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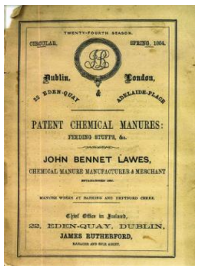

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Report on the Effects of Different Manures on the Mixed Herbage of Grass Land

J. B. Lawes and Dr. Gilbert

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EFFECTS OF DIFFERENT MANURES ON THE MIXED HERBAGE OF GRASS-LAND.

BY

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AND

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IN Vol. XIX., Part II., and Vol. XX., Parts I. and II. of the Journal of the Royal Agricultural Society, we gave a Report on Experiments with different manures on permanent meadow land, in which we treated of the subject under the following heads:—

Part I. The produce of hay, per acre.
Part II. The produce of constituents, per acre.
Part III. The description of plants developed by different manures.
Part IV. The chemical composition of the hay.

Perhaps the most striking points brought out in the inquiry, were those which illustrated the very great difference in the description and character of the plants developed by the different manures. The general results arrived at under this head, may be very briefly re-stated here.

The unmanured crops, and the light ones grown by manure, were by far the most complex in character; consisting of a comparatively large number of species of plants, or descriptions of herbage, and showing less predominance of a few species than did the more bulky produce obtained by means of more active manures. The smaller crops consisted not only of a greater variety of Graminaceous herbage, or grasses properly so called, but also contained a greater variety, and greater proportion, of miscellaneous or weedy herbage.

As a rule, whatever the description of manure employed, any considerable increase of crop was accompanied by greater simplicity of herbage, greater predominance of grasses proper, and also, generally, a greater predominance of individual species, as well among the Graminaceous or grassy, the Leguminous, and the miscellaneous herbage.

But different descriptions of manure had very different effects.

Mineral manures alone (salts of potass, soda, magnesia, and superphosphate of lime) only moderately increased the amount of crop; rather diminished the proportion of the grasses, and

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considerably that of the weedy herbage; greatly increased the amount per acre, and the proportion in the produce, of the Leguminous herbage, especially the perennial red clover and the meadow vetchling; and also enhanced the ripening tendency, rather than luxuriance of foliage.

Ammonia-salts alone, considerably increased the amount per acre, and the proportion in the crop, of the grasses, but tended very remarkably to the development of leaf rather than of stem and seed; and they also diminished the proportion of both the Leguminous and the weedy herbage, the former being almost excluded.

Mixtures of both the mineral manure and ammonia-salts, gave by far the greatest increase of crop. The produce so obtained was in a much larger proportion Graminaceous, or grassy, than that yielded under any other conditions; clover and other Leguminous plants were almost entirely excluded; and the number of species and amount of weedy herbage were but small, though some few plants grew luxuriantly. Lastly, comparatively few species of grasses contributed to the great bulk of this very luxuriant and highly Graminaceous produce, and the development of stem and seed was very remarkable.

Farm-yard manure alone, with the increase of total produce, also increased the amount and proportion of the Graminaceous herbage; and diminished the variety, and the proportion, of the Leguminous and the miscellaneous herbage.

Farm-yard manure and ammonia-salts gave considerably more increase of crop than farm-yard manure alone; and the produce contained a large proportion of Graminaceous and miscellaneous, but very little Leguminous herbage.

This great variety in the herbage, both as to the description of the plants developed, and the character of their growth, according to the manures employed, and to the consequent amount of crop obtained, is obviously a point of great practical interest and importance in its bearing upon the question of the proper manures to be employed to increase the produce of grass-land.

The results briefly enumerated above are also of great interest in another point of view.

Thus, exclusively mineral manures, when applied to Graminaceous plants grown separately (as wheat, barley, or oats, under ordinary circumstances), produce very similar effects to those upon the allied plants of the mixed herbage; that is to say, they increase the crop comparatively little, but prominently develop the seeding tendency; and again, when these manures are applied to Leguminous crops grown separately, as in the case of the allied plants of the mixed herbage, they considerably increase the luxuriance of their growth.

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Ammonia-salts, on the other hand, which produce such characteristic effects upon the growth of the Graminaceous plants of the mixed herbage, have also a marked influence upon that of the Graminaceous plants grown separately in rotation, and but little on that of the Leguminous ones so grown.

For various reasons, therefore, both practical and scientific, it seemed very desirable that the subject should be further investigated, both here and elsewhere. The experiments at Rothamsted have, accordingly, been continued up to the present time, and they are still in progress.

Our first report, to which we have been referring, gave the results of the first three seasons, (1856, 1857, and 1858), relating to three divisions of the subject, namely—the produce of hay per acre, the produce of constituents per acre, and the chemical composition of the hay—and on these points we have now on hand the accumulated results of four more seasons. The results formerly given on the remaining branch of the subject—*the description of plants developed by the different manures*—related to the produce of the third season only, 1858; and the further details obtained on this head have reference to the produce of the seventh season, 1862. It is to these that it is proposed to confine attention on the present occasion, presenting only such an outline of the voluminous records as will bring to view the points of most interest to the readers of an Agricultural Journal.

Method of Experimenting.

Taking advantage of the experience gained in some attempts to separate and determine the proportion of the different plants, in carefully averaged and weighed samples of the produce in the previous year (1857), the produce of 1858 had been separated into—(1) Graminaceous herbage, stems bearing flower or seed; (2) Graminaceous herbage, detached leaves and indeterminate stems; (3) Leguminous herbage; (4) Miscellaneous herbage, chiefly weeds. The components classified under these heads gave from 14 to 23 different descriptions of herbage; and, no doubt, the results, so far as they went, clearly and truthfully indicated the characteristic and comparative distribution of plants on the different plots. But as there remained, in the separations in question, an amount equal in several cases to a fourth, and in one to more than a half of the whole produce, to be set down as Graminaceous herbage in "detached leaves and indeterminate stems," to the components of which the specific names could not with any confidence be given, it seemed desirable, in again taking up the subject, to follow it out in considerably more of detail. Accordingly, in the separations recently made, of the produce of 1862,

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it was sought to determine the species to which the detached leaves and imperfect stems belonged, and so to include in the amount given for each grass, as far as possible its total yield, whether in culm bearing flower and seed, or in a less definite condition. The classification of the Graminaceous herbage will, therefore, on the present occasion, be somewhat different; and hence the present and the former results will not be strictly comparable.

It will be obvious that to conduct the work on the plan just indicated, not only involved an immense amount of labour, but required very considerable technical knowledge and experience in those superintending the separations. Accordingly, we applied to several botanical friends for a competent botanical assistant; and we have now to express our best thanks to Dr. J. D. Hooker, of Kew, for recommending to us, Mr. W. Sutherland, a young man who, as foreman of the "Hardy Herbaceous ground" in the Kew Gardens, had had, to use Dr. Hooker's words, "the charge of a most extensive named collection of herbaceous plants (some 4-5000), including a good collection of grasses." We have also much satisfaction in bearing testimony to the competency of Mr. Sutherland for the work he undertook, and to the conscientious and assiduous manner in which he has performed his tedious and difficult task.

The mode of taking the samples for the botanical separations was as follows: eight or ten mowers were put upon the half-acre experimental plot, and small quantities of grass were taken immediately after the scythe from each swathe until nearly the whole of the plot was down. The quantities so taken, amounting to very many times more than the required sample, were then carefully mixed on a cloth, so as to shake out as little seed as possible, and from the bulk a sample of 10 lbs. was immediately weighed, before any material change in the condition of the grass could take place by evaporation.

The samples taken as above described were spread out to dry at the ordinary temperature, and afterwards carefully preserved for future operation.

In all, twenty samples have been submitted to botanical analysis; occupying Mr. Sutherland for about four months, and another assistant, and from three to half a dozen boys, for a period of nearly six months.

The plan adopted in the first instance was to work down each sample to the point of something like equal difficulty of further separation. The remaining undetermined residue was then put into a sieve, and the larger stemmy and leafy portions were thus separated from the shedded flowers and seeds, and finely broken leafy matter. The mass of the latter was then separated, by

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means of other sieves of varying fineness, into four or five different lots, in order to facilitate the examination and identification of its components; and notes were made accordingly as to their apparent character. But it was found that there still remained, in some cases, nearly one-fourth of the original sample as undetermined stemmy and leafy residue. Hence, all such residues that amounted to more than 10 per cent. of the original sample were afterwards submitted to a further separation—a most tedious labour—which, however, has in very few cases left as much as 10 per cent. of undetermined matter. Still, after these further separations, the relative proportions of the final stemmy and leafy residues will, to some extent indicate the ease or difficulty attending the separations and identifications, and at the same time, be some indication of the character of development of the herbage. For, it will be readily understood that a very luxuriant and stemmy Graminaceous produce, would be much more easily separated into its components, than a mass consisting almost exclusively of leafy herbage. Indeed, while some of the individual samples required more than a week for the first, and afterwards some days for the second separation, others were worked much more easily.

The numerical results of the inquiry, showing the proportion per cent. in each sample, of each separated portion, are given in the large folding Table, facing p. 48; in which the individual plants, or descriptions of herbage otherwise defined, are classified into—

1.—Graminaceous herbage:
- Determined species;
- Undetermined stem and leaf;
- Shedded flowers and seeds, &c. (chiefly Graminaceous)

2.—Leguminous herbage.
3.—Miscellaneous herbage.

And, as will be seen, the different plants composing the Miscellaneous or weedy herbage, are classified into the Natural Orders to which they respectively belong.

The following is a detailed statement of the manuring of the different plots; a brief description of which is given under the corresponding plot-numbers in the Tables. Unless otherwise stated, the same description and amount of manure has been applied to the respective plots every year since the beginning of the experiments in 1856. The quantities are given *per acre*.

Plot 1.—Unmanured.

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

Plot 3 *a*.—Superphosphate of lime; composed of 200lbs. bone-ash, and 150lbs. sulphuric acid of sp. gr. 1·7. 4th season, commencing in 1859; sawdust alone the three previous seasons.

Plot 3 *b*.—Superphosphate of lime; and 400lbs. ammonia-salts (equal parts sulphate and muriate of commerce, supplying about 82lbs. nitrogen per acre). 4th season, commencing in 1859; the three previous seasons sawdust alone.

Plot 4.—400lbs. ammonia-salts.

Plot 5.—400lbs. ammonia-salts; and 2000lbs. sawdust.

Plot 6.—275lbs. nitrate of soda of commerce (containing about 41lbs. nitrogen). 5th season, commencing 1858.

Plot 7.—550lbs. nitrate of soda (containing about 82lbs. nitrogen). 5th season commencing in 1858.

Plot 8.—Mixed mineral manure, composed of—

300lbs. sulphate of potass.
200lbs. sulphate of soda.
100lbs. sulphate of magnesia.
Superphosphate of lime, as above.

Plot 9.—Mixed mineral manure; and 2000lbs. sawdust. (The mixed mineral manure as Plot 8 to 1861 inclusive, and in 1862 the sulphate of potass excluded, and the amount of sulphate of soda raised to 500lbs).

Plot 10.—Mixed mineral manure, as Plot 8; and 400lbs. ammonia-salts.

Plot 11.—Mixed mineral manure, as Plot 9; and 400lbs. ammonia-salts.

Plot 12 *a*.—Mixed mineral manure, as Plot 8; 400lbs. ammonia-salts; and 2000lbs. cut wheat straw.

Plot 12 *b*.—Duplicate of Plot 12 *a*, but rather sheltered on the west by trees.

Plot 13 *a*.—Mixed mineral manure, as Plot 8; and 800lbs. ammonia-salts, equal about 164lbs. nitrogen (only 400lbs. ammonia-salts, in 1859, 1860, and 1861).

Plot 13 *b*.—Mixed mineral manure as Plot 13 *a*, to 1861 inclusive; the same with 200lbs. silicate of soda and 200lbs. silicate of lime in addition in 1862; and 800lbs. ammonia-salts (only 400lbs. ammonia-salts in 1859, 1860, and 1861).

Plot 14.—Mixed mineral manure, as Plot 8; and 275lbs. nitrate of soda. 5th season, commencing in 1858.

Plot 15.—Mixed mineral manure, as Plot 8; and 550lbs. nitrate of soda. 5th season, commencing in 1858.

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Plot 16.—14 tons farm-yard manure.
Plot 17.—14 tons farm-yard manure; and 200 lbs. ammonia-salts.

With the view of both controlling and adding to the numerical results of the botanical separations, it was decided to have systematic series of notes taken on the ground. To this end, between three and four weeks prior to the date of cutting were devoted to making observations, as under:—

1. On each plot seriatim; remarking the predominance, and character of development, of the different plants.

2. On each of the most important plants seriatim; comparing its predominance, and character of development, on the different plots.

3. On the relative conditions of ripeness of the plots generally, and of individual descriptions of plants, just before cutting.

Then, after the crop was cut, and before its removal from the ground, further notes were taken, with the full view of the produce of the entire plot then at command, the former ones having been made only at either end of the respective plots.

Lastly, notes on the second crop were taken.

In the separations of 1858, the number of species determined in any one sample in no case amounted to twenty; the undetermined Graminaceous herbage was, however, subdivided into four or five different lots, supplying, in addition to the defined species, so many different descriptions of herbage; but in the separations of 1862, forty or more defined species were in some cases identified. It is not supposed that a greater number of plants occurred in the produce of 1862 than in that of 1858. The result is doubtless due to the much greater amount of attention and labour bestowed upon the more recent separations. There is, however, no doubt, that, although the more general characteristics of the herbage on the respective differently-manured plots remain the same as formerly—that is to say, as to the general predominance respectively of Graminaceous, Leguminous, and Miscellaneous herbage, and tendency to stemmy or leafy development—yet that there is a considerably altered predominance of particular plants, as a further consideration of the results will show.

It is not proposed to comment in detail upon the numerical results given in the large folding Table (facing p. 48), nor to quote at any length from the voluminous written observations to which reference has been made, as such a treatment of the subject is more suitable to the pages of a Botanical than of an Agricultural Journal.

The most important practical points for consideration are those which illustrate the character of the herbage *in relation to*

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the manures employed, and to the amounts of crop yielded. In relation to these points, therefore, we shall briefly consider—

1. The general description, and proportion per cent., of the different kinds of herbage (Graminaceous, Leguminous, or Miscellaneous), and the number of species.
2. The description, and proportion per cent., of the predominating species.
3. The tendency to the development of leafy or stemmy produce, and the order of ripeness.

I.—*The general description, and proportion per cent., of the different kinds of herbage (Graminaceous, Leguminous, and Miscellaneous), and the number of species, in relation to the manures employed, and to the amounts of crop yielded.*

In Table II. (pp. 28-29), are given the results relating to this branch of the subject. On the left hand will be found a short description of the manures employed, and a column showing the average annual yield of hay per acre on each plot, reckoned from the commencement of the experiments to 1862 inclusive; the records for the plot giving the largest amount of produce standing at the head of the list, and so on, in order, according to the crop yielded. Side by side with these particulars, on their right, are given, for each plot, the proportion per cent. in the produce, of—

1.—Graminaceous herbage:
  Determined species;
  Undetermined stem and leaf;
  Shedded flowers, seeds, &c., chiefly Graminaceous.
2.—Leguminous herbage.
3.—Miscellaneous or weedy herbage.

Also the number of species, respectively of the Graminaceous, the Leguminous, and the Miscellaneous herbage.

It will be seen that the average annual amount of produce at the head of the list is 6877 lbs., and that there is a pretty gradual diminution down to 2720 lbs., which is the yield without manure of any kind. The heaviest produce was obtained where, in conjunction with the mixed mineral manure, the largest amount of ammonia-salts (containing about 164 lbs. of nitrogen) was applied. Leaving out of consideration for the present the comparatively immaterial influence of cut wheat-straw, or sawdust, the next in order as to amount of crop are the five plots where, with the mixed mineral manure, half the quantity of nitrogen (about 82 lbs.), either in the form of ammonia-salts or nitrate of

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soda was used. Then come two plots, the one with about 41lbs. nitrogen, supplied in the form of ammonia-salts, and the other with the same amount in the form of nitrate of soda; the former with farmyard dung manure in addition, containing, of course, besides a large amount of mineral constituents and carbonaceous organic matter, a considerable quantity of nitrogen; the latter with the mixed mineral manure. Next comes the plot with ammonia-salts (= 82 lbs. nitrogen) and superphosphate of lime instead of the mixed mineral manure, showing a deficiency of produce, due to the exclusion of the alkaline salts, of 1,200 lbs. to 1,400 lbs. per acre per annum. Still, this obviously defective combination gives more produce than an annual dressing of 14 tons of farm-yard manure per acre, with all its mineral and carbonaceous organic matter, and a good deal of nitrogen also. Nitrate of soda alone = 82 lbs. nitrogen, stands next to farmyard manure alone, giving more produce than the mixed mineral manure alone, which, in its turn, gives slightly more than ammonia-salts alone = 82 lbs. nitrogen, or nitrate of soda alone = 41lbs. nitrogen, and considerably more than superphosphate of lime alone. But although the mixed mineral manure alone gave more total produce than the ammonia-salts alone (= 82 lbs. nitrogen), it in point of fact gave very much less of Graminaceous herbage, its increase consisting in very large proportion of Leguminous plants.

The general result is, then, that the largest amounts of gross produce were obtained where the largest amounts of nitrogen were applied in the manure; provided only, that a sufficiency of mineral constituents was at the same time supplied. Further, that much larger crops were obtained by means of artificial manures supplying nitrogen and mineral constituents, than by a heavy dressing of farmyard manure, with all its carbonaceous organic matter, in addition to its large amount of nitrogen and mineral constituents. And again, a complex mineral manure alone gave about as much total produce as ammonia-salts alone or nitrate of soda alone; but the description of herbage developed was very different in the two cases.

Let us now consider the varying character of the herbage coincident with the use of such very different descriptions of manure, and the production of such very varying amounts of crop.

A glance at the Table (II.) shows that with the highest amount of produce there was the highest proportion in it of Graminaceous herbage, = about 95 per cent., no Leguminous herbage whatever, and the lowest proportion of Miscellaneous herbage = not quite 5 per cent. There was also, with the lowest amount of produce, only about 74 per cent. of Graminaceous herbage (which is

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almost the lowest proportion), about 7 per cent. of Leguminous herbage, and nearly the highest proportion of Miscellaneous or weedy herbage.

Again, whilst the smallest number, or only 21 species of plants, was discovered in the sample of the heaviest produce, the largest number, or 43 species, was found in that of the smallest produce.

These extreme results prominently bring to view the fact that with large produce there was an almost exclusively Graminaceous, and a comparatively simple herbage; and that with small produce the herbage was at once much less Graminaceous, and much more complex. There is, moreover, with some instructive exceptions, to which attention will be directed, something like a gradual decrease in the proportion of Graminaceous, and increase in that of the Miscellaneous herbage, and especially in the number of species, as we proceed from the larger to the smaller crops.

Taking the results given in the Table a little more in detail, it will be well to bear in mind the general character of the herbage on the unmanured land, as the standard by which to compare that on the variously manured plots.

The unmanured produce, taking the mean result of the two plots, consisted, in round numbers, of about 74 per cent. Graminaceous, 6 to 7 per cent. Leguminous, and about 19 per cent. Miscellaneous herbage; and it comprised about 40 species of plants.

In contrast with the above composition, that of the six or seven heaviest crops at the head of the list in the Table (II.) may be taken, in round numbers, at from about 90 to 95 per cent. Graminaceous, from 0 to 0·86 per cent. Leguminous, and from 5 to something over 10 per cent. Miscellaneous herbage; the number of species varying from 21 to 30.

Comparing these heavier crops with one another, it is interesting to observe that Plot 13 *b*, manured with ammonia-salts and a mineral manure including silicates, gave a higher per-centage of Graminaceous, and a lower per-centage of Miscellaneous herbage, than Plot 13 *a*, with otherwise the same manure, but excluding silicates. Again, Plot 10, with ammonia-salts, and mineral manure, including potass, gave rather more produce, and a rather higher proportion of Graminaceous herbage, than Plot 11, with the same amount of ammonia-salts, and otherwise the same mineral manure (and sawdust in addition), but excluding potass. Plot 10 also gave rather more produce than either Plot 12 *a* or Plot 12 *b*, which had the same amount of ammonia-salts and mineral manure, with 2,000 lbs. of cut wheat straw per acre per annum in addition, though these plots, with the cut wheat-straw, gave a slightly higher proportion of Graminaceous herbage.

Plot 15, with the same mineral manure as Plot 10, and with about

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TABLE II.—Showing the General Description, and Proportion per Cent., of the employed, and to the amounts of Crop

ORDER OF MOST PRODUCE, PER ACRE.			GENERAL DESCRIPTION	
			Per Cent.	
			Graminaceous.	
Plot Nos.	General Description of Manures.	Hay, per Acre per Annum; average of 7 Years, 1855-62.	Determined Species.	Undetermined Stem and Leaf.
		lbs.		
13*b*	Ammonia-salts=164 lbs. nitrogen, and mixed mineral manure, including silicates - - - -	6877	81·95	8·88
13*a*	Ammonia-salts=164 lbs. nitrogen, and mixed mineral manure (without silicates) - - - -	6876	80·91	5·69
10	Ammonia-salts=82 lbs. nitrogen, and mixed mineral manure - -	6357	77·57	6·31
11	Ammonia-salts=82 lbs. nitrogen, and mixed mineral manure (excluding potass in 1862), and sawdust -	6216	72·97	8·91
12*a*	Ammonia-salts=82 lbs. nitrogen, mixed mineral manure, and 2000 lbs. cut wheat-straw - - - -	6159	80·61	6·52
12*b*	Duplicate of plot 12*a* (half of the plot rather sheltered by trees) - -	6141	74·39	12·69
15	Nitrate of soda=82 lbs. nitrogen, and mixed mineral manure - -	5783*	67·39	12·65
17	Ammonia-salts=41 lbs. nitrogen, and farmyard manure - - -	5468	73·48	5·82
14	Nitrate of soda=41 lbs. nitrogen, and mixed mineral manure - -	4939*	65·78	8·27
3*b*	Ammonia-salts=82 lbs. nitrogen, and superphosphate of lime - -	4877†	69·45	6·40
16	Farmyard manure, alone - -	4775	60·33	7·88
7	Nitrate of soda, alone=82 lbs. nitrogen	4126*	52·34	17·65
9	Mixed mineral manure (excluding potass in 1862), and sawdust -	4100	65·21	4·40
8	Mixed mineral manure, alone - -	3919	56·47	5·83
5	Ammonia-salts=82 lbs. nitrogen, and sawdust - - - -	3839	77·43	1·59
6	Nitrate of soda, alone=41 lbs. nitrogen	3805*	57·27	14·61
4	Ammonia-salts, alone=82 lbs. nitrogen	3719	78·68	5·07
3*a*	Superphosphate of lime, alone -	3164†	62·36	8·90
2	Unmanured - - - -	2927	58·13	11·61
1	Unmanured - - - -	2720	58·82	7·43

* Average of 5 years only, 1858-62 inclusive.
† Average of 4 years only, 1859-62 inclusive.

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different kinds of Herbage, and the Number of Species, in relation to the Manures yielded. SEVENTH SEASON, 1862.

OF HERBAGE.							
Per Cent.				Number of Species.			
Graminaceous.							
Shedded Flowers and Seeds, &c., chiefly Graminaceous.	Total.	Leguminous.	Miscellaneous.	Graminaceous.	Leguminous.	Miscellaneous.	Total.
4·19	95·02	0·00	4·98	14	0	7	21
3·81	90·41	0·00	9·59	15	0	9	24
5·78	89·66	0·12	10·22	14	2	12	28
4·96	86·84	0·13	13·03	15	2	13	30
3·25	90·38	0·46	9·16	14	2	13	29
5·06	92·14	0·02	7·84	14	2	10	26
9·71	89·75	0·86	9·39	13	2	10	25
10·28	89·58	0·21	10·21	16	4	8	28
5·64	79·69	1·92	18·39	15	3	13	31
7·63	83·48	0·11	16·41	13	3	16	32
10·86	79·07	1·72	19·21	13	3	11	27
10·32	80·31	0·17	19·52	16	2	10	28
8·07	73·58	18·28	8·14	16	4	16	36
4·10	66·40	24·09	9·51	17	4	19	40
3·25	82·27	0·24	17·49	16	4	15	35
12·34	84·22	0·32	15·46	15	3	13	31
4·59	88·34	0·15	11·51	16	3	14	33
7·46	78·72	2·60	18·68	16	4	19	39
4·25	73·99	6·16	19·85	15	3	20	38
7·95	74·20	7·61	18·19	16	4	23	43

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about the same amount of nitrogen, but in the form of nitrate of soda instead of ammonia salts, gave considerably less produce but almost exactly the same proportion of Graminaceous herbage, and more Leguminous herbage (0·86 per cent.), than any of the plots manured with ammonia-salt.

The better adaptation of nitrate of soda than ammonia-salts as a manure for Leguminous plants, a fact which we have in other cases observed, is again seen in the results of Plot 14. In that case, with a smaller amount of nitrate of soda and the mixed mineral manure, the Leguminous herbage amounted to nearly 2 per cent. of the produce. There was, at the same time, a larger proportion of Miscellaneous or weedy herbage (18·39 per cent.), and consequently a smaller proportion of the Graminaceous, than in any other case with an equally bulky crop. Ammonia-salts, even in conjunction with farm-yard manure, increased the proportion of Graminaceous plants at the expense of the Leguminous and Miscellaneous herbage.

Farm-yard manure alone, increased the proportion of the Graminaceous at the expense of the Leguminous herbage, the proportion of Miscellaneous herbage remaining about the same, though its character was very different, there being much fewer species and much greater predominance of individual weeds. In fact, under the influence of farm-yard manure there were fewer species developed within each division—Graminaceous, Leguminous, and Miscellaneous—the manured crop affording only 27 species, against 38 in one case, and 43 in another, without manure.

Perhaps the most striking of the results recorded in the Table is that obtained on Plot 8, by means of the mixed mineral manure alone. Whereas, without manure we have 74 per cent. Graminaceous, 6 to 7 per cent. Leguminous, and nearly 20 per cent. Miscellaneous herbage; and with the mixed mineral manure, *and ammonia-salts in addition*, 90 to 95 per cent. of the produce Graminaceous, either no Leguminous herbage at all, or but a fraction of 1 per cent. of it, and 5 to 10 per cent. of Miscellaneous herbage; we have, with mixed mineral manure *alone*, only about 66½ per cent. of Graminaceous herbage, as much as 24 per cent. Leguminous herbage, and only about 9½ per cent. Miscellaneous. Thus, two-thirds only of the produce by the mixed mineral manure alone consisted of grasses, whilst nearly one-fourth of it consisted of clovers, meadow vetchling, and trefoil. The total number of species was, however, about as high as without manure, and very much higher than with the same mineral manure and ammonia-salts in addition.

As already alluded to, when such mineral manures are applied to crops grown separately, as in rotation, instead of together in a

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mixed herbage, they generally increase the produce of Graminaceous ones but little, and that of Leguminous ones very characteristically. It has been found, too, that even in a clayey soil, the constituent of mineral manures which seems to have the most influence upon the growth of the Leguminous plants of rotation, beans and clover for example, was potass; and we have in the results under consideration a striking instance of the effects produced on the growth of the allied plants of the mixed herbage by a liberal supply to the soil of that constituent. Thus, Plot 9 had in every previous year of the experiments received the same description and amount of mineral manure as Plot 8, but in 1862 the potass was excluded (from Plot 9), and a larger amount of soda-salt substituted. The result was that the produce of Plot 9, without the potass, gave only 18 instead of 24 per cent. of Leguminous herbage, or only three-fourths as high a proportion as that of the plot manured otherwise similarly, but with the potass in addition.

Superphosphate of lime alone, used for a series of years, has somewhat increased the amount and proportion of the grasses, at the expense of the Leguminous plants; the proportion of the Miscellaneous herbage remaining about the same. Still, the proportion of the Leguminous herbage under the influence of this manure, though considerably less than without manure, and little more than one-tenth as great as with the mixed mineral manure (containing salts of potass, soda, and magnesia, as well as superphosphate of lime), was considerably greater than in any case where either ammonia-salts or nitrates were used, whether they were employed alone, in combination with mixed mineral, or with farm-yard manure.

Lastly, ammonia-salts alone (or with only sawdust in addition), or nitrate of soda alone, considerably increased the proportion of the grasses, almost excluded the Leguminous herbage, reduced the proportion of Miscellaneous plants, and also the total number of species.

It will perhaps, be remembered that some years ago Baron Liebig stated he had obtained marked effects by the use of sawdust as a manure; a result which he considered due to the evolution of carbonic acid from the decomposing sawdust, by means of which the supply of mineral constituents within the soil was rendered more rapidly available.

We have, therefore, for some years past, applied 2000 lbs. of sawdust per acre, per annum, to a few of the experimental plots. Where, in previous years, the sawdust was used, either alone, with mineral manure without ammonia-salts, or with ammonia-salts without mineral manure, some, but generally a very small increase of produce, has been the result. But where the sawdust has been

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employed with both mineral manure and ammonia-salts, that is to say, with a combination itself yielding a pretty full increase of produce, no further increase has been obtained by its means; nor has the use annually of 2,000 lbs. of finely-cut wheat-straw, in addition to the mixture of mineral manure and ammonia-salts, had as yet any beneficial effect upon the amount of gross produce per acre, notwithstanding the large amount of mineral matter peculiarly adapted for the growth of Graminaceous plants, which in addition to its decomposing carbonaceous substance, it would in the course of time supply.

Sawdust has, for similar reasons, also been tried on some of the crops grown on land under tillage, and with equal failure of beneficial result.

So far as observation goes, the effects of sawdust have been as immaterial on the character of the mixed herbage as on its amount; but as in the past season, 1862, in two out of the three cases where sawdust was employed potass was excluded from the mixed mineral manure used with it, the results are not in the season in question, strictly comparable with those of the plots with which they had previously been compared, but which now differ, not only in not having sawdust, but in having potass. The only strictly comparable experiments in 1862 are that of Plot 4 with ammonia-salts alone, and that of Plot 5 with the same amount of ammonia-salts, and sawdust in addition; and so far as the figures go, it would appear that the sawdust somewhat reduced the proportion of the grasses, and increased that of the Miscellaneous or weedy herbage.

We now turn to a consideration of the next branch of the subject.

II.—*The description and proportion per cent. of the predominating species, in relation to the manures employed, and to the amounts of crop yielded.*

Table III. (pp. 34, 35) illustrates this branch of the subject. As in table II., the Plots are arranged in order according to the amount of produce, the one yielding the most being at the head of the list, and so on. The particulars given relating to the predominating plants are—

1. The names, and proportion per cent., of the 5 predominating Graminaceous plants, or genera.
2. The names, and proportion per cent., of the 2 predominating Leguminous plants, or genera.
3. The same particulars for the 3 predominating Miscellaneous or weedy plants.

Although it is believed that the figures in the various Tables

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may be fully relied upon as showing the general relation to one another of the individual species, or different orders of plants, it is by no means supposed that small numerical differences, or even in all cases, greater ones, are to be taken unconditionally as representing corresponding differences in the character of the herbage. It will be readily understood that in any case, and especially in that of a very heavy and luxuriant crop, there must be great difficulty in collecting a sample of no more than some ten pounds weight which will absolutely represent the bulk of the mixed herbage. Then again, the difficulty of separation and identification, in the case of a mass of ill-defined and mutilated leafy produce, is extremely great. It was with a full appreciation of these difficulties that we felt it necessary, if for no other reason than as a means of control over the numerical results, that the several series of notes to which reference has been made should be taken.

And although the botanical separations have been conducted at the cost of an immense amount of care and labour, we shall, in the few remarks we have to make on the results on the present occasion, be guided by a careful consideration of the recorded observations, as well as of the figures given in the Tables.

Taking the distribution of plants in the produce of the unmanured land as the standard by which to compare that of the other plots, attention will be directed in some detail to its components.

The Unmanured Produce.

Sixteen Graminaceous species were identified in the unmanured produce, constituting together about 74 per cent. of its weight; and although their distribution was more even than in most of the cases of the manured land, the species of the five predominating genera amounted in one case to 43, and in another to 47 per cent. of the total produce. In the produce of the heaviest crops, however, generally over 60, and sometimes as much as 68 or 69 per cent. were referable to the five predominating species, or at any rate to the species included within the five predominating genera.

In the unmanured produce, Festuca duriuscula, or F. pratensis, which are hardy and good grasses, Avena pubescens and A. flavescens, sweet and good grasses, adapted to dry and chalky land, and much liked in hay, were the most prominent; but they were by no means in such large proportion as the predominating grasses on most of the manured plots. Next to these were Lolium perenne, a very good and free-growing grass; Agrostis vulgaris, a creeping-rooted plant, said to be not liked by cattle; and Holcus lanatus, also a bad food-grass, being too soft and woolly. After these came Arrhenatherum avenaceum, a rather favourite

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TABLE III.—Showing the Description, and Proportion per Cent, of the predominating

SEVENTH

Order of Most Produce, per Acre.			Description, and per Cent., The Five predominating			
Plot Nos.	General Description of Manures.	Hay, per Acre per Annum; average of 7 Years 1856-62.	1	2	3	4
		lbs.				
13b	Ammonia-salts = 164 lbs. nitrogen, and mixed mineral manure (including silicates)	6877	Dactylis gl. 21·9	Agrostis vul. 19·3	Poa tr. & pr. 14·3	Holcus lan. 7·0
13a	Ammonia-salts = 164 lbs. nitrogen, and mixed mineral manure (without silicates)	6876	Dactylis gl. 23·6	Poa tr. & pr. 16·6	Agrostis vul. 9·2	Holcus lan. 8·8
10	Ammonia-salts = 82 lbs. nitrogen, and mixed mineral manure . . .	6357	Avena p. & f. 18·1	Poa tr. & pr. 12·7	Lolium per. 11·9	Agrostis vul. 11·6
11	Ammonia-salts = 82 lbs. nitrogen, and mixed mineral manure (excluding potass in 1862), and sawdust . .	6216	Avena p. & f. 19·2	Dactylis gl. 11·9	Poa tr. & pr. 9·1	Holcus lan. 8·6
12a	Ammonia-salts = 82 lbs. nitrogen, mixed mineral manure and 2000 lbs. cut wheat-straw	6159	Dactylis gl. 23·6	Avena p. & f. 12·6	Agrostis vul. 12·0	Poa tr. & pr. 9·0
12b	Duplicate of Plot 12a (half of the plot rather sheltered by trees . .	6141	Dactylis gl. 31·0	Poa tr. & pr. 12·0	Holcus lan. 6·3	Festuca p. & d. 6·3
15	Nitrate of soda = 82 lbs. nitrogen, and mixed mineral manure . . .	5783*	Poa triv. 7·11	Dactylis gl. 11·6	Lolium per. 10·0	Bromus mol. 9·4
17	Ammonia salts = 41 lbs. nitrogen, and farmyard manure	5468	Poa tr. & pr. 29·5	Dactylis gl. 16·9	Bromus mol. 12·5	Holcus lan. 6·0
14	Nitrate of soda = 41 lbs. nitrogen, and mixed mineral manure . . .	4939*	Avena f. & p. 17·8	Festuca d. & p. 11·1	Agrostis vul. 10·3	Holcus lan. 9·6
3b	Ammonia-salts = 82 lbs. nitrogen, and superphosphate of lime . . .	4877†	Agrostis vul. 18·6	Holcus lan. 15·3	Avena p. & f. 8·4	Poa triv. 7·3
16	Farmyard manure, alone . . .	4775	Poa triv. 27·4	Bromus mol. 9·6	Avena p. & f. 7·3	Dactylis gl. 4·9
7	Nitrate of soda alone = 82 lbs. nitrogen	4126*	Festuca d. & p. 16·0	Alopecurus pr. 6·9	Agrostis vul. 6·2	Avena p. & f. 6·0
9	Mixed mineral manure (excluding potass in 1862), and sawdust . .	4100	Avena p. & f. 17·7	Festuca d. & p. 9·9	Agrostis vul. 7·6	Lolium per. 7·0
8	Mixed mineral manure, alone . .	3919	Avena p. & f. 16·7	Festuca d. & p. 12·8	Poa tr. & pr. 6·7	Arrhenath. av. 5·3
5	Ammonia-salts = 82 lbs. nitrogen, and sawdust	3839	Agrostis vul. 20·5	Avena p. & f. 16·6	Festuca d. & p. 14·4	Holcus lan. 8·1
6	Nitrate of Soda, alone = 41 lbs. nitrogen	3805*	Alopecurus pr. 19·7	Festuca d. & p. 8·0	Agrostis vul. 6·8	Holcus lan. 6·7
4	Ammonia-salts, alone = 82 lbs. nitrogen	3719	Festuca d. & p. 23·3	Agrostis vul. 21·3	Holcus lan. 9·7	Avena p. & f. 8·5
3a	Superphosphate of lime, alone . .	3164†	Avena p. & f. 12·5	Festuca d. & p. 12·2	Holcus lan. 11·9	Lolium per. 9·5
2	Unmanured	2927	Festuca p. & d. 16·2	Avena p. & f. 11·3	Agrostis vul. 5·5	Dactylis gl. 5·2
1	Unmanured	2720	Festuca p. & d. 13·9	Avena p. & f. 11·0	Lolium per. 8·7	Agrostis vul. 8·6

* Average of 5 years only, 1858-62 inclusive.
† Average of 4 years only, 1859-62 inclusive.

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Species, in relation to the Manures employed, and to the Amounts of Crop yielded.

SEASON, 1862.

OF PREDOMINATING SPECIES.

Graminaceous Plants.		The Two predominating Leguminous Plants.			The Three predominating Miscellaneous Plants.			
5	Total per Cent.	1	2	Total per Cent.	1	2	3	Total per Cent.
Arrhenath. av. 5·7	68.2	0·00	0·00	0·00	Rumex acet. 3·72	Carum Car. 0·82	Achillæa mil. 0·39	4·93
Lolium per. 8·6	66·8	0·00	0·00	0·00	Rumex acet. 6·40	Achillæa mil. 1·53	Carum Car. 1·35	9·28
Holcus lan. 11·1	65·4	Lathyrus pr. 0·11	Trifolium rep. 0·01	0·12	Rumex acet. 4·93	Carum Car. 2·34	Achillæa mil. 1·96	9·23
Agrostis vul. 8·0	56·8	Lathyrus pr. 0·12	Trifolium rep. 0·01	0·13	Rumex acet. 9·26	Carum Car. 1·47	Achillæa mil. 0·90	11·63
Lolium per. 7·5	64·7	Lathyrus pr. 0·41	Trifolium pr. 0·05	0·46	Rumex acet. 4·88	Achillæa mil. 2·08	Carum Car. 1·74	8·70
Avena p. & f. 6·0	61·6	Lathyrus pr. 0·01	Trifolium rep. 0·01	0·02	Rumex acet. 5·56	Carum Car. 1·33	Achillæa mil. 0·75	7·64
Holcus lan. 6·7	54·8	Lathyrus pr. 0·84	Trifolium pr. 0·02	0·86	Rumex acet. 7·09	Carum Car. 1·09	Ranun. a. & b. 0·52	8·70
Avena f. & p. 3·8	68·7	Lathyrus pr. 0·14	Trifolium pr. 0·05	0·19	Rumex acet. 5·76	Achillæa mil. 1·39	Ranun. a. & b. 1·39	8·54
Poa triv. 7·3	56·1	Trifol. p. & r. 1·87	Lathyrus pr. 0·05	1·92	Rumex acet. 5·33	Ranun. a. & b. 5·18	Carum Car. 3·75	14·26
Festuca d. & p. 6·9	56·5	Lathyrus pr. 0·07	Trifol. p. & r. 0·04	0·11	Rumex acet. 11·05	Ranun. a. & b. 1·73	Achillæa mil. 1·70	14·48
Arrhenath. av. 2·7	51·9	Lathyrus pr. 0·90	Trifol. p. & r. 0·82	1·72	Rumex acet. 10·33	Ranun. a. & b. 2·34	Achillæa mil. 2·34	15·01
Lolium per. 4·6	39·7	Trifolium pr. 0·16	Lotus cornic. 0·01	0·17	Plantago lanc. 6·99	Rumex acet. 5·72	Achillæa mil. 2·55	15·26
Arrhenath. av. 5·1	47·3	Trifol. p. & r. 10·01	Lathyrus pr. 8·10	18·11	Rumex acet. 1·70	Carum Car. 1·39	Achillæa mil. 0·95	4·04
Holcus lan. 4·9	46·4	Lathyrus pr. 13·24	Trifolium pr. 7·51	20·75	Rumex acet. 1·86	Carum Car. 1·79	Achillæa mil. 1·69	5·34
Lolium per. 5·8	65·4	Lathyrus pr. 0·22	Trifolium pr. 0·01	0·23	Rumex acet. 10·64	Achillæa mil. 3·37	Galium ver. 0·95	14·96
Poa tr. 5·7	46·9	Trifolium pr. 0·28	Lotus cornic. 0·03	0·31	Centaurea nig. 3·93	Plantago lanc. 3·06	Rumex acet. 2·84	9·83
Arrhenath. av. 5·8	68·6	Lotus cornic. 0·07	Trifolium pr. 0·07	0·14	Rumex acet. 7·88	Achillæa mil. 1·33	Carum Car. 0·86	10·07
Poa tr. & pr. 5·7	51·8	Trifol. p. & r. 1·93	Lotus cornic. 0·39	2·32	Plantago lanc. 5·35	Ranun. a. & b. 4·27	Rumex acet. 3·17	12·79
Holcus lan. 4·8	43·0	Trifolium pr. 2·66	Lathyrus pr. 1·88	4·54	Plantago lanc. 7·72	Rumex acet. 2·68	Carum Car. 2·52	12·92
Holcus lan. 5·0	47·2	Trifol. p. & r. 4·73	Lotus cornic. 1·69	6·42	Plantago lanc. 6·87	Ranun. a. & b. 3·61	Luzula camp. 1·54	12·02

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grass as early feed, and for its second cut; Poa trivialis, also a good grass for early feed and second crop, but from its tufty growth and strong creeping roots said to be apt to banish other grasses; Anthoxanthum odoratum, a fragrant grass, but not relished in large quantity; and Alopecurus pratensis, better as green food than as hay. All the above were more evenly distributed in the small unmatured produce than in any other; and it contained besides, insignificant quantities of Dactylis glomerata, a bulky and free-growing grass under favourable conditions, and much liked by stock when not too old; Briza media, a plant of limited growth, and not much relished as food; Cynosurus cristatus, varying in character considerably, according to circumstances of growth, better for pasture than for hay, but upon the whole of little utility; and lastly Bromus mollis, a soft and very bad food-grass.

It is true that on one of the unmanured plots (No. 2) Dactylis glomerata occurred in notable quantity; but as that plot was situated between plots 12 *a* and 13 *b*, on both of which Dactylis was very luxuriant, it is more probable that it has, from time to time, been seeded from them, than that such a grossly-feeding grass flourished naturally on the unmanured land. Observation, indeed, led to the conclusion that in some other cases unexpected differences in the indications of the figures are attributable to adventitious circumstances of an allied kind.

Of Leguminous herbage, the unmanured produce contained from 6 to 7 per cent., the larger portion of which consisted of perennial red clover, with a little white clover. Lathyrus pratensis (meadow vetchling), and Lotus corniculatus (bird's-foot trefoil) occurred in less quantity, but the two about equally, and more largely than in any other case excepting where the mixed mineral manures were employed.

The Miscellaneous or weedy herbage, of which nearly 20 per cent. of the unmanured produce was composed, also consisted, like the Graminaceous herbage, of a great variety of species, of which few specially predominated, excepting the Plantago lanceolata (ribwort plantain). The next in prominence were the Ranunculus acris and R. bulbosus (crow-foots), Rumex acetosa (sorrell dock), Carum Carui (common caraway), Achillæa millefolium (milfoil), and Luzula campestris (field wood-rush). In smaller quantity occurred—of the Order *Compositæ*—Centaurea nigra (black knapweed), Leontodon hispidus (rough hawkbit), Tragopogon pratense (yellow goat's beard), Taraxacum Dens-leonis (dandelion), Hypochœris radicata (cat's-ear), and Bellis perennis (daisy); of the Order *Umbelliferæ*, Pimpinella saxifraga (burnet saxifrage), and Heracleum sphondylium (hogweed); and of plants of various other natural Orders, occurring still less pre-

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valently, where the Veronica chamædrys (germander speedwell), Cerastium vulgatum (mouse-ear chickweed), Stellaria graminea (lesser starwort), Scabiosa arvensis (field scabious), Hypnum squarrosum (squarrose moss), Primula veris (cowslip), Sanguisorba officinalis (great burnet), Geum urbanum (common avens), Galium verum (yellow bed-straw), Ajuga reptans (bugle) and Ophioglossum vulgatum (adder's tongue). And there were probably others of too unpretending and restricted growth to be observed on the ground, or to come within reach of the scythe.

Upon the whole the unmanured produce—Graminaceous, Leguminous, and Miscellaneous—was more complex, and less characterised by the prevalence of individual species, than that of any of the manured plots. The most predominating plants were, of the grasses Festuca duriuscula and F. pratensis, Avena pubescens and A. flavescens; and of the Miscellaneous or weedy plants, Plantago lanceolata.

It is only necessary to add that the meadow yielding the mixed herbage composed as above described, though giving hay of fair average quality, and useful after-feed for store stock, or sheep, by no means partakes of the character of a fattening pasture.

Effects of Mineral Manures alone.

The plots on which the Graminaceous herbage more nearly approached to that of the unmanured land, both in complexity and in general prevalence of the same species, were plot 3 *a* manured with superphosphate of lime alone, and plots 8 and 9 with the mixed mineral manure. The chief distinctions apparent are, that by superphospate of lime alone the inferior grass Holcus lanatus was brought into somewhat greater prominence, and that by it, as well as by the mixed mineral manure alone, the useful grass Poa trivialis was somewhat increased in relative amount. By the mixed mineral manure, Arrhenatherum avenaceum also appears to be somewhat encouraged. The free growing and bulky Dactylis glomerata was in very small quantity on either of the plots manured with mineral manure alone; nor are either of the other grasses which occur in predominating amount on one or other of the plots yielding the heavier crops, found at all prominently in the comparatively small produce grown under the influence of mineral manures alone.

It was on the amount and character of the Leguminous herbage that the mineral manures alone produce the most striking effects. Superphosphate of lime alone, considerably reduced the proportion of such herbage; but when with it salts of potass, soda, and magnesia were used, Trifolium pratense perenne, and Lathyrus pratensis, were developed in an extraordinary degree. When the

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mixed mineral manure contained potass, as well as soda and magnesia (Plot 8), the Lathyrus somewhat predominated; and where the potass was excluded (Plot 9) it was in a smaller proportion. Lotus, again, was more abundant on Plot 8, where the potass was employed. As already alluded to, however, the total amount of Leguminous herbage was very much the less on Plot 9, where the potass was excluded; and as at present it has only been for one season excluded, it is not improbable that the proportion of such herbage will in future be greatly reduced. It is worthy of remark, too, that on Plot 8, where the application of potass is continued, the proportion of Leguminous herbage was almost exactly the same in the produce of the seventh year of the experiments, 1862, as it had been found to be in that of the third season, 1858.

Superphosphate of lime alone, which tended to decrease the proportion of Leguminous plants, seemed to be generally favourable to the development of the Miscellaneous ones, both the variety and amount of such herbage being considerable. The proportion of Plantago lanceolata was nearly as great as on the unmanured plot, and that of Ranunculus (acris and bulbosus), Rumex, Achillæa, and Carum Carui, was also comparatively large. On the other hand, the mixed mineral manures, which so much increased the proportion of the Leguminous plants, considerably diminished that of the Miscellaneous ones. The variety of such herbage was, however, considerable; the reduction in amount being due to the diminished luxuriance of several species, and especially the Plantago, which was in very small amount.

Effects of Ammonia-Salts alone.

Compared with the unmanured produce, ammonia-salts alone, or with sawdust only in addition, considerably increased the proportion of total Graminaceous herbage, and also the amount referable to the species of the five predominating genera, the latter reaching from 65 to 68 per cent. of the total produce. To a great extent, however, the same grasses prevailed as in the small crops without manure, or with mineral manures alone. The most prominent effect of this relatively excessive nitrogenous condition, was the encouragement of the Festuca duriuscula and Avena pubescens, two good elements predominating in the produce without manure; to a greater extent still that of the objectionable creeping-rooted Agrostis; and in some degree also that of the inferior Holcus lanatus. Compared with the effects on the distribution of the Graminaceous herbage of mineral manure alone, the most marked result of the ammonia-salts alone was the great increase of the Agrostis and the Holcus, at the

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expense, to some extent, of the superior Poa trivialis, but in a greater degree of the Leguminous herbage. The free growing and bulky Dactylis, as by mineral manures alone, so also by ammonia-salts alone (which characteristically favour the growth of Graminaceous herbage generally), appears to be kept in the background. In fact, although the increase by ammonia-salts alone was exclusively Graminaceous (other plants being actually reduced in amount), it was also almost exclusively composed of the leafy herbage of the less grossly growing grasses.

Under the influence of ammonia-salts alone the produce did not contain a quarter of 1 per cent. of Leguminous herbage.

The proportion of total Miscellaneous plants and the number of species, were reduced by the use of ammonia-salts alone; but some few plants were very strikingly encouraged, especially the Rumex acetosa, which was both abundant and luxuriant. Carum Carui was also very prevalent, more so than the figures would indicate; the small weight being probably due to its being ripe, and having shedded much seed before being cut. Achillæa millefolium was also a very prominent plant; and Luzula campestris was more so than on most of the manured plots.

Effects of Nitrate of Soda alone.

The effects of nitrate of soda alone, though in many respects similar to those of ammonia-salts alone, show some peculiarities. The proportion of the total herbage referable to the five predominating Graminaceous genera is unusually small; whilst a plant occurring in the produce without manure in very small quantity, and in less amount still in that by mineral manure alone, or ammonia-salts alone, comes here into very great prominence. This grass, Alopecurus pratensis (fox-tail grass), a good pasture plant, but not a good element in hay, contributed 19·7 per cent. to the produce where the smaller amount of nitrate of soda was used alone, and nearly 7 per cent. where the larger amount was employed; though, in only one other case, excepting in the produce without manure did it exceed 2 per cent. This grass was, in fact, quite characteristic of the nitrated plots. Otherwise, there was a pretty equal distribution of the grasses prevailing on the plots hitherto considered; though, as with ammonia-salts without mineral manure, there was here a great tendency to development of foliage from the base, rather than to the growth of stem and stem-leaves.

Nitrate of soda alone, like ammonia-salts alone, very much discouraged the Leguminous herbage. Lathyrus and Lotus were almost totally excluded; and Trifolium only contributed about a quarter of 1 per cent. of the produce.

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Unlike ammonia-salts alone, the nitrate of soda seemed to encourage the Plantago lanceolata; and under its influence Centaurea nigra and Taraxacum Dens-leonis, though in small amount, were somewhat more prominent than usual. But next to Plantago lanceolata, Rumex acetosa, Achillæa millefolium, Ranunculus (acris and bulbosus), and Carum Carui were the most abundant of the Miscellaneous plants, though none of them were very luxuriant. The total amount of Miscellaneons herbage was comparatively large, but resulted from the great frequency of some few species, rather than from either great variety, or great luxuriance of any particular plants.

Effects of Farm-Yard Manure alone.

Farm-yard dung alone, the manure upon which dependence must to a great extent be placed for grass-land devoted to the production of hay, gave a produce containing 79 per cent. of total Graminaceous herbage, but a comparatively small proportion (51·9 per cent.) referable to the five predominating genera; and this was the case notwithstanding that one grass, Poa trivialis, which was not at all prominent on any of the plots already considered, contributed 27½ per cent. of the total herbage as sampled. The notes taken on the ground agree with the figures in showing this plant to have been very prominent; and, as will presently be seen, it also occurred in very predominating amount on the plot manured with farmyard-manure and ammonia-salts. So far farmyard-manure improves the character as well as increases the amount of the Graminaceous herbage; but it also brings into greater prominence than any of the other manures Bromus mollis, which is reputed to be a very bad food-grass. It, at the same time, encourages the free-growing, productive, and, upon the whole, good but somewhat coarse grass Dactylis glomerata more than any of the manures yielding the smaller crops. The three grasses Poa trivialis, Bromus mollis, and Dactylis glomerata, which are thus seen to be increased in their development by farmyard-manure, are so at the cost chiefly of Festuca duriuscula and F. pratensis, but partly of Avena pubescens and Agrostis vulgaris, and in a less degree of some other grasses.

The produce by farmyard-manure contained a much less amount and proportion of Leguminous herbage than that without manure; both Trifolium and Lathyrus being much reduced, and Lotus excluded, at any rate from the mown sample. This result is probably due more to the increased luxuriance of the grasses and certain Miscellaneous plants, by which the Leguminous ones are displaced, than to any directly injurious effect of the farmyard-manure; for the notes taken on the ground show

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that although Trifolium and Lathyrus were less frequent on the farmyard-manure than on the unmanured plot, they were on the other hand more luxuriant.

The Miscellaneous or weedy plant most prominently developed by farmyard-manure was the Rumex acetosa, or sorrel dock, which amounted to rather more than 10 per cent. of the sample examined; though, from the notes taken on the ground, it is concluded that the sample perhaps included a somewhat undue proportion. According to the notes, Carum Carui was by far the most frequently occurring weed. Ranunculus (acris and bulbosus), and Achillæa millefolium were also each very frequent; and Plantago lanceolata was more so than in most of the crops of equal bulk. Besides those mentioned, scarcely any other weedy plants occurred; there being a large total per-centage of Miscellaneous herbage, but referable to comparatively few species, and it was the frequency rather than the luxuriance of these that contributed to the large amount.

Effects of Farmyard-manure and Ammonia-salts.

As already alluded to, the combination of farmyard-manure and ammonia-salts, like farmyard-manure alone, very strikingly developed the Poa trivialis, and to a considerable extent the Bromus mollis also. The chief distinction is, that the ammonia-salts used in conjunction with a manure supplying a large amount of mineral matter, strikingly increases the growth of the Dactylis glomerata, apparently at the expense of the Miscellaneous herbage, of which there were but very few species, and but a small amount, whilst the proportion of total Graminaceous herbage was considerably increased. In other respects, the produce was very similar in its Graminaceous components to that by farmyard-manure alone; there being, in the two cases, besides the grasses which have been specially noticed, pretty equal proportions of most of those occurring on the unmanured plot. Holcus lanatus was, however, rather more plentiful and luxuriant where the ammonia-salts were used.

Under the influence of ammonia-salts in conjunction with farmyard-manure all the elements of Leguminous herbage were almost as completely excluded as when ammonia-salts were used alone.

The number of species of Miscellaneous plants was unusually small under the conditions of manuring now in question; and the proportion in the produce of such herbage was also small. As in the case of farmyard-manure alone, Rumex acetosa was the most prominent weed. Judging from the notes and figures together, Carum was probably next in order of prevalence; and after it

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came Ranunculus (acris and bulbosus), and Achillæa millefolium. But none of the Miscellaneous plants enumerated were so abundant here as under the influence of the farmyard-manure alone; still, the amounts recorded in the Tables are attributable rather to their frequency than to great luxuriance.

Effects of Ammonia-Salts and Superphosphate of Lime.

Ammonia-salts in conjunction with superphosphate of lime, gave considerably more produce, a larger proportion of Graminaceous herbage, and a larger proportion referable to the five predominating Graminaceous genera than superphosphate of lime alone: the proportion of the latter being increased from 51 to 56½ per cent. of the total produce. The proportions of Poa trivialis and Lolium perenne are not much affected by the addition of the ammonia-salts; but those of Festuca duriuscula, Avena pubescens, and A. flavescens are considerably reduced; whilst the inferior grasses, Agrostis vulgaris and Holcus lanatus (especially the former), are brought into very considerable prominence. Although, therefore, the amount of produce was much increased by the addition of the ammonia-salts, the character of the Graminaceous plants developed was somewhat inferior. Dactylis glomerata was not encouraged by the combination in question.

As in other cases where nitrogenous manures were freely employed, Leguminous herbage of all kinds was almost excluded.

Of Miscellaneous herbage—as under somewhat similar conditions in other cases—Rumex acetosa was by far the most prominent element, being both very abundant and very luxuriant. Carum Carui was likewise both abundant and luxuriant, but had shedded a good deal of its seed; Ranunculus acris and R. bulbosus were frequent rather than luxuriant; Achillæa millefolium occurred in notable quantity; other Miscellaneous species were somewhat few in number and insignificant in amount.

Effects of Nitrate of Soda and Mixed Mineral Manure.

By nitrate of soda and mixed mineral manure together, both the amount of produce and the proportion of it referable to the few predominating Graminaceous species were greater than by either nitrate of soda alone or mixed mineral manure alone. Where the smaller amount of nitrate of soda was used with the mixed mineral manure, Avena flavescens, Holcus lanatus, and Poa trivialis were the predominating grasses; and, according to the figures, Festuca duriuscula and Agrostis vulgaris were also in large amount, though the notes taken on the ground did not lead

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to the conclusion that they were predominating. All these grasses occurred in larger amount than where the nitrate of soda was used alone. But the most remarkable effect of the addition of the mixed mineral manure was the almost entire exclusion of the Alopecurus pratensis, which had flourished in such an extraordinary degree under the influence of the nitrate of soda alone, and the great development in its stead of the Avena flavescens, which under the latter condition had occurred in very insignificant amount. With twice the amount of nitrate of soda and the same mixed mineral manure, the distribution of Graminaceous species was again very strikingly but very differently affected. Poa trivialis was now the predominating species; and Dactylis glomerata, Lolium perenne, and bromus mollis were also in considerable quantity; Holcus lanatus coming next in order. Here again Alopecurus pratensis—the characteristic plant with nitrate of soda alone—was almost excluded; whilst Festuca duriuscula was reduced to a very insignificant amount, and Avena flavescens —so luxuriant with the smaller amount of nitrate and mineral manure—was here by no means prevalent. With regard to the great prominence of Poa trivialis and Bromus mollis on the plot now under consideration, it is, however, worthy of remark that it adjoined Plot 17, manured with farmyard-manure and ammonia-salts, where these two grasses were the characteristic plants. It would seem probable, therefore, that the result was, at any rate partly, due to seeding from the farmyard manure plots, and hence so far accidental.

Of Leguminous plants, there was a somewhat larger proportion than by nitrate of soda alone, or by ammonia-salts either alone or in combination with the mixed mineral manure, though much less, especially of Trifolium, where the larger than where the smaller amount of nitrate of soda (with the mineral manure) was used, and in both cases very much less than without manure. The Lathyrus was more frequent than the Lotus: the latter, indeed, was all but wanting.

The amount and character of development of the Miscellaneous herbage differed very greatly on the two plots with nitrate of soda and mineral manure, both the proportion and the luxuriance being generally much greater with the smaller amount of nitrate. With the smaller amount of nitrate, Rumex acetosa, Ranunculus (acris and bulbosus), Carum Carui, and Achillæa millefolium were all both frequent and luxuriant, and Plantago lanceolata was somewhat so. With the larger amount of nitrate, Rumex acetosa was by far the most frequent and abundant weed; neither Achillæa millefolium nor Plantago lanceolato was at all prevalent; whilst Carum Carui and Ranunculus (acris and bulbosus), though somewhat frequent, were not luxuriant; and other weeds

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were small, both in number and amount. The general result is, that with the larger amount of nitrate and the mixed mineral manure, as with the corresponding amount of ammonia-salts and mixed mineral manure—both the number of species and the total amount of Miscellaneous plants were comparatively small.

Effects of Ammonia-salts and mixed Mineral Manure.

There remain to be noticed the distribution and predominance of species on Plots 10, 11, 12*a*, 12*b*, 13*a*, and 13*b*, on which both ammonia-salts and mixed mineral manure were employed, and on which by far the largest crops were obtained.

Excepting in the case of Plot 11, where in 1862 potass was excluded from the mineral manure, the produce contained from 89½ to 95 per cent. of Graminaceous herbage; and the five predominating grasses ranged from about 61½ to about 68¼ per cent. of the total produce. In four out of the six cases the free-growing and bulky Dactylis glomerata was the predominating grass, contributing in one case 31 per cent., and in the case of the smallest amount of it, nearly 22 per cent. of the total produce. In the other two cases, the Avena pubescencs and A. flavescens, in about equal proportions, predominated, amounting together to from 18 to 19 per cent. In two out of the four cases where Dactylis predominated (Plots 13*a* and 13*b*) a very excessive amount of ammonia-salts was employed; and in the one case the mineral manure contained silicates, when a considerably larger amount of Agrostis was found in the produce; but whether the result were really due to the supply of the silicates may be a question. In fact, it was in dealing with the very heavy and luxuriant crops that the difficulty of fairly sampling was the greatest; and we would therefore, especially in such cases, rest our conclusions much more upon the general than upon the exact indications of the figures. Although Agrostis and Holcus, two bad elements, occurred in considerable quantity in the bulky produce of all the highly-manured plots, it is satisfactory to observe that the free-growing and useful Dactylis, the sweet and much-relished Avena pubescens and A. flavescens, the useful Poa trivialis, and the free-growing and nutritive Lolium, were all prominent components in these luxuriant crops. Of other grasses, Festuca duriuscula or F. pratensis, came next in order of prevalence, the rest occurring, for the most part, in very insignificant proportions.

Of Leguminous plants these heavy crops in some cases contained scarcely a trace, and in others only very insignificant amounts.

Of Miscellaneous herbage, Rumex acetosa, as usual with full

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manuring of any kind, is by far the most predominating plant; Carum Carui and Achillæa millefolium coming next in order. All others, Ranunculus and Plantago included, occurred in very small amounts; and the total quantity of Miscellaneous herbage, which was small, was attributable chiefly to the luxuriance of the Rumex and the Carum, and the frequency of the Achillæa millefolium.

III. *The tendency to the development of leafy or stemmy produce, and the order of ripeness.*

As already explained in the separations of 1858, the results of which were recorded in our former Report, the Graminaceous herbage was classified into "Stems bearing flower or seed," which could be referred to particular species, and into "Detached leaf and indeterminate stems;" and hence the figures pretty directly indicated the relative tendency to the production of stem and seed, or of leaf. But since in the recent separations all the detached leafy matter that could be identified is included, with the stemmy portion, under the head of "Determined species" —the remainder only being put down as "Undetermined stem and leaf," or "Shedded flowers and seeds, &c."—the numerical results of the present inquiry do not serve to illustrate the subject of the tendency to the development of leafy or stemmy produce. The figures in the column in Table II., showing the amounts remaining as "Undetermined stem and leaf," do indeed indicate, where the amount is large, that the separation and identification were unusually difficult, and so far, generally, that the produce was leafy and ill-defined rather than stemmy and matured; but in the few remarks we have to make on the point in question, as well as on that of the relative ripeness, we shall rely on careful observations made on the ground, just before and at the time of cutting, in which ten conditions or orders of ripeness of the produce (of the 20 plots) were noted.

The unmanured plots presented a very thin crop of stem, with a full and uniform development of leaves, which were, however, very short, affording, upon the whole, a pretty even and close, but meagre bottom herbage, which was green and late at the time of cutting, its order of ripeness being No. 8. Leguminous and Miscellaneous plants were numerous, but mostly of stunted growth.

Superphosphate of Lime alone gave a crop very much like the unmanured one as to general relation of leaf and stem, &c., but it was rather more luxuriant, and showed more tendency to the production of fine leaf, chiefly belonging to the smaller and later

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grasses; it contained much less Leguminous herbage, nearly the same proportion of Miscellaneous plants, and was somewhat more matured at the time of cutting, its order of ripeness being No. 6.

Mixed mineral manures alone gave a very equally maturing and generally ripe crop, but with only a small proportion of the more grossly growing grasses; the finer ones, however, mostly flowering or seeding. Leguminous plants were very numerous and luxuriant, but few of the Miscellaneous ones were so. Order of ripeness No. 2.

Ammonia-salts alone gave a very green and unripe crop, the order of ripeness being No. 10. There was a dense bottom herbage, with the foliage coming chiefly from the root, and very little flowering tendency. Upon the whole the grasses, which were for the most part of the smaller kinds, seemed but partially developed, apparently exhausted, and not likely to mature. Lolium perenne showed the most tendency to form stem and seed, but was frequently monstrous or dying.

Nitrate of soda alone gave a crop which at the time of cutting was very late, dark green, and still growing, without the look of exhaustion exhibited by the herbage grown by ammonia-salts alone; it was much more leafy than stemmy, forming a dense mass of grassy produce, for the most part referable to the smaller-leafed species; and, as the amount of undetermined stem and leaf will show, the separation and identification of its components were unusually difficult. The order of ripeness was No. 9.

Farm-yard manure alone yielded a produce which was, upon the whole, comparatively ripe, standing 4th in this respect, but it was very unequally so. All the grasses gave a fair proportion of stem, and they were also generally plentiful in both base and stem-leaves. Poa trivialis and Bromus mollis were the predominating grasses, but there was a fair proportion of most of the others found on the unmanured land, the grosser species being, however, somewhat restricted in development.

Farmyard manure and ammonia-salts, like farmyard-manure alone, gave a very unequally ripe crop, which also in order of ripeness was No. 4. Its characteristics were great luxuriance, a fair proportion of both stem and leaf, and a considerable variety of herbage; but with Poa trivialis, Dactylis glomerata, and Bromus mollis, by far the most prominent species among the grasses, giving upon the whole a strong and thick-bottomed, but rather rough crop.

With superphosphate of lime and ammonia-salts the crop was much more backward than with superphosphate of lime alone, coming 10th instead of 6th in order of ripeness. There was,

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relatively, much less development of stem and much more of leaf, forming a strong and luxuriant bottom-grass, of a dark-green colour.

The mixed mineral manure and nitrate of soda gave crops which were very much riper, especially where the double amount of nitrate was used, than those by nitrate of soda alone; the order of ripeness was with the smaller amount of nitrate (and minerals), No. 5, and with the larger amount, No. 1; the crops with nitrate alone standing 9th, and those with the mixed mineral manure alone 2nd. There was, however, a great tendency to the production of leaf, the stems being somewhat thinly distributed.

The mixed mineral manure in conjunction with ammonia-salts, as with nitrates, greatly enhanced the production of stem and the ripening tendency. The crops grown by this combination —which were the heaviest in the series—were very luxuriant, and still vigorously growing at the time of cutting, the grosser species of grass predominating. There was a very full development of both stem and leaf; the foliage, however, coming in larger proportion than usual from the stem. With the smaller amount of ammonia-salts the crops were 4th in order of ripeness; but with the larger amount they were only 7th, being later, greener, and more vigorously growing, and showing a greater abundance and luxuriance of Dactylis glomerata.

In connexion with the results brought out in this inquiry into the action of special manures on the mixed herbage of grass-land, it will be interesting, at the present time, when the subject of the utilisation of *town sewage* is so much discussed, to call attention to the prominent characters of the herbage developed when it is applied to permanent meadow land.

In some experiments conducted during the last two years by the Royal Sewage Commission, and still in progress on the application of the town sewage to grass land at Rugby, it is found that effects have resulted very similar to those recorded in this paper. The prevailing grasses on the unsewaged land were Dactylis, Holcus, Lolium, Festuca, Agrostis, Poa, and Avena; a number of others occurring in smaller proportion. Of the sewaged produce, by far the largest proportion consists of Dactylis, Holcus, and Lolium; whilst Festuca, Agrostis, Avena, Poa, and other grasses, are far less prominent than in the unmanured produce. Under the influence of sewage too, the Leguminous herbage is found to be almost excluded; and the Miscellaneous weedy plants are very much reduced in variety, though some few are very much increased in luxuriance, among which Rumex, Ranunculus repens, and sometimes Taraxacum, are the most prominent.

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In the well-known Edinburgh sewaged meadows again, the herbage is for the most part of a very simple character. Of the grasses the most prominent, and the most valued for its yield of green food, is the Poa trivialis; next in prevalence, and perhaps in general estimation also, is the Triticum repens, or couch grass; and after these, frequently occur Lolium perenne and Dactylis glomerata. Of weedy plants, the Ranunculus seems to be the most prevalent and luxuriant, especially where the drainage is imperfect. It should be observed, however, that many of the Edinburgh meadows have been laid down specially with a view to sewage irrigation; though, where old permanent meadows have been brought under treatment, or a considerable mixture of grasses has been sown in laying down for irrigation, it is still found, after a few years, that the great bulk of the herbage is composed of but a few of the freer growing grasses.

It will be readily understood, however, that the value of the produce of ordinary permanent meadow land, and of a sewage-irrigated meadow, depends upon very different qualities, and that a character of growth which may be a disadvantage in the one case, may be advantageous in the other.

The produce of the ordinary meadow, if designed for hay, is allowed to approach nearly to maturity before being cut, and over luxuriance of growth, tending to the great predominance of a few very free growing grasses, is likely to be accompanied by an undue development of woody stem, giving a hard, coarse, and comparatively indigestible and innutritious food. There is, in fact, an obvious limit beyond which it is not advantageous to go in forcing the hay crop by means of artificial manures; for, beyond a certain point, which the intelligent practical farmer will not be slow in discerning, not only is less increase of produce obtained for a given amount of manure employed, but the increased quantity is gained at too great a sacrifice of quality.

It is quite otherwise with the sewage-irrigated meadow, the produce of which is to be cut green. Although it may happen that only the very free growing (and under some circumstances objectionable) grasses may be encouraged, yet they are mown in a young and succulent condition, before their objectionable qualities have been developed, and the faster they grow the oftener they are cut. Hence, whilst their great luxuriance is only an advantage, their tendency to yield a hard later growth is not against them.

The most prominent results of the whole inquiry may be briefly enumerated as follows:—

1. So far as the general distribution of Graminaceous, Leguminous

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BAGE OF GRASS-LAND.

S OF HERBAGE. SEVENTH SEASON, 1

ARTIFICIAL MANURES.				
Mixed Alkalies and Superphosp				
With Ammonia Salts— (= 82 lbs. Nitrogen.)	With Ammonia Salts— (= 82 lbs. Nitrogen; & Sawdust.)	With Ammonia Salts (= 82 lbs. Nitrogen and Cut Wheat Stra		COMMON NAMES.
10	11	12 a	12 b	
14	15	14	14	
2·98	3·42	2·03	0·95	Hard Fescue.
1·35	1·90	1·57	5·36	Meadow Fescue.
9·35	10·43	8·93	1·79	Downy Oat-grass.
8·75	8·79	3·68	4·20	Yellow Oat-grass.
11·55	7·96	11·97	5·25	Common Bent-grass
11·89	6·08	7·46	4·41	Rye-grass.
11·06	8·63	4·00	6·25	Woolly Soft-grass.
5·04	11·91	23·55	30·97	Rough Cock's-foot.
12·00	8·97	8·63	11·69	Rough Meadow-grass.
0·72	0·13	0·40	0·34	Smooth Meadow-grass.
0·14	0·30	1·22	0·77	False Oat.
0·49	1·42	1·23	0·54	Sweet Vernal-grass.
0·04	1·55	5·65	1·55	Fox-tail.
...	...	...	...	Quaking-grass.
...	0·11	...	...	Crested Dog's-tail.
2·21	1·37	0·29	0·32	Soft Brome grass.
...	...	...	...	Cat's-tail.
...	...	...	...	Tufted Hair-grass.
77·57	72·97	80·61	74·39	
6·31	8·91	6·52	12·69	
5·78	4·96	3·25	5·06	
89·66	86·84	90·38	92·14	

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5. *Nitrate of soda alone*, like ammonia-salts alone, considerably increased the produce of Graminaceous herbage, and tended chiefly to the production of root-foliage. The nitrate, however, strikingly brought into prominence the Alopecurus pratensis, at the expense, compared with the produce by ammonia-salts, chiefly of Agrostis vulgaris, and partly of Festuca duriuscula. Otherwise, the distribution of species was not very materially altered, the more luxuriantly-growing grasses not being much developed. The crop was much more leafy than stemmy, very dark green, and late; contained very little Leguminous herbage, though rather more than the produce by ammonia-salts alone; and the weedy plants were luxuriant rather than numerous—Plantago lanceolata, Centaurea nigra, Rumex acetosa, Achillæa millefolium, Ranunculus, and Taraxacum, all being more or less encouraged.

6. *The combinations of nitrogenous manure* (ammonia-salts or nitrates) *and mixed mineral manures*, gave by far the largest crops, the largest proportion of Graminaceous herbage, the largest proportion referable to a few species, scarcely a trace of Leguminous plants, and a small proportion both in number and amount of Miscellaneous or weedy ones. The produce was very luxuriant, with a great development of stem and stem leaves, and a much greater tendency to ripen than when the ammonia-salts or nitrates were used without the mineral manure. The predominating grasses were the most bulky and free-growing ones; Dactylis glomerata, and Poa trivialis, being very prominent; and Avena pubescens or A. flavescens, Agrostis vulgaris, Lolium perenne, and Holcus lanatus, somewhat so. Festuca duriuscula, F. pratensis, Arrhenatherum avenaceum, Alopecurus pratensis, Bromus mollis, and others, were almost excluded.

7. *Farmyard-manure* considerably increased the growth of the grasses, and of some few weeds, particularly Rumex, Ranunculus, Carum, and Achillæa, and reduced that of clover and allied plants, more especially when used in combination with ammonia-salts. It greatly encouraged the growth of the good grass Poa trivialis, and of the bad one Bromus mollis; and when in conjunction with ammonia-salts the Dactylis glomerata. Under both conditions Festuca duriuscula and F. pratensis were nearly excluded, and Avena flavescens, A. pubescens, Agrostis vulgaris, Lolium perenne, and Arrhenatherum avenaceum, were very much reduced. The crops were upon the whole bulky, comparatively simple as to description of herbage, fairly luxuriant both in stem and leaf, somewhat rough and coarse, and showing a tendency to unequal ripeness.

8. *Leguminous herbage* was almost entirely excluded whenever nitrogenous manures were used in any quantity, whether in

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the form of ammonia-salts or nitrates, alone or in combination with mineral manures; but it was somewhat less so with the nitrate than with the ammonia-salts. Mineral manure alone, containing both potass and phosphoric acid, greatly increased the growth of the Leguminous plants, perennial red clover and meadow vetchling. Farmyard-manure like artificial nitrogenous manures, also, but in a less degree, much diminished the proportion of the Leguminous herbage.

9. Every description of manure diminished the number of species, and the frequency of occurrence, of the *Miscellaneous* or *weedy herbage;* mineral manures alone less so than any other; nitrogenous ones, especially in combination with mineral constituents, did so very strikingly, but they at the same time greatly increased the luxuriance of a few species, especially Rumex acetosa, and frequently Carum Carui and Achillæa millefolium. Plantago and Ranunculus were generally discouraged by active manures, excepting farmyard-manure and nitrate of soda. The nitrate also favoured Centaurea nigra and taraxacum dens-leonis.

10. Considerable increase of produce was only obtained by means of farmyard-manure, or artificial manures containing both mineral constituents and ammonia-salts or nitrates. The crops so obtained were much more Graminaceous, and consisted in much greater proportion of but a few species of plants. The grasses developed were chiefly of the more bulky and freer growing kinds, and the produce was generally very stemmy—being the more so, and the coarser, the more excessive the manuring.

11. Meadow-land mown for hay should not be manured exclusively with artificial manures, but should receive a dressing of well-rotted farmyard-dung every four or five years.

12. Sewage irrigation, like active manures applied to meadow-land in the ordinary way, has also a tendency to develop chiefly the Graminaceous herbage, excluding the Leguminous, and to a great extent the Miscellaneous or weedy plants. It also, at the expense of the rest, encourages a few free-growing grasses, among which, according to locality and other circumstances, Poa trivialis, Triticum repens, Dactylis glomerata, Holcus lanatus, and Lolium perenne have been observed to be very prominent. The result is an almost exclusively Graminaceous and very simple herbage. But, as the produce of sewage-irrigated meadows is generally cut in a very young and succulent condition, the tendency which the great luxuriance of a few very free-growing grasses has to give a coarse and stemmy later growth is less objectionable than in the case of meadows left for hay.