops, depending, of course, on the varying character and amount of the residual or unused manure. They are, moreover, useful aids in forming a judgment respecting the comparative cumulative effects, from year to year, of the different manures. But when, in a subsequent Part of this Report, we come to consider the debtor and creditor account of certain constituents on the several plots—the relation of the amounts removed in the produce to those supplied in manure—we shall assume the amounts taken off in the increase of the first crop only, as the most nearly representing the gain due to the supply in the manure employed.

It is proposed, on a future occasion, to show the acreage amounts of certain constituents removed in the produce from the different plots, and the relation of these in the increase, to those supplied in the manures—to consider in some detail the varying description of the herbage according to the manure employed—and to show the consequent variations in the chemical composition of the complex gross produce, or *hay*. In the mean time, founded upon the evidence thus far recorded, relating to the amount per acre, and the general character, of the hay obtained by the different manures, the following general results and conclusions may be enumerated:—

That the effect of a mixed, but purely *mineral manure*, upon the complex herbage of permanent meadow land, was chiefly to develop the growth of the *Leguminous* plants it contained; and scarcely at all to increase the produce of the *Graminaceous* plants, or commonly called *Natural Grasses*.

That the action of purely *nitrogenous manures*, upon the per-

manent meadow, was to discourage the growth of the *Leguminous* herbage, and to increase the produce of the *Graminaceous* hay.

That by the combination of both nitrogenous and proper mineral manures, the produce of *Graminaceous* hay was very much increased. In the particular soil and seasons in question, the increase obtained by the combination was far beyond the sum of the increase yielded by the two descriptions of manure, when each of them was used separately.

That *farmyard manure* gave a considerable increase of chiefly *Graminaceous* hay. In the soil and seasons in question, however, the artificial combination of nitrogenous and mixed mineral manure yielded a very much larger increase than an annual dressing of 14 tons of farmyard manure.

That peculiarly *carbonaceous manures* had little or no beneficial effect on the amount of produce of the hay. That the little effect (if any) which the carbonaceous manures did exhibit, seemed to be favoured by admixture with mineral manures; and then (as when the mineral manures were used alone) it appeared to be the *Leguminous*, rather than the *Graminaceous* herbage, that was encouraged.

That the beneficial action of *farmyard manure* upon the Grass crop is to be attributed chiefly to its *mineral and nitrogenous constituents*, and comparatively little to its large amount of carbonaceous substance.

That the large increase of produce obtained by the combination of nitrogenous and mixed mineral manure, being almost entirely *Graminaceous*, the mineral manures, when in this combination, did not act as when used alone, in developing the highly nitrogenous *Leguminous* herbage. The great increase in the produce of hay obtained by the conjunction of the mineral with the nitrogenous manure is to be attributed to the supply, within a limited range of the soil, of a sufficient amount of the necessary mineral constituents, to enable the *Graminaceous* plants to turn to the account of growth, the nitrogen at the same time artificially supplied.

The general result is, that the *Leguminous* plants in the meadow, like those grown in our *arable fields*, were much increased in growth, and assimilated more nitrogen from unaided sources over a given area, when they were liberally supplied with certain *mineral, or primarily soil-constituents*. At the same time, notwithstanding the high (both percentage and acreage) yield of nitrogen in *Leguminous* produce generally, the increased growth of the *Leguminous herbage of the meadow* was not favoured by the direct supply of nitrogenous manures—a result which is again very similar to that obtained with the *Leguminous crops of our rotations*. On the other hand, the *Graminaceous hay*

plants, like the Gramineous *corn-crops of our rotations*, assimilated but little more nitrogen, from natural sources, under the influence of liberal supplies of purely mineral manure; they gave a largely increased growth, only when there was an artificial supply of *available nitrogen within the soil*; and when this was provided, the direct supply of mineral constituents was essential to its full effects.

The more practical conclusions may be very shortly stated. In order that the more temporary, or more rapidly acting means of increasing the produce of meadow land, may have their full effect, the more permanent means of amelioration that may be required—such as draining, marling, liming, and the like—must not be neglected. The application of bones is not recommended for general adoption. They appear to be chiefly adapted to the exhausted pastures of certain localities, and not to be generally applicable to meadow land which is mown for hay. The hay crop is a great exhauster of the mineral constituents of the soil; and these, owing to the high price of salts of potash, cannot, with profit, be fully restored in artificial manures. The return of the mineral constituents is better accomplished by means of farmyard manure, stable dung, night soil, and the like; which, at the same time, bring on to the land a more or less considerable quantity of available nitrogen. The best artificial manures for grass-land, are, Peruvian guano, which is rich in phosphates as well as nitrogen; and nitrate of soda, and sulphate of ammonia, which are rich in nitrogen, but contain, of course, no phosphates. Peruvian guano, when used alone, may be employed at the rate of from $1\frac{1}{2}$ to $2\frac{1}{2}$ cwts. per acre; nitrate of soda alone, or sulphate (or muriate) of ammonia, at the rate of $1\frac{1}{2}$ to 2 cwts. per acre. The salts of ammonia are, however, relatively too expensive to be employed largely with profit; and both ammoniacal salts and nitrate of soda are more advantageously used in combination with guano. A very generally useful top-dressing for the hay crop may be made of 3 parts Peruvian guano, 1 part nitrate of soda, and 1 part sulphate of ammonia. Of this mixture, 2 to $2\frac{1}{2}$ cwts. per acre may be employed. With this applied annually, and the application of 10 or 12 tons per acre of poor rotten dung once every four or five years, a good crop of hay may be taken off every year, without injury to the land. The best time of sowing the “artificial” manures is generally in January; and it should at any rate be seldom postponed beyond February.

[To be continued.]
